Summary of the doctoral dissertation titled:

Use of the geographic information systems (GIS) to model the impact of selected municipal waste management facilities on the environment.

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Waste generation has been an inherent characteristic of human economic activity over the centuries, whereas its management is becoming a big problem in all societies and economies. Therefore, there is a requirement for the process not to harm the environment. Functioning of municipal waste facilities poses a potential threat to the environment.

The aim of this doctoral dissertation was to determine the extent and nature of the potential impact of selected municipal waste facilities, i.e. a municipal landfill site and a waste-incineration installation, on the environment, as well as selection of the optimal location for a new waste treatment facility. With this end in view, mathematical modelling, Geographic Information Systems (GIS) and computer software were used to model the impact of the municipal waste management facilities on the environment on the spatial numerical maps.

The two chosen objects, which implement two different technologies for waste neutralization, require different conditions for choosing the place of their location and interact with the environment in definitely different ways, were analyzed in the dissertation. An examination of the surface and underground water levels was done within the active landfill. A tool that has been applied is the mathematical modelling, using the geographic information systems (GIS) in the form of the sozological maps used for air-pollutant distribution, which constitute a valuable source of information about the condition of the environment in the analyzed object locations.

The quality of the groundwater in the vicinity of the landfill was determined based on the tests of samples taken from control piezometers, whereas the physical and chemical parameters of the surface water were determined at some points of the watercourse in the area of the landfill. The surface and underground water tests and the analysis of their results indicate that the waters within the landfill are in a good condition, suggesting that the sealing of the landfill basement fulfills the intended functions.

Using the Visual MODFLOW Pro ver. 4.2. software, a conceptual hydrodynamic model of the municipal waste landfill was built, allowing for modelling of contaminant migration in the underground and surface waters in the case of damage to the insulation of the landfill foundation. The hydrodynamic model built is a two-layer dynamic, spatial, model of the indicative value, i.e. it allows to determine the trend of propagation of contaminants in the aquifer and to estimate its speed.

The results of the performed modelling of contaminant migration in the ground waters in the case of damage to the landfill foundation insulation indicate that migration of contaminants in the natural directions of water runoff is practically impossible due to the limited possibility of contaminant infiltration. This situation is caused by two factors; firstly, by the direct occurrence of impervious layers – the sandy clays and secondly, in the case of landfill leachate seizure by a drainage system, there is no possibility of contaminants penetrating the surface waters. Within the landfill, the aquifer is relatively deep which further limits the speed and possibility of contaminant migration.

The potential possibility of contaminant migration into the underground waters occurs only in the event of disturbing – damaging the layer which insulates the landfill foundation. In such a case, vertical infiltration will take place in the aeration zone for a relatively long time - more than 17 years. However, contaminant migration already in the saturation zone (rehydrated) will take place very fast. After 50 days of reaching the aquifer level, contaminants have travelled to the main stream draining the analyzed area, consequently they get diluted rapidly.

Implementation of the modelling to determine contaminant migration into the ground- water environment at the stage of the facility functioning, based on the example of the landfill, makes it possible to verify the modelling results with the results obtained from the tests and allows the use of any corrective or compensation actions in the event of damage to the insulation layer of the landfill and infiltration of the contaminants into the ground-water environment.

The dissertation addresses also the issue of location of the facility which is an installation for thermal treatment of municipal waste, particularly in terms of environmental sustainability. These types of solutions will be a priority in designing, constructing and functioning of such facilities in the coming years. The proposed solution, based on the modelling of air contaminant distribution, uses the Geographic Information Systems (GIS) at the very stage of drawing up plans for the location and construction of municipal waste treatment plant. Implementation of the Geographical Information Systems (GIS) is necessary to define an appropriate environment in the vicinity of the plant and to determine the potential impact of the facility on the environment.

An analysis of simulations of the air contaminant distribution for selected locations of municipal waste incineration installation was performed, which helped determine the optimal (in terms of the environment) location of the municipal waste management facility which is the thermal waste processing plant.

An allocation of a mathematical model developed for determination of the environmental quality index was proposed, including a set of data structures (parameters) which identify unambiguously the contaminant dispersion process and methods (algorithms) to process the data. The concept of environmental quality index is based on a mathematical model, which is a discrete, deterministic model, based on the analysis of the distribution of contaminant concentrations in the individual components of the environment. The model data structure of the environmental quality index is based on groups of parameters describing the process of dispersion of contaminants in the environment.

The defined environmental quality index applies to the given facility containing a group of the contaminant sources in the terms of the given cover of the sets (the vertex cover in the graph). This solution is a functional module of the global application model, allowing for a simulation of the impacts of the individual elementary processes on the environment in multi-criteria analyses of alternative solutions of integrated waste management systems. The values of the matrix components representing the given index determine selection of the optimal solution of the system variant, taking into account the cumulative impact of the group of sources on the selected components of the environment (ambient air).

The introduction of the environmental quality index can provide a solution to support the decision-making process in choosing the location for a municipal waste facility in terms of the facility impact on the individual elements of the environment. Therefore, this solution is a functional module of

the global application model, allowing for simulation of the impacts of the individual elementary processes on the environment in the analyzed variants of solutions. The environmental quality index is of a quality character only in the issues of the optimal facility location which can affect the environment adversely.

The proposed solution consisting in usage of the GIS in analyses of the impact of waste management facilities on the environment creates new opportunities in assessment of the effect of a proposed investment on the environment. Practical implementation of such a solution will be indispensable in the decision-making process of selecting the location for a new investment and in assessment of the potential impact of municipal waste neutralization facilities during their lifetime.