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AUTOMATED SOLID WASTE DISPOSAL SYSTEM

Abstract: The article is devoted to solving the problem of solid waste disposal in cities. The solution is based on the analysis of the latest research and development of other countries in solving this problem. The proposed solution is the construction of special landfills to ensure the decomposition of organic and biodegradable waste for the use of raw materials in the production of a closed cycle. This landfill includes many environmental monitoring sensors that transmit information to the city control center to inform, control and respond to relevant situations.

Keywords: solid waste disposal, automation, “smart” city.

Introduction

The planet is currently suffering from large amount of rubbish, especially solid waste, which is the most difficult to dispose of. Most of the garbage accumulates in special or natural landfills, or is discharged into reservoirs, which has a detrimental effect on soil, surface and groundwater. Incineration, as the cheapest method of waste disposal, is one of the key aspects of air pollution with harmful substances, so developed countries are creating a legal framework to minimize the use of this method.

Most modern problems are not being solved without the involvement of the principles of automation and this is no exception. After all, this approach allows you to control all the necessary processes and their performance without human intervention.

The purpose of this article is to describe the process of solid waste disposal with the involvement of automated systems.

Formulation of the problem

Most waste in cities around the world is not currently sorted, making it much more difficult to find the best method of solid waste disposal. It is also necessary to reduce the impact of the disposal process on the environment, so the area allocated for this activity should not contaminate soils and groundwater, and therefore not depend on them. That is, it is necessary to develop a recycling project that can have any location, but not far from the city to reduce transportation costs, and with minimal impact on nature.

The most common endpoints of the waste disposal process are landfills. Therefore, it is necessary to improve their work first, but this should be done with minimal change of waste collection stages, such as sorting waste at the human level and its transportation. Also, the principle of chaotic waste storage is not recommended to change drastically, so as not to increase the price of this solution, which allows its widespread use.

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The waste balance can be written in the form of equality [1]:

$$_1 + \ _2 = \ _3 + \ _4 + \ _5, \quad (1)$$

where $_1$ – waste balance at the beginning of the year, t, m^3; Q_2 – the amount of waste generated per year, t, m^3; Q_3 – the amount of waste removed per year, t, m^3; Q_4 – the amount of waste used per year, t, m^3; Q_5 – waste balance at the end of the year, t, m^3.

Ideally, the annual waste balance should look like this:

$$_2 = \ _3 + \ _4 \quad (2)$$

But the indicator $_4$ must be much larger than $_3$ ($Q_4 \gg \ _3$).

Analysis of recent research

The simplest, but at the same time the most effective, waste disposal technology is a special algorithm for constructing landfills (Fig. 1) [2]. The landfill is covered with a material that does not absorb liquid. A system for collecting wastewater, which is emitted by garbage, is being built in the deepening. The waste is lined in a line of a certain width and length for faster decomposition of materials and covered with a layer of clay. A ventilation pipe is set up for each line to remove air and flammable gases. This system provides fast cleaning of waste from organic matter and materials that decompose quickly, which prepares waste for recycling.

To control all aspects of the city, the technology of the "smart city" has become very popular now, or, in general, the technology of combining electronic devices into a single network - the Internet of Things (IoT) [3]. It is a coverage of the city by various sensors and a combination of different utilities into one integrated system. Specialists who monitor various indicators of sensors have a complete picture of the work of the city as a whole and can respond in a timely manner to relevant factors. Artificial intelligence technologies are also currently being integrated into this system, allowing city regulation without human intervention.

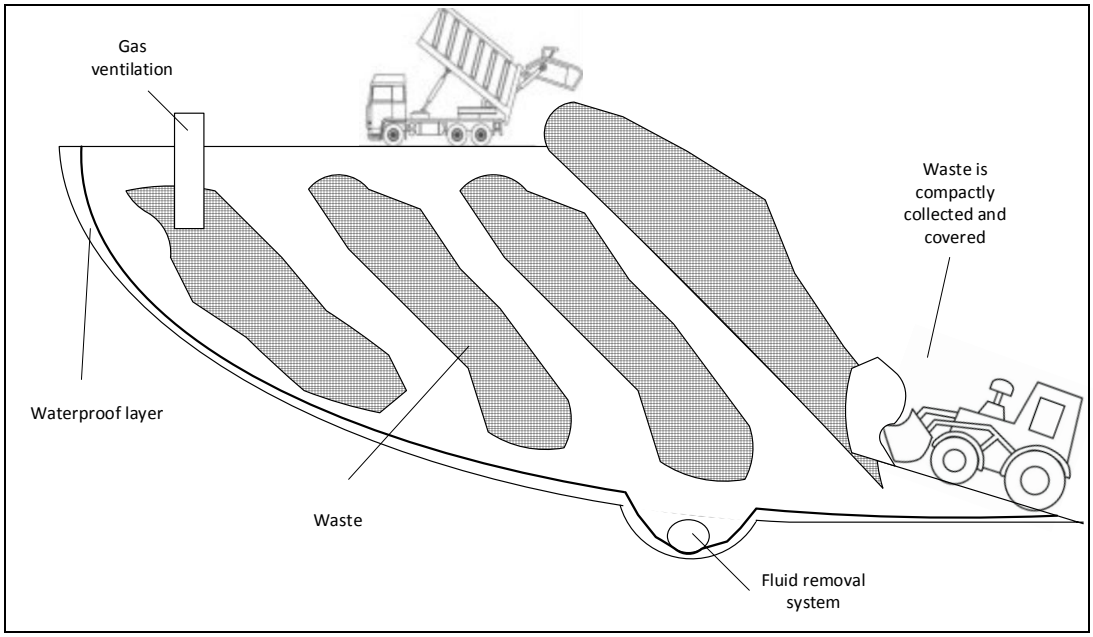

Figure 1. Typical sanitary landfill for solid waste

Suggested solution

Examining the existing solutions, we can see that the traditional system of solid waste disposal is unstable to critical situations and mostly depends on the human factor. Mistakes can lead to groundwater, air and fire hazards.

The solution to this problem is to use automated systems. During the development, an automated waste disposal system was obtained (Fig. 2). It allows you to monitor the soil and groundwater for gases and liquids that are emitted by waste, and respond properly.

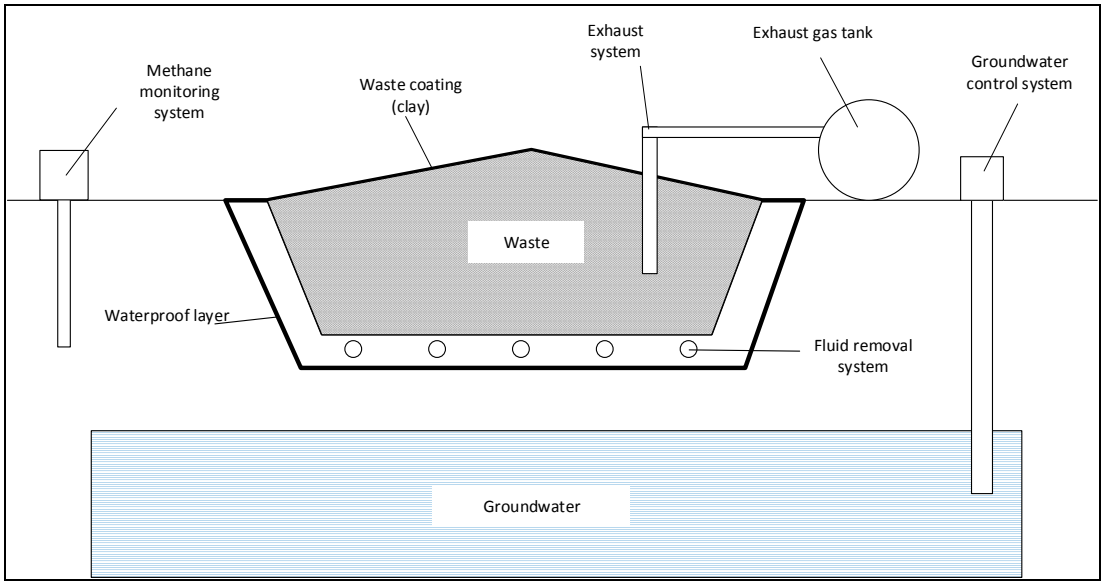

Figure 2. Automated waste disposal system (landfill)

The disposal process consists of the following stages:

- an underground landfill, covered with a waterproof layer, is excavated to prevent harmful substances from entering the soil and groundwater;
- waste is brought to the landfill and covered with solid materials, such as clay;
- a system for removing liquids that are emitted by waste is installed between the debris and the waterproof layer. It is connected to the tank and also makes various measurements, such as flow rate and composition of substances;
- a gas removal system is installed inside the waste pile to prevent the risk of methane debris igniting or air pollution. It also includes a system for monitoring indicators;
- to prevent emergencies of environmental pollution, in addition to the constructed structure, sensors for monitoring soil (methane content) and groundwater are installed.

The landfill must be covered by the Internet (Wi-Fi) for the system to work properly. All sensors use it to transmit information to the control center of the landfill, which is already making decisions about the critical situation. For example, the liquid monitoring sensors will signal the desired reduction or increase in the fluid flow pressure when the air monitoring sensors prompt the gas output to be adjusted. In exceptional cases, further disposal may be stopped and the landfill must be inspected for damage.

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After some time required for the decomposition of organic and perishable materials, the waste is unloaded from the landfill and can be taken to sorting stations, where garbage is converted into secondary raw materials, which leads to the creation of closed-loop production at enterprises.

To attract the recycling center to the network of the "smart" city, the information collected by the relevant sensors is assembled and sent to the data center of the city. In this way, cities will be aware of the state of waste disposal and the presence of exceptional situations at landfills, about which the population can be warned in advance, which will significantly reduce the damage from the event.

Conclusion

The amount of garbage generated even by small towns is constantly growing. There is a problem of disposing of this waste, while spending the minimum necessary money and time, without polluting the environment, because otherwise, the health of the population falls. Developed countries already have some developments on this topic, so they were taken as a basis for the principle described in this article. Disposal takes place at a special landfill, to which sensors are connected, which transmit all available information via Wi-Fi and control the level of debris decomposition and monitoring of surrounding soils and groundwater. They allow to determine the level of methane in soils, groundwater pollution by decay products, and control the level of emissions of substances and gases from waste. This avoids the emergence of critical situations that can have negative consequences in the form of fire due to flammable gases, and oversaturation of the landfill with harmful substances, which will lead to their spread in the soil and surrounding waters. It also provides an opportunity to pass all the necessary information to the city management center for appropriate information, monitoring, and response to any events in the city.

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