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Disinfecting of the leachate of solid waste landfills with the application of hydrobiological cleaning

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Abstract. Methodological and technical approaches to cleaning of the leachate of the municipal solid waste (MSW) on hydrobiological constructions are offered. The purpose of work was justification of cleaning of drains of MSW by means of community of plants (including natural vegetation of grounds and dumps of MSW). The major factors influencing design solutions of hydrobiological constructions for cleaning of drains of MSW are shown. It is shown that cleaning of drains of MSW requires cleaning in three-stage ponds. On a first stage the shallow ponds no more than 0.5 m in depth for a destruction of organic pollution by means of saprophytic bacteria, utilization of biogenic elements with use of a complex of microalgas and disinfectings of drains due to formation of food chains, and removals of pathogenic bacteria are provided. On a second stage ponds with planting of water vegetation are provided deep-water (not less than 0.5 m). For three-stage cleaning of drains after a second stage as a part of hydrobiological constructions biochannels are provided. The method of calculation of a response time of water at each step of cleaning and the area of a mirror of ponds is presented. Hydraulic loading proceeding from the area of landing of gidromakrofit and a daily consumption of the purified water is calculated. For decrease in an index of BOD before dumping of drains into the superficial reservoirs the special structure of biocanals is provided. Basic elements of biochannels known in biomeliorative practice are presented in article. The technique of definition of a hydraulic radius necessary for calculation of driving of water is given in channels.

1. Introduction

Current problem is cleaning of a leachate of municipal solid waste (MSW) landfills, considered in works [1,2]. The known developments [3] allow to use vegetation in the course of biological cleaning of a leachate of MSW. Earlier researches on selection of vegetation at a biological stage of



recultivation of dumps and solid waste landfills were conducted. Also the technology of a recycling of a leachate with application of vegetation was offered [4].

2. Object and research methods

At justification of hydrobiological systems of neutralization of leachate organoleptic, physical and chemical, chemical analysis, biological methods, methods of systems analysis were used. Models were developed with use of the general theory of systems, a calculus, mathematical physics, statistics and accidental processes.

3. The results of the study and their discussion

Defining factors for construction of hydrobotanical stations as a part of hydrobiological constructions for cleaning of drains of MSW are hydraulic efficiency and loading on carbon and nitrogen [4,5]. The special complexity is represented by calculation of a response time of drains of MSW at the station and the required square for them. There is an experience of purification of economic and household sewage with hydrobotanical methods in which N-NH_4 makes 50 mg/l while in a leachate of MSW concentration of ammonium nitrogen can reach 900 mg/l.

Considering the known experience of purification of utility fluids [1,4] and results received when using vegetation (*Dactylis glomerata*) and trees of the sort *Salix* for cleaning of drains of MSW the area of the hydrobotanical stations for cleaning of the drains which are formed on the ground of low power, the leachate of 15 m³/day which with an average is allocated was calculated and loading on N-NH_4 – 15 kg/day [6]. In calculations considered loading on nitrogen since it in a leachate is especially high. The total area of the botanical station for cleaning of drains of MSW has to be in this case 5000m². To avoid seasonal changes of hydraulic loading, it is necessary to have the big tank store. As it primary pond store containing in itself up to 30% of annual volume of the formed leachate is offered (during the cold (winter) period).

For assessment of the required leachate response time at the hydrobotanical station, it is necessary to consider pollution on nitrogen and carbon in a filtrate that predetermines increase in time recommended in practice of purification of utility fluids by 2–3 times. Besides at botanical stations of a leachate the periodic dehumidification of the earth increasing the content in it of oxygen and promoting process of a denitrification is desirable (the effect of cleaning of nitrogen at such technology increases from 25 to 90%).

The water response time in step ponds was counted, proceeding from the processes of a self-cleaning which are followed by oxygen consumption on a mineralization of organic matters and a reaeration.

By BOD values on an entrance and an exit and to literary data according to which extent of cleaning at each step of biological cleaning in hydrobotanical ponds is accepted equal 70% of initial BOD, determined the intermediate BOD full values: on escaping of a first stage – 100, on escaping of a second stage – 45 mg of O₂/dm³. In the given sizes calculated a water response time in step ponds of these hydrobiological constructions which made 10–15 days.

In the technological line on a first stage shallow ponds with the flat bottom and no more than 0.5 m in depth, with the dispersed release and drainage of water (2–3 points) and the general response time of drains have to be provided in ponds not less than 5 days. The main purpose of ponds to 1 steps – a destruction of organic pollution by means of saprophytic bacteria, utilization of biogenic elements with use of a complex of microalga's and disinfecting of filtrational waters due to formation of food chains. Additional aeration isn't provided in this pond, enough oxygen is provided due to photosynthetic activity of microscopic algaes. Functioning of the first pond begins with approach of the vegetative period. For acceleration of process of start of a pond it is possible to bring the adapted complex of microalgas including algaes of various systematic groups in it.

Ponds are equipped with the spare channel (or additional botanical platforms) for a possibility of shutdown of ponds for the purpose of carrying out necessary works on landing of plants and their

cleaning. The disseminating water outlet and a water inlet for ensuring movement of water on all section of a pond are provided in all ponds.

In the technological line on a first stage shallow ponds with the flat bottom and no more than 0.5 m in depth, with the dispersed release and drainage of water (2–3 points) and the general response time of drains have to be provided in ponds not less than 5 days. Ponds are equipped with the bypass channel for a possibility of shutdown of a pond for the purpose of carrying out necessary works on landing of plants and cleaning of a pond. The area of one pond is 500 m² of calculation that the total area of a first stage of the hydrobotanical station about 2000 m². On stream there have to be not less than 3 ponds, the earth in other three ponds during particular time dries up for increase in efficiency of cleaning of nitrogen. Filtrate layer height on a first stage averaged 10–20 cm. The bottom of all ponds has to be covered by clay and is laid out by gravel. On a second stage ponds with planting of water vegetation are provided deep-water (depth not less than 0.5 m). Process parameters of steps of biological ponds are presented in table 1.

Table 1. Process parameters of steps of biological ponds.

Indexes	1-st step	2-nd step	Biocanal
Area of a mirror of ponds S_{all} , m ²	1554	230	1560
Depth H , m	0.5	1	1
Volume, m ³	772	230	1560
BOD on O ₂ /dm ³ mg entrance	200	100	45
BOD at O ₂ /dm ³ mg exit	100	45	3
Average temperature, °C	13	13	13

At the given consumption of the purified water Q , the given width of a pond of B and its depth of H optimum for body height and development of plants, water velocity v in ponds on hydrobiological constructions is determined by a formula

$$v = \frac{Q}{BH}.$$

Hydraulic load of N of a step of cleaning is defined proceeding from the area of landing of gidromakrofit (m²) and a daily consumption of the purified water (m³/day)

$$N = \frac{Q}{S}.$$

Length of a pond of L was calculated by a formula $L = \frac{S}{B}$.

Task of necessary extent of water treatment at each step C_{IN}/C_{OUT} at the known values of a consumption of the purified water Q and coefficient of speed of weakening of pollutants of k allows to determine the necessary geometrical sizes of the block

$$\frac{kLBH}{Q} = \ln \frac{C_{IN}}{C_{OUT}},$$

where C_{IN} concentration of pollutants on an entrance of the block, mg/l; C_{OUT} – the same, at the exit, mg/l; k – coefficient of speed of weakening of pollutants.

Taking into account that drains on escaping of bioponds of the 2-nd step have the indicator of BOD exceeding permissible values before dumping of drains into the superficial reservoirs additional cleaning of drains is necessary. For this purpose, as a part of hydrobiological constructions introduction of biochannels in which it will be reached necessary parameters of the purified water is planned.

At projection of the biochannel it is necessary to consider a transverse section form which can be: rectangular, trapezoidal, polygonal, parabolic, compound, triangular. In classical literature for problem solving on meliorative practice the cross profile of the irrigation canal includes the following elements:

- width of the channel on the bottom of B . For small channels B makes 0.2 to 1 m, for larger – 10m and more. For small channels width is determined by the bottom by type of the channel of the digger;
- water depth in channel H . For small channels H from 0.3 to 1 m, for larger – from 1 to 4 m change.

Water depth in the channel for the purpose of decrease of filtration, keeping of admissible speeds and smaller alienation of the earth is accepted based on the ratio of $B/H = 1$ that is when the hydraulic radius of R is close or equal to 1.

The living part of the channel (flow) is the area of the diameter of the channel through which water flows. It is defined as the area of a geometric figure, most often as the area of a triangle (half the base product at height), a trapezium (half the sum of the bases at a height), and so on. The live part of the channel can be calculated using the value of the channel slope coefficient. The moistened perimeter of the channel P is the length of the water contact line with the bottom and the channel slopes. The perimeter of the canal humidity determines the loss of water due to filtration from the canal, the resistance of the reservoir to the movement of water, etc. The value of the hydraulic radius R (the ratio of living space to wetting perimeter: $R = F/P$). It is necessary to calculate the canals and the movement of water in the canals.

Main objective of introduction of the biochannel on hydrobiological constructions is bringing quality of the cleaned drains to maximum allowable concentration for their dumping into general use reservoirs. For waste grounds where each warm period accumulates network of the polluted drains of MSW, it is possible to offer biological rehabilitation of the soils polluted by drains and cleaning of drains during the warm period [7].

At the first stage of works as a particular method the most polluted layers of earth are removed. At the second stage (figure 1): 1. The low dams forming shallow estuaries are established. It is better to use the temporary, easily removable, not breaking a landscape membranous dams from fabric materials; 2. Estuaries are filled in with water from natural sources; 3. Estuaries become populated by water vegetation; 4. At the end of the vegetative period water goes down, dams are removed; 5. The died-off and mowed plants can be used, for example, for receiving biogas or briquetting and combustion (what it will be told below about); 6. Vegetation oddments will bury the polluted spot. As a dam for the estuary it is necessary to use temporary designs from fabric filled or membranous with a float-operated belt of a dam.

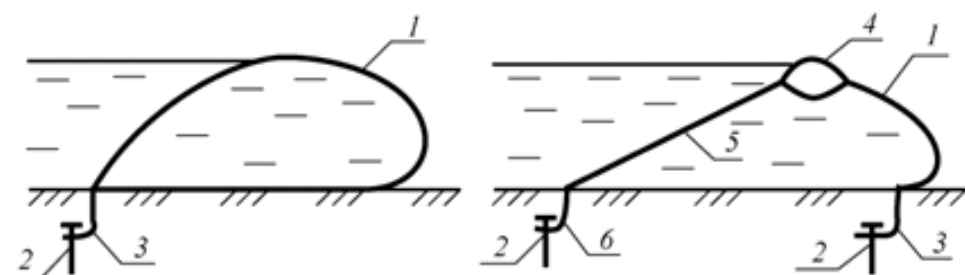


Figure 1. Scheme of fabric dams: 1 – envelope of a dam; 2 – anchors; 3 – anchored edge of an envelope of a dam; 4 – fabric float; 5 – hummock delays; 6 – anchored end of hummock delays.

4. Conclusions

Thus, the system of complex technological cleaning of drains of MSW allowing to vary cleaning steps depending on changes of chemical composition of drains is developed. On the basis of model of water

balance of solid waste landfill calculations of loadings are executed: hydraulic, on BOD, COD, N-NH₄, on heavy metals on treatment facilities of drains of MSW on the ground of big power on the offered complex cleaning, taking into account serial commissioning of working sections. Effective decrease in pollution at introduction of a system of complex cleaning of drains of MSW is shown.

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