Use of the Lightproof Greenhouse for Autonomous Wastewater Treatment

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***Abstract*—The design and perspectives for development of wastewater processing with the help of facilities located in lightproof thermoizolated greenhouse are discussed. There are created rational thermal and light conditions which allow to optimizes processes of biological treatment of sewages. It is shown that diluted wastewaters can be treated to desired quality. Recycling of water and utilization of nutrients from sewage on site does technology ecologically safe.**

I. INTRODUCTION

Systems of natural ecological wastewater treatment can minimize environmental problems and facilitate utilization of the resources in the wastewater. These systems use devices which treat wastewater on site. Among the devices biofilters, hydroponics system, composting reactor, storage conditioning units, soil- plant filters at all. Especially successfully these devices can be applied in technologies of separate processing of wastes of distinct origin [1]. Uncontrollable mixing of the wastes of various originations is the most undesirable at operation of small local wastewater treatment systems.

II. LABORATORY EXPERIMENTS

We have made preliminary laboratory experiments with model solutions for gray waste waters.

Model waters were prepared of milk, vegetable oil, chloride sulphonoule, NH_4Cl, KH_2PO_4. Sometimes instead of NH_4Cl, KH_2PO_4 diluted urine was added. This composition approximately corresponds to the composition of drain which is flowing from filter-homogenizer containing zeolite. The composition of model and purified waters after processing in aerobic biofilters is shown in the table below:

TABLE I.
QUALITY INDEXES FOR PURIFIED WATER

Index, mg/l	Processing time, hours		
	0	24	52
pH	7 -8	7,7	7,7
BOD_5	20 - 40	7.0	4.4
COD	70 - 95	32	31
SS	5 - 8	3.7	3.2
NH_4^+	2 – 4	0.4	0.2
NO_3^-	0.5 – 1.6	1.5	1.9
PO_4^{3-}	0.5 - 2	0.75	0.8
SAS	5 - 7	1.1	0.7

In these experiments we have used aerobic bioreactor equipped with nets for attached micro flora. The main reactor characteristics were: technological volume 1.5 m^3, active operation square – 15 m^2/m^3, oxygen concentration – approximately 3-4 mg/l, water exchange in vicinity of bottom is approximately 0.05 m/c.

Obtained results have shown that the offered technology allows receiving the purified water of desirable quality. It is represented obvious, that the purified water of mentioned quality may be used for agricultural needs and separate household requirements. It means, that devices for natural processing have high efficiency, are ecologically safe and at the same time inexpensive in operation and manufacturing. Unfortunately cold Siberian climate make it impossible to process wastewater on open ground in cold period and especially in winter. This is why there are no doubts that base devices of system must be located in an all-the-year-round greenhouse where it is possible to prepare compost, to optimize temperature regime, illumination and other conditions suitable for plant cultivation and microorganisms dwelling. However in this case traditional glass greenhouses have high power intensive especially in winter. This is why we suggest locating the devices inside lightproof greenhouse. See also [2].

III. TECHNOLOGY DESCRIPTION

In base of the technology are separate processing of waters of different quality, their effective utilization on site and the use of natural processes for wastewater treatment. The principle block-scheme of suggested technology is given on fig.1. Black waters flows to inclined partly opened tube 8 to composting reactor 7, located in warm lightproof greenhouse 1. Liquid fraction flows to collector 9, solid fraction of black waters and surplus of green plants cultivated in greenhouse are collected for composting in block 7. Wastewater after mechanical removal of rough particles pass into a filter– homogenizer 2. Here floating particles and coarse-dispersion fraction are separated. Filtrate containing dissolved impurities is diluted by purified water from anaerobic filter-collector 3 and reservoir with aquaculture 10. Then it passes through heat exchanger 6, to inner slope soil- plant filter 5 located inside greenhouse and saturate it. There are at least three sectors of soil plant filter. One of them is located in greenhouse. Others are outside. After that water pass by the trench 14 outdoor to a ditch or small pond with aquatic plants 15. A part of water is evaporated during processing on soil – plant filter. Outflow from the ditch 15 is collected in the anaerobic filter-collector 3, which is located inside an underground heat accumulator 4. Treated water pass to the reservoir with aquaculture 10.

Purified water is discharged periodically. This allows intermittent drying of the soil-plant filter. During processing water undergoes conditioning. In the filter - homogenizer it is diluted by purified water and alkalized (first stage of conditioning). Tab.1 presents composition of wastewater after this stage of conditioning. At the second stage of conditioning small water portions are mixed with large masses of water, which circulate between soil-plant filter, trench with aquatic plants and the anaerobic filter-collector. If necessary purified water may be detoxicated by UV-irradiation. Warm wastewater flows in heat exchanger. It makes warm the soil-plant filter and the upper part of the anaerobic biofilter that is constructed as a part of underground heat accumulator. The size of anaerobic biofilter equals water volume consumed in the house during approximately ten days. It provides sufficient long time for wastewater processing. In winter the processing and utilization of water is carried out mainly on the basis of filter- homogenizer 2 and the soil-plant filter section 5, which are located in warmed lightproof building compactly placed in the effective zone of ground heat accumulator4 (see fig.1). Excesses of purified water may be collected in ditch 15 after ice breaking. Radiation from lamps in lightproof greenhouse is spent mainly for photosynthesis and greenhouse heating. This makes energy losses negligibly small.

IV. LIGHTPROOF GREENHOUSE STRUCTURE

There are particular aspects of lightproof greenhouse design. In any case greenhouse may have thick lightproof thermoisolated walls and a roof supplied with ventilating air tubes and soil plant filter above it. The variant of an underground lightproof greenhouse is shown on fig. 1.

In this case the equipment is placed at different heights but at the same floor. It allows organizing a liquid flow under the influence of gravitation. Inside slope roof there are ventilation tubes above which there are some sections of soil –plant filter. Experiences on creation and operation of lightproof greenhouses in Siberia and Yakutia have proved some advantages of two-storeyed buildings [3]. In this case it is easier to organize optimum distribution of heat and light. Two-storeyed greenhouse became divided into two workrooms. It allows regulating its heat radiation and light exposure in a mode "day – night". Heating of the day workroom is made by heated air moving from light irradiators of night workroom. It allows reaching the optimum mode of air exchange in a greenhouse placed on two floors.

One of the key parameters of microclimate of a greenhouse is light exposure. Investigations [3] have shown that high intensive lamps of Russian production are especially well suitable for use in greenhouse conditions. These lamps possess high luminous efficacy and are characterized by a spectrum shifted in dark blue area. The minimum height of installation of a lamp of this type over a plant is about 0.15 m. Our experiments show that this distance between the lamp and a plant is the most optimal.

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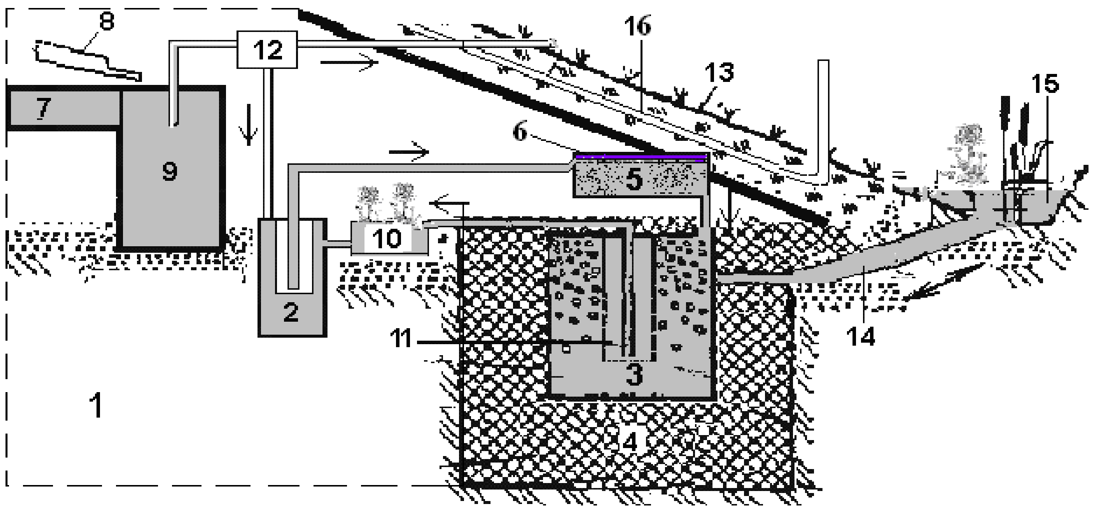

Fig. 1. The device scheme