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ENVIRONMENTALLY COMPATIBLE LOW-BUDGET TECHNOLOGY OF ORGANIC WASTE DISPOSAL DURING WARTIME AND UNDER PROBLEMS OF HOUSING AND COMMUNITY MANAGEMENT FOR INDIVIDUALS AND LOCAL COMMUNITIES

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Summary – The article examines the expediency of implementing an environmentally compatible low-budget technology for the disposal of organic waste in wartime conditions and service problems of communal services, suitable for use in auxiliary farms and at the level of local communities. The author shares his personal experience of construction and operating low-budget bioreactors suitable for use in the conditions of subsidiary farms and local communities.

Key words: organic waste, composting, bioreactor, operation.

A constant problem of our world is the existence of military conflicts. One of the results of military actions is the destruction of houses, power supply lines, housing and communal services facilities, the presence of displaced persons who need temporary detention facilities, including places for the safe collection of organic waste. This, in particular, leads to the need for the fastest recovery of the housing sector, taking into account the limitation for budgets. At the same time, the use of primitive structures for the accumulation of human waste and organic waste leads to the pollution of soils and water springs, creates a threat of the spread of infectious diseases and significantly reduces the quality of the human life. At the same time, the construction of an autonomous sewage system for homesteads is quite expensive (3,000 USD and more) and quite long (requires earthworks), leads to excessive consumption of water, makes such structures dependent on energy and water supply [1-3].

A specific problem is the termination of the electricity supply and, accordingly, the water supply to residential high-rise buildings, since when the water supply is cut off for several days it becomes impossible to use the sewage system and there is a threat of the spread of infectious diseases.

It is known that one person produces about 60 liters of excrement and used toilet paper per year, which contains 0.55 kg of nitrogen and 0.18 kg of phosphorus [1, 3]. Almost 20 million people live in Ukraine alone, who are responsible for the disposal of such waste in their households.

Both in our country and in many other countries of the world, especially in rural areas, far from all houses are equipped not only with centralized, but also with autonomous sewage, and where this is done, they do not always fully comply with the applicable sanitary standards. In addition, in those houses where there is a sewage system, the use of flush toilets, which we are used to, leads to increased water consumption. For example, flush toilets use from 26% (data from Canada) to 40% (data

from Israel) of all water used for domestic purposes. And this is despite the fact that over the past 20 years, the average water consumption for one flush of the toilet (thanks to the improvement of structures) has been reduced from 13 to 6 liters. At the same time, a large amount of hazardous waste, the so-called "black water", is formed, the cleaning of which requires the presence of expensive treatment facilities. Therefore, the construction and operation of a composting toilet can be considered as a reasonable and incomparably much cheaper alternative to the construction of an autonomous sewage system in a personal utility farm or a centralized one in a settlement, which is especially important where there is a noticeable lack of drinking water.

Thus, the most acceptable way to solve this problem is the use of composting toilets with a combination of properly equipped bioreactors, provided they are properly operated based on the use of global and local experience in this field, which will allow to significantly (up to ten times) reduce the costs of construction and operation and terms of construction with the wide use of construction materials that were in use and local materials and raw materials available in a specific area, to get rid of dependence on energy and water supply, to save water resources, to rationally use local raw materials, while satisfying sanitary and hygienic requirements, to protect the environment from potentially hazardous waste, to improve the quality of life of the population and, moreover, to obtain free of charge valuable fertilizer for use in agriculture and/or homesteads, in particular in organic crop production [2, 4].

With the correct operation of the composting toilet, you can regularly receive valuable and safe organic fertilizer, which can become a significant factor in maintaining soil fertility and thereby increasing the vitamin content of vegetables and berries, as well as a noticeable improvement in their taste properties, which is especially important for personal consumption.

In particular, the links to the article include a small selection of materials on composting **humanure** ("night gold" = human excrement) and the use of the resulting compost. The basis of this selection is the short guide presented here by Dr. Joseph Jenkins, which is posted here with the kind permission of the author (translation from English to Russian by me) [4-6].

The specified technology can be used both for individual homesteads and in the variant of centralized collection and composting of organic waste within rural communities. This technology allows you to achieve the following goals:

- Reduction of costs for disposal facilities by 10 or more times
- Reduction of construction time to a few days (up to 1-2)
- Ensuring environmental and sanitary-hygienic safety for auxiliary farms, rural communities, places of detention of displaced persons, etc.
- Obtaining organic fertilizers without using energy resources
- Organization of centralized waste collection for rural communities that have expressed a desire to have such an option

Composting is a process of biological decomposition of organic substances under controlled conditions, which occurs when the number of microorganisms and invertebrates increases. Although the process of decomposition of organic matter is natural, it can be accelerated and improved with reasonable human intervention.

During composting, organic matter is stabilized and the final product is formed, which contains humus and has a loose, uniform texture. In order to obtain a quality product and prevent possible problems, it is important to understand the basics of the composting process. Figure 1 shows the main features of the composting process.

Microorganisms and invertebrates that break down humanure and other waste require oxygen and water to survive. At the same time, compost is obtained, with the release of carbon dioxide, a certain amount of heat and water. Organic waste used for composting contains nutrients (primarily nitrogen and carbon compounds) that are necessary for microorganisms involved in the process of decomposing waste and obtaining compost. During the vital activity of these microorganisms, heat is released, due to which the temperature of the compost rises from a temperature approximately equal to the temperature of the surrounding air to a temperature of about 70°C. An increase in temperature leads to an increase in evaporation. As the process nears completion (which usually takes one month to one year), the temperature of the compost is gradually reduced to about ambient air temperature. During composting, the volume of material decreases. Most of this reduction is the result of the release of carbon dioxide, water and some other gases into the atmosphere.

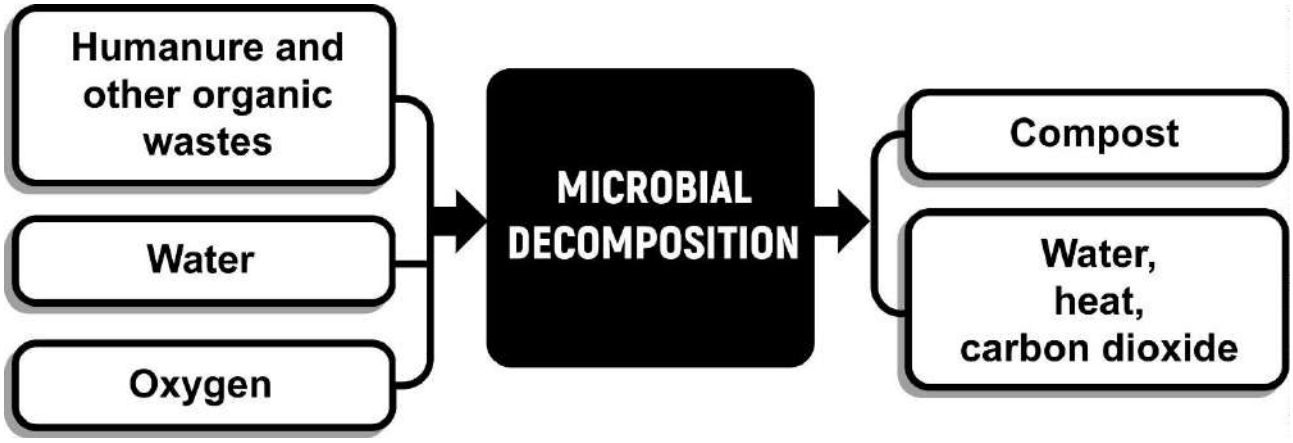

Figure 1. General diagram of the composting process.

The initial temperature of the compost usually corresponds to the temperature of the surrounding air. If the initial temperature of the pile is lower than 21°C, then psychrophilic bacteria start the decomposition process. At the same time, a small amount of heat is released, which, however, leads to an increase in the temperature of the pile. Due to a change in conditions, mesophilic bacteria begin to dominate the heap. In turn, due to even faster decomposition by bacteria, the temperature of the pile increases even more, which creates an environment favorable for thermophilic bacteria. Then, when the number of thermophilic bacteria in the pile decreases, the temperature gradually decreases, and mesophilic bacteria prevail again. High temperatures have the advantage of killing pathogenic organisms and weed seeds, while moderate temperatures promote the growth of mesophilic bacteria, which most efficiently break down organic matter. If the material to be composted does not contain pathogenic organisms or weed seeds, there is no need to worry about reaching high temperatures. Most organisms that decompose organic matter die or become inactive if the

temperature rises above 60°C. The amount of temperature rise and fall during composting depends on the material being composted, the composting method used, and the amount of water available for evaporative cooling [1].

Along with this, the author considers it appropriate to share some considerations regarding the feasibility of composting humanure in the conditions of personal homesteads and his personal experience of building and operating a compost box, that is, a bioreactor.

In those places where wood is not cheap or not available, other materials can be used in the construction of compost bins. A good and fairly cheap alternative is the use of asbestos-cement pipes as racks and flat slate sheets as the walls of the box in the construction of the compost box. This material could be cut and drilled quite well. Additionally, it is very durable and easy to clean if necessary. The construction shown in fig. 1 were designed for a family of 4 people and an estimated volume of compost produced in 1.2-1.4 cubic meters per year. It has 2 compost boxes and a compartment (under the roof) for storing organic material for backfill and it costs about $90 (all material and labor). Such a structure was operated by the author of the article in his own yard in during 2009-2014. This item was located in the corner of the land plot.

Due to moving to another place of residence in 2017, the author built another structure in a new place, which was made of construction materials that were in use - metal fittings and corrugated slate. Even taking into account the general increase in prices, the new construction cost less - somewhere around 70-80 dollars (all material and work of the welder). This design, shown in fig. 2 and 3, is still in use today.

Before starting the operation of the compost box, it is recommended to put a layer of chopped branches of trees, shrubs or vine prunings on its bottom. It is recommended to purchase and use a garden shredder to obtain such a material. During the operation of the mentioned facility, sawdust (to fill the contents of the replaceable containers of the compost toilet in the house) and straw (to fill the contents of the compost boxes) were used as organic material. Later, straw (which was bought once in bales) was replaced by a more accessible, convenient and absolutely free material - fallen leaves, which were collected both from the yard.

Figure 2. Bioreactor: design #1.

Figure 3. Bioreactor: design #2.

Figure 4. Bioreactor: design #2 when the front wall is removed – composting process is completed.

You can also use chopped dried weeds, dried grass clippings, etc. At the same time, the annual consumption of sawdust, which was bought at a nearby sawmill, was about 8-9 bags per year. Instead of sawdust, you can use fine wood shavings, but it is not as convenient, and, as rightly stated in the manual, the consumption of shavings will be about 1.2-1.5 times more for about the same price.

As practice has shown, the recommendation to wash removable containers using detergents is redundant. It is enough to rinse the container well with water (you can use rainwater, water left after washing dishes or taking a bath/shower, etc.) and hang the replacement container on a tree or on the rack of the compost box: in 3-4 days, which is the period of changing containers in the compost toilets, rain, snow and sun will make this container clean enough for further use. The resulting compost may contain roach larvae. When extracting compost and spreading it on the beds, it is easy to detect and destroy them mechanically.

With the correct operation of the composting toilet, you can regularly receive valuable and safe organic fertilizer, which can become a significant factor in maintaining soil fertility and thereby increasing the vitamin content of vegetables and berries, as well as significantly improving their taste properties, which is especially important for your consumption. As you know, both the taste properties and the vitamin content of vegetables, fruits and berries depend on the conditions and soils in which they are grown. It is the decrease in soil fertility that is the main reason for the drop in

the content of vitamins and minerals in fruit and vegetable products, which has been observed in many countries in recent decades [1, 3].

Without regular addition of organic matter to the soil, there is a tendency to increase leaching, erosion and gradual deterioration of the physical properties of the soil. In addition, if the soil degrades, this is accompanied by a decrease in the efficiency of using nutrients to form a crop from fertilizer, especially nitrogen.

Table 1.

Typical nutrient content in ready compost

Nutrient	Content (% in dry mass)
Nitrogen	1.0 – 4.5
Potassium	0.6 – 1.1
Calcium	1.9 – 3.1
Magnesium	2.0 – 3.0
Phosphorus	0.8 – 1.1

In the organic part of the soil, the C:N ratio has a value, as a rule, in the range from 12:1 to 20:1. Any compost or other organic waste that has more than a 30:1 C:N ratio can reduce plant-available nitrogen, but will supply carbon to the soil. Compost with C:N ratios below 20:1 will increase the nitrogen content of the soil. Compost has a wide range of applications and provides a number of agronomic advantages. The demand for compost is a function of price, availability, quality and, to some extent, the quality of service provided by the distributor. Potential buyers of compost are mainly those who work in agriculture, utilities and home gardening.

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