UTILISATION OF SLUDGE FROM TREATMENT OF WASTEWATERS COMING FROM YEAST PRODUCTION

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Abstract The article presents the general characteristics of wastewater coming into the average Ukrainian city sewage clearing system. Greater attention is given to wastewater generated during the production of baker's yeast. The characteristics data of wastewater shown on example of a yeast factory. Considered the possibility of using the surplus activated sludge as fertilizer.

Keywords Aerobic biological treatment, anaerobic biological treatment, baker's yeast, fertilizer, sewage, sludge, surplus activated sludge, wastewater

INTRODUCTION

Domestic sewage and industrial effluents (including wastewater from the baker's yeast production) both goes to urban sewage clearing system. Urban sewage disposal plants of Ukraine after mechanical treatment receive 20 million tons of fresh sewage sludge with 96-97% humidity annually, which are submited to the sludge filter fields. Fresh sediment enriched in nutrients and contain 1-3% of nitrogen (dry), 1-2% of phosphorus, 0.5-1.2% of potassium and 9-31% of organic content (Shevchuk *et al.* 2001).

In raw sewage sludge (RSS) of modern big city can be a significant number of elements that at high values gain properties of heavy metals, including zinc (mg/kg) - 130-360, copper - 100-650, manganese - 380-530, bromine - 60 -200 mg/kg. As a satellite of industrial cities can be a high concentration of heavy metals in RSS: lead - 13-130 mg/kg, cadmium - 0-120, Cr - 700-3000, strontium - 170-250 (Degodyuk, 1989; Degodyuk, 1988; Nanshteyn *et al.* 1978; Shevchuk *et al.* 2001). Fresh sewage sludge of urban sewage may contain pathogenic and conditionally pathogenic microflora.

Below is a description of Bortnitska sludge wastewater treatment plant as a model of big city RSS, and the maximum permissible concentrations of heavy metals (Table 1):

Table 1. Characterization of Bortnitska WWTP sewage sludge at different times (Delalyo, 2003)

Indicators	Dehydrated sludge			Standard concentration		
	1992	**1993**	**2003**	Ukraine	EU	France
Humidity,%	60.7	75.9	83.3	-	-	-
PH	6.52	6.25	6.54	-	-	-
Nitrogen (Overall%) (on dry basis)	1.9	2.4	2.6	-	-	-
P_2O_5, % (on dry basis)	3.6	2.7	3.8	-	-	-
K_2O, % (on dry basis)	0.39	0.53	0.55	-	-	-
Pb, mg/kg dry sediment	85	109	88	750	750	300
Cd, mg/kg dry sediment	53	15	14	30	20	15
Ni, mg/kg dry sediment	207	81	65	200	300	100
Hg, mg/kg dry sediment	<2	<2	< 1	15	16	8
Cu, mg/kg dry sediment	920	394	298	1500	1000	1500
Zn, mg/kg dry sediment	2261	1256	980	2500	2500	3000
Cr, mg/kg dry sediment	2170	364	326	750	-	200
As, mg/kg dry sediment	Not find	Not find	Not find	-	-	-
Se, mg/kg dry sediment	37	34	26	-	-	-
Al, mg/kg dry sediment	10655	9930	5762	-	-	-
Tl, mg/kg dry sediment	<6	<6	<6	-	-	-
Total activity, Bq / kg dry sediment	158	162	309			

Dewatering and disinfection of sewage sludge.

The main method of dewatering and disinfection of sewage sludge is a natural drying of sludge on the sludge pits during at least 2 years. Low efficiency of this method of dehydration and lack of lands have resulted in mechanical methods of dehydration at a press filters, centrifuges, as well as by stabilizing and conditioning by using coagulants - CaO, $FeCl_2$, SO_4, and others. Conditioning occurs in the reactor under pressure at temperatures 160-180 ^{0}C. If necessary, sewage sludge is dried and granulated (Degodyuk, 1988; Zapolsky, 2000).

Composting of sewage sludge.

The most common way of treatment is composting of sewage sludge with municipal wastes or other natural fillers.

Sediment that was required exposure time, put at sludge sites with hard surface to a height of 2.0-2.5 m and weighing up to 1000 tons. For further disinfection and sludge dewatering it's monthly mixed in the warm season and kept at least 3 years.

Sediment, from which compost will be produced, must meet specific requirements for content: organic content not less than 40% by weight of dry content, nitrogen (N) - 1.6, phosphorus (P_2O_5) - 0.6, potassium (K_2O) - 0.2%, humidity - less than 82% (Popov *et al.* 1988).

MATERIALS AND METHODS

Production of baker's yeast generates quite aggressive wastewater (Table 2). Before the sewage clearing system they should be pre-cleared and decontaminated.

Table 2. Parameters of yeast production waste water without treatment and purified wastewater

Parameter Name	Units measurement	Waste water without treatment	Purified wastewater
General COD	mg / l	8500	600-810
BOD	mg / l	4800	40-150
pH		6.5-7.0	7.2-7.8
Temperature	ºC	22-26	28
PO_4	mg / l	75	0.01-0.1
SO_4	mg / l	900	450
NH_4	mg / l	85	25

Wastewater treatment produces excessive aerobic sludge, which can be used as fertilizer. One of the ukrainian baker's yeast producers use this method. Aerobic sludge, which is produced during the biological treatment of yeast production sewage, is the initial product of fertilizers production.
"Agro Bellum NPK" is the complex organic-mineral fertilizer (Table 3), which contains in its composition macro-and micronutrients and organic content of soil and plants. "Agro Bellun NPK" intended for use in agriculture as the primary fertilizer for growing spring wheat, corn and silage, spring rape, sugar beet with normal expenses 16.3 t/ha.

Table 3. Fertilizers' active ingredients and additives

№	Chemical name of active ingredients and additives	Result analysis,%	
		natural	dry content
1	Mass fraction of total nitrogen, including ammonia nitrogen	0.84 0.12	7.6 1.1
2	Mass fraction of total phosphates in terms of P_2O_5 common.	0.21	1.9
3	Mass fraction of potassium compounds in terms of K_2O	0.10	0.94
4	Mass fraction of water	89.1	-
5	Mass fraction of ash	3.01	27.6
6	Mass fraction of sulfur in terms of S (total) including sulfide sulfur (S)	0.084 0.053	0.75 0.47
7	Mass fraction of chloride	0.08	0.73
8	Mass fraction of carbonate in terms of CO_2	0.97	8.93
9	Mass fraction of organic compounds	not less than 6.5	not less than 60
10	Mass fraction of calcium compounds in terms of CaO	1.48	13.45
11	Mass fraction of magnesium compounds in terms of MgO	0.067	0.62
12	Mass fraction of iron compounds in terms of Fe_2O_3	0.027	0.25
13	Mass fraction of aluminum compounds in terms of Al_2O_3	0.016	0.15
14	Mass fraction of fluoride in terms of F (overall)	0.006	0.05
15	Mass fraction of silicon compounds in terms of SiO_2	0.08	0.74
16	Mass fraction of sodium compounds in terms of Na_2O	0.18	1.65
17	Mass fraction of water-soluble compounds of sodium in terms of Na_2O	0.125	1.15

Average concentration of organic substances (Chemical Oxygen Demand) in wastewater from yeast production is 15 kg/m^3. Sewage goes into the wastewater preparation tank. Then homogeneous wastewater containing dispersed suspension, soluble and colloidal organic, go on anaerobic and

aerobic biological wastewater treatment. As a result of using anaerobic sludge (biomass of active bacteria from a group of anaerobic bacteria) occurs:

1) degradation of organic content to their concentration in the initial flow (30-40)%;
2) biogas production (methane and carbon dioxide);
3) small (3-5)% increase in biomass.

Anaerobic biological treatment.

Anaerobic biological treatment stage occurs in the anaerobic bioreactor using active anaerobic bacteria and is designed to decrease the concentration of organic substances in the wastewater to (30 - 40)%. This carbon organic content is removed from the flow of biogas, which directed to cogeneration installation to obtain heat.

Aerobic biological treatment.

Aerobic biological treatment of wastewater used to purify water to the level that allowed for admission to the city's clearing system. On this stage aerobic bacteria serve to aerobic biological oxidation of organic content. It transformes dissolved organic into new living cells (surplus activated sludge) and carbon dioxide.

Aerobic treatment system includes aeration camera and consistently working reactors, which are combined in a single stage aeration basin and lighting (sludge settles to the bottom of the basin). Because at this stage is a significant increase in biomass, excess of surplus activated sludge is removed from the sedimentation process. This excess of surplus activated sludge is the raw material for manufacturing fertilizer “Agro Bellum NPK”.

Excessive surplus activated sludge submitted for compaction and dewatering. Obtained treated water goes into the city sewage system. Dehydrated surplus activated sludge concentration of dry content not less than 13% used as fertilizer.

RESULTS AND DISCUSSION

Agro Bellum NPK fertilizer is planed to be used in agriculture as organic-mineral fertilizer. This is the best fertilizer to use on acid soils for all crops. Fertilizer provides even distribution of nutrients in the soil, the rapid penetration to the roots, full feed.

Existing substances of «Agro Bellum NPK» are nitrogen in ammonium and nitrate forms - not less than 5.5%, phosphorus in terms of P_2O_5 - less than 1.4%, potassium in terms of K_2O - not less than 0.5%, organic content - not less than 65%. Effects of fertilizer on the soil content due to increased rates of organic content, macro-and microelements, improve its physical and chemical properties (Table 4, Table 5).

Table 4. Physical and chemical rates of a fertilizer

№	Denomination	Result
1	pH	7.65
2	Mass fraction of dry residue, %	12.73
3	Mass fraction of organic content,%	78.38
4	Mass fraction of total nitrogen, %	8.57
5	Mass fraction of total phosphorus,%	1.92
6	Mass fraction of potassium, %	3.2

Table 5. Comparing performance with other fertilizers

Parameter	Sawdust	Peat	Peat + Filings	Cattle dung (manure)	Chicken Litter	Dehydrated sludge
Nitrogen overall, %	0.14	1.68	1.09	0.60	1.61	8.57
Phosphorus,%	0.075	0.36	0.16	0.22	3.0	1.92
Potassium,%	0.021	0.07	0.042	1.48	2.26	3.2
Water pH	3.7	5.3	5.5	7.9	8.0	7.65
Humidity,%	56	53	53.4	81.4	79.2	87.27

Physical and chemical properties.

Plastic mass of gray and various shades - from light to dark, with a sharp specific smell, characteristic of organic content, pH of 7.0 to 8.5, density - 1.0695 g/cm^3; fertilizer partially soluble in water (0.3%), soluble in organic solvents (acetone - 3.2%), not volatile, fire and explosion safe. When heated (> 75 ^{0}C) fertilizer loses ammonia and water. At a temperature of 0 ^{0}C to minus 5 ^{0}C fertilizer crystallize. After melting, fertilizer will not change its qualitative properties. Shelf life: at a temperature of plus 10 ^{0}C to plus 25 ^{0}C - 1 month, with temperatures from 0 ^{0}C to plus 10 ^{0}C - 2 months, with temperatures from 0 ^{0}C to minus 5 ^{0}C - 3 months at a temperature of minus 5 ^{0}C to minus 20 ^{0}C - 6 months. Guaranteed shelf life - 6 months from date of manufacture.

Microelements and heavy metals.

The contents of microelements and heavy metals (in terms of dry content, %): S (total) - 0.75, chlorides - 0.73, carbonate in terms of CO_2 - 8.93, calcium in terms of CaO - 13.45, magnesium in terms of MgO - 0.62, Fe in terms of Fe_2O_3 - 0.25, aluminum in terms of Al_2O_3 - 0.15, silicon in terms of SiO_2 - 0.74, F (total) - 0.05, sodium equivalent Na_2O - 1.65, As (total) - $1.8 * 10^{-4}$, Cd (total) - $<1 * 10^{-5}$, Pb (total) - $<2 * 10^{-4}$, Cu (total) -$2.9 * 10^{-3}$, Zn (total) - $6.6 * 10^{-3}$, Ni (total) - $1.5 * 10^{-3}$, Co (total) - $8.7 * 10^{-4}$, Mn (total) - $1.2 * 10^{-2}$, Cr (total) - $6.2 * 10^{-4}$, Hg (total) - $<3 * 10^{-6}$.

Content of toxic and hazardous elements in the fertilizer does not exceed the established values of hygienic standards, this product complies with regulations. Among the most important hygiene factors of production is possible leakage of biogas. For toxicological properties of fertilizer "Agro Bellum NPK" refers to 4th class of danger.

Fertilizer added to the soil mechanically in autumn and spring sowing of crops, as well as irrigation water for irrigation during the early phases of the feeding of plants.

Qualitative composition of the product includes chemicals from the standpoint of toxicity related to little dangerous compounds. In the process of transformation and expansion of the fertilizer dangerous to human health and the environment metabolites are not formed. Application of fertilizer did not affect the nutritional value of agricultural products.

CONCLUSIONS

Application and benefits of dehydrated sludge

Scope of application:

(i) agriculture (including - cottages and farms) – for primary and pre-distribution in feed, technical and cereal cultures;

(ii) greenhouse management - to support the soil in the "live" condition;

(iii) utilities cities - for reclamation of soil beds and ornamental plantings of trees in the city polluted with toxic substances and heavy metals, making composts and soils in urban households for planting;

(iv) forestry - the creation of green space on the sand and the affected lands, for reclamation of lands after forest fires, fertilizing trees and shrubs in forest nurseries;

(v) industrial, ornamental and potted floriculture - for earlier seedlings, increase the number of flowers on the bushes;

(vi) environmental organizations - for reclamation of lands affected by solid wastes, oil polluted soil, and after the construction and mining processing operations.

Dehydrated sludge advantages over traditional organic and mineral fertilizers

Unlike chemical fertilizers:

(i) dehydrated sludge - is environmentally friendly fertilizer, which has no harmful toxic effect on humans and animals, enriched with microelements, which increases the time and reduces storage losses grown crops;

(ii) reduces the negative effect of chemical plant protection;

Unlike manure:

(i) in dehydrated sludge nutrients are available to plants, no need to wait two years for organic decomposition;

(ii) unlike manure, which makes soil acidic with pH 6,5-8,5, it helps neutralize excess soil acidity;

(iii) contains more useful agronomic and physiological groups of microorganisms;

(iv) manure returnes to the fields as weed seeds and pathogens that cause enormous damage to agriculture. Using "Agro Bellum NPK" such factors are excluded, which significantly reduces the amount of herbicides and pesticides made;

(v) does not contain pathogenic microorganisms, eggs, worms, weed seeds, nitrates and nitrites, heavy metals, specific odor.

Unlike mineral fertilizers:

(i) nitrogen, phosphorus and potassium in fertilizer are more effective that stipulates the nature of their availability for the root system at the time of mineral nutrition of plants, reducing losses of nitrogen by nitrification and leaching, losses in the process of denitrification;

(ii) using mineral fertilizer and dehydrated sludge at the same time increases the effectiveness of the first;

(iii) fertilizers have one-sided impact on agrochemical indices of soil fertility, increasing content of nitrogen, phosphorus and potassium in single-acidification of soil solution due to the fact that all fertilizers are physically or physiologically acidic compounds.

Integrated action. Manure contains organic content, calcium and magnesium, which creates a complex reclamation. Organic fertilizers are part of an effective material for the development of useful soil biota, providing balancing the synthesis and decomposition of organic content in soil, resulting in soil solution enriched by available elements, which are exempt from organic remnants. The combination of biotic and abiotic factors and reduce of the soil solution acidity provides enrichment of arable soil on stable and labile forms of humus, which is an integral component of soil, its fertility rate, and affects almost all indicators of fertility.

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