

Investigation of Toxicological Properties of Organic Agricultural Waste

Irina Sippel^{1,*}, Guzel Hannanova¹ and Kirill Magdin²

¹Kazan Federal University, Kazan, Russia

²Saint Petersburg State University of Architecture and Civil Engineering, St. Petersburg, Russia

Abstract. The increasing volumes of formation and accumulation of organic agricultural waste pose the task of investigating the nature of the impact of waste on the environment and finding ways to efficiently dispose of them. The toxicological properties of organic animal waste (cattle manure) were investigated by the method of biotesting. Planktonic non-oceanic crustaceans *Daphnia magna* Straus were used as test objects. The physicochemical characteristics of the waste were also determined: humidity, ash content, bulk density, the value of the hydrogen pH of the water extract. It is shown that the waste has hazard class IV, that is, it is low-hazard. Possible ways of waste disposal in the conditions of an agro-industrial enterprise are considered.

1 Introduction

Currently, the accumulation of organic waste from agricultural production is a significant environmental problem that requires urgent solutions due to the increasing volumes of waste generation [1]. Animal husbandry waste is partially used as fertilizer in traditional agriculture, however, a significant part of it is not disposed of and accumulates on the territory of agro-industrial enterprises [2].

Excessive formation of organic waste from animal husbandry leads to an increase in the greenhouse effect due to the release of methane from the waste, which has the ability to intensively absorb infrared radiation, as a result of which global climate change increases [3]. The placement of waste on the territory of agro-industrial enterprises leads to the alienation of areas. The composition of organic waste includes nitrogen and phosphorus compounds in the form of nitrates, nitrites, phosphates, ammonium salts, when they enter reservoirs, eutrophication occurs associated with an increase in phytoplankton productivity.

At the same time, organic waste is valuable secondary energy resources suitable for the production of electric and thermal energy, biogas, biofuels [1, 2, 4]. Modern biotechnologies are often used to process agricultural waste into useful products [4-9]. The main methods of recycling organic agricultural waste are: obtaining organic fertilizers to increase crop yields, obtaining biogas using anaerobic fermentation technology and its further use as fuel for engines or energy carrier for the generation of electrical and thermal energy. In general, the utilization of organic waste from animal husbandry will reduce the

* Corresponding author: irina.sippel@yandex.ru

anthropogenic burden on the environment, and their use as raw materials and secondary energy resources will lead to a reduction in the cost of products produced by agricultural enterprises.

The development of recycling methods should be preceded by an assessment of the toxicity of waste. Various chemical and biological methods are used to study the toxicity of various objects (wastewater and surface water, soil, industrial waste) and assess their negative impact on the environment. The method of biotesting is promising and effective, while both single-celled and more highly developed organisms can be used as test systems [10-13].

The purpose of this work is to assess the toxic and physico-chemical properties of organic agricultural waste and to develop proposals for their disposal in the conditions of an agro-industrial enterprise.

2 Materials and methods

Sampling for the analytical determination of physico-chemical parameters and the composition of organic agricultural waste (cattle manure) was carried out from 4-5 sites after mixing the waste, the sample weight was 10 g.

The moisture content of the samples was determined by the gravimetric method by drying and bringing them to a constant mass at a temperature of $105 \pm 2.0^\circ\text{C}$ in a Yamato-type laboratory drying cabinet, similar to the method presented in [14] for sawdust

To determine the pH value of the hydrogen index of the aqueous extract of waste, hydrogen ions were extracted from them with bidistilled water, for which the waste was mixed with water in a ratio of 1:10. The measurements were carried out using a laboratory pH meter of the ANION-4100 brand.

The ash content of the waste was determined by burning the sample and calcining the residue to a constant mass in a muffle furnace of the SNOL type at $700 \pm 10^\circ\text{C}$. The ash content was calculated as the ratio of the mass of non-combustible mineral components remaining in the porcelain crucible after calcination to the mass of the initial sample, expressed as a percentage.

The determination of physico-chemical parameters was carried out at least 3 times under the condition of good reproducibility, after which metrological processing of the results was carried out.

The toxicity of waste was determined by the method of biotesting using planktonic non-oceanic crustaceans *Daphnia magna* Straus as test objects. Initially, water extracts were prepared from the waste, which were then diluted with bidistilled water in the ratio 1:10, 1:100, 1:1000, 1:10000. 10 individuals of *Daphnia magna* Straus were added to each sample, after which the samples were kept in the Climatostat P-2. The number of crustaceans was determined by the direct counting method. The toxicological properties of the waste were assessed by the lethality of the test objects as a result of the presence of *Daphnia magna* Straus individuals in the analyzed sample for 48 hours, provided that their viability was preserved in the control sample. Toxicity was calculated as the ratio of the number of test objects that died in the analyzed water extract to the number of survivors in the control sample, expressed as a percentage. Bidistilled water for the preparation of aqueous extracts from waste was obtained using the "SPECTRUM-OSMOSIS" water treatment system.

3 Results and discussions

As an object of research, the paper considers organic waste from agricultural production (cattle manure) formed at one of the leading agro-industrial enterprises of the Republic of Tatarstan. Tons of organic waste accumulate at the enterprise every year, and the volume of their formation is constantly increasing. The dynamics of the formation of organic waste of animal husbandry at the enterprise in recent years is shown in Fig.1

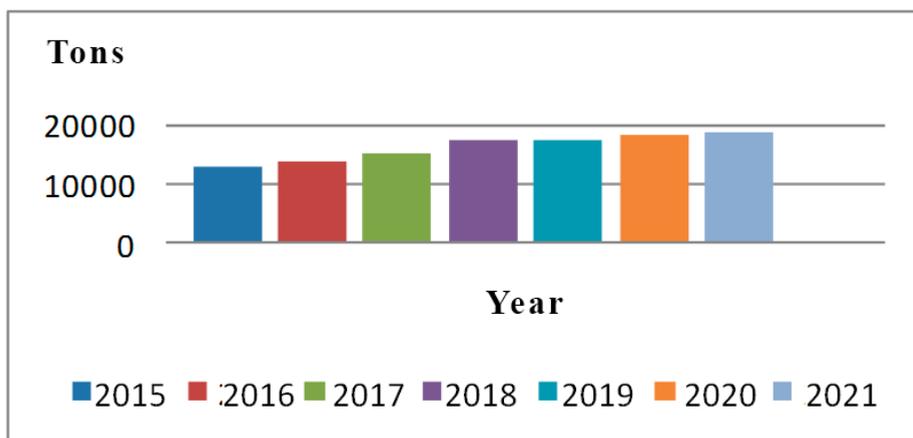


Fig. 1. Dynamics of the formation of organic waste of animal husbandry at the enterprise

The study of the toxicological and physico-chemical properties of waste was carried out in order to assess their negative impact on the environment, as well as to develop methods for the disposal of organic waste accumulated in large quantities at the enterprises of the agro-industrial complex.

The physico-chemical properties of animal husbandry waste obtained from the enterprise were determined: humidity, ash content, pH of the water extract, bulk density, as well as the total nitrogen content as a percentage by weight. The physico-chemical parameters of the analyzed organic waste are presented in Table 1.

Table 1. Properties of organic waste

Indicator	Value
Humidity, % by weight.	77.1±2.5
Ash content, % by weight.	12.5±1.2
pH of the water extract	6.9±0.2
Bulk density, kg/m ³	1320±11.2
Total nitrogen, % by weight.	0.51±0.05

The value of the hydrogen index of the water extract, equal to 6.9, is close to neutral, that is, the placement of waste on the territory of an agricultural enterprise does not lead to a noticeable change in the pH of surface waters, in particular, does not cause acidification of surface reservoirs. The humidity and ash content of waste must be taken into account when choosing waste recycling methods. The nitrogen content indicates the presence of nitric and nitrous acid salts in the waste, as well as ammonium salts, the ingress of which in

significant quantities into natural reservoirs can cause their eutrophication. As a result, it is possible to lower the redox level of natural water and initiate sulfate reduction processes, the consequence of which is the formation of hydrogen sulfide and sulfides toxic to biota.

The toxicity of the waste was determined by the biotesting method, which is based on determining the mortality of *Daphnia magna* Straus test objects in aqueous extracts obtained from the analyzed waste and comparing it with the mortality of test objects in a control sample containing a pure solvent. The results of the study of the toxicity of aqueous extracts of organic agricultural waste are presented in Table 2.

Table 2. The results of the study of the toxicity of aqueous extracts of organic agricultural waste.

Dilution	Mortality of test objects, %				Toxicity
	1 hour	19 hours	24 hours	48 hours	
1:10	0	0	0	0	none
1:100	0	0	0	0	none
1:1000	0	0	0	0	none
1:10000	0	0	0	0	none
Original extract	0	0	80	100	acute
Control sample	0	0	0	0	none

The results obtained indicate that acute toxicity was detected only in the original extract, it is absent in all diluted samples. The harmless dilution ratio of aqueous extracts HDR₁₀₋₄₈ was calculated, causing the death of no more than 10% of *Daphnia magna* Straus individuals during 48 hours of stay in the analyzed samples:

$$BKP_{10-48} = 10^{\frac{(\lg 10 - \lg 1) \cdot (1 - 0.1) + \lg 1}{1 - 0}} = 7.94 \quad (1)$$

Thus, the analyzed animal husbandry waste belongs to hazard class IV, that is, it is low-risk and does not have a significant negative impact on ecosystems.

Currently, at the enterprise in question, manure is partially used as fertilizer for growing crops.

Taking into account the low-hazard nature of waste and the volume of its formation, it is possible to propose a waste disposal method that provides for the separation of manure into liquid and solid fractions. After separation, the liquid fraction is supposed to be disinfected by electrolytic sterilization using copper (II) ions, and then used as a fertilizer. Processing of the solid fraction, its drying and disinfection will make it possible to obtain environmentally and veterinary safe bedding materials for keeping animals. After use, the bedding materials can be used as solid organic fertilizers. This technology is serial and is used in a number of agricultural enterprises in our country.

4 Conclusions

Agriculture, including animal husbandry, makes a significant contribution to the global economy, but is a source of waste generation that can pose a danger to the environment.

The toxicological and physico-chemical properties of organic animal waste generated in significant volumes as a result of the production activities of agro-industrial enterprises were investigated. Toxicity assessment was carried out by biotesting using *Daphnia magna* Straus as test objects. It is shown that the disposed waste belongs to hazard class IV, the harmless dilution ratio of aqueous extracts HDR is 10^{-48} , that is, the waste is low-hazard.

The determination of the toxicological and physico-chemical properties of organic waste preceded the development of methods for their rational use in the conditions of an agro-industrial enterprise. The separation of waste into liquid and solid fractions with the further use of the liquid fraction as fertilizer, solid - as a litter for animals is proposed.

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