CHEMICAL SCIENCES

QUANTITATIVE ASSESSMENT OF LABORATORY CHEMICAL WASTE

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Abstract

Using the example of a specific laboratory, the problem of the formation and accumulation of chemical waste as a result of its testing activities is considered. It has been shown that during the year, more than 100 kg of chemical reagents belonging to substances of different chemical classes, having different physical states and degrees of danger, are consumed to test agricultural and food products. It is recommended to develop standard laboratory regulations on accounting, collection and storage methods, and methods of disposal of the resulting residues of laboratory chemicals.

Keywords: laboratory chemical waste, treatment.

Introduction. At present, the problem of disposal of chemical reagent wastes generated in the course of numerous studies of various product groups is becoming acute. There are more than 2,000 accredited testing laboratories in Belarus and even more production laboratories that use various chemicals, including toxic ones, to test products. In addition, during these tests, new chemical compounds are formed, which can also be toxic. An analysis of the regulatory documentation in force in Belarus in the field of chemical waste management from laboratory research [1, 2] showed the following. Classification codes have been established for such substances [3]. The code consists of 7 digits showing the assignment of a chemical to a specific block, section, group, subgroup and species. Laboratory chemical waste codes include: 5930100 (chemicals), 5930200 and 5930300 (organic and inorganic laboratory chemical residues), 5930400 (expired chemicals), 5931000 and 5931900 (other chemicals). According to Instruction No. 41/108/65 [4], all chemicals belong to 4 hazard classes, which are classified according to seven indicators and the following properties: ecotoxicity, toxicity, explosion and fire hazard, toxicity of combustion products and infectiousness. In the literature available to us, we did not find information on the rules for the disposal of such chemicals, with the exception of article [5], which provides the following recommendations for handling chemical waste in a testing laboratory:

a) the disposal of chemical reagents is carried out in a complex manner, taking into account the physicochemical properties of a particular substance;

b) the process is carried out only by highly qualified personnel using special equipment, containers and transport;

c) to eliminate hazardous waste generated in the laboratory, neutralization with other reagents is used to obtain a neutralized product (carried out in the laboratory itself) and incineration in a vacuum (waste is transferred to third-party organizations licensed for this type of activity).

Analyzing some foreign sources of literature [6, 7], it turned out that chemical wastes are classified as hazardous if they have any of the following four characteristics: flammability, corrosivity, reaction hazard, toxicity. In the United States, the classification of chemical waste from laboratory activities consists of a code and a name of the substance. The code consists of letters and numbers. The letter denotes belonging to one of the lists, denoted by F (highly hazardous for disposal), U (unused chemicals that become waste (for example, chemicals that have expired, spilled or no longer needed for laboratory experiments)), P (frequently generated chemical waste in certain concentrations). Two methods for reducing chemical waste are recommended for waste reduction: neutralization (pH is brought to a neutral value using a neutralizing agent) and distillation with processing in place (distillation for reuse). Utilization of chemical waste is carried out by specialized organizations. For chemical waste removal by a third party, the laboratory must collect and store chemical waste in appropriate containers and plastic bottles with specific labeling; for each sealed container (bottle), fill out a form and send it to the Office of Environmental Protection and Safety to obtain a permit for the export of chemical waste. Disposal of chemicals in the sewer system requires a written permit from the EHS [8].

Thus, the correct handling of chemical waste generated in testing laboratories is not only aimed at protecting the environment, but is also important for ensuring the safety of personnel working with chemical reagents.

Aim. Assess the significance of the problem of handling chemical waste from laboratory activities using the example of a specific testing laboratory.

Materials and methods. The objects of the study were accounting cards for chemical reagents (responsible for maintaining – leading engineers of divisions; frequency of filling – once a month) used in the testing laboratory of the territorial body of state supervision accredited in the National Accreditation System of the Republic of Belarus. The field of activity of the laboratory is the testing of agricultural and food products in terms of quality and safety.

The subject of the study was the kinds and amount of chemical waste generated in the testing laboratory from 01/01/2022 to 12/31/2022. Research methods:

analysis and classification, as well as mathematical data processing using MS Excel.

Results and discussion. As a result of summarizing the information given in the accounting cards for chemical reagents, we found the following. In 2022, 315 kg of chemical reagents were spent, of which 42.81 % were flammable liquids, 5.46 % – other solvents, 32.49 % – acids, 16.73 % – alkalis and 2.51 % – salts. More than 150 types of chemical reagents were used monthly in the testing laboratory, the remains of which were subject to disposal. We divided these substances into 4 groups (Table).

Table

Classification of chemical waste generated in the testing laboratory

Groups	Kinds
Inorganic and organic chemicals	Acids
	Alkalis
	Salts
Organic solvents	Flammable liquids
	Halogenated solvents
	Non-halogenated solvents
Hard materials	Contaminated filter and chromatographic materials
Product examples	With inorganic residues
	With solvent residues

To determine the dynamics of the consumption of chemical reagents and waste generation, we constructed histograms of the distribution of the total amount of chemicals most often used when testing chemical reagents in the period from January to December 2022 in the testing laboratory (Fig. 1–4).

As can be seen from the data shown in Fig. 1, the minimum consumption of acids during the year was 5 kg, the maximum was 16 kg. As the analysis of the working records of the tests performed showed, the increased consumption of these reagents (from 10 to 16 kg) was associated with testing a large number of samples of agricultural raw materials in terms of physical and chemical indicators.

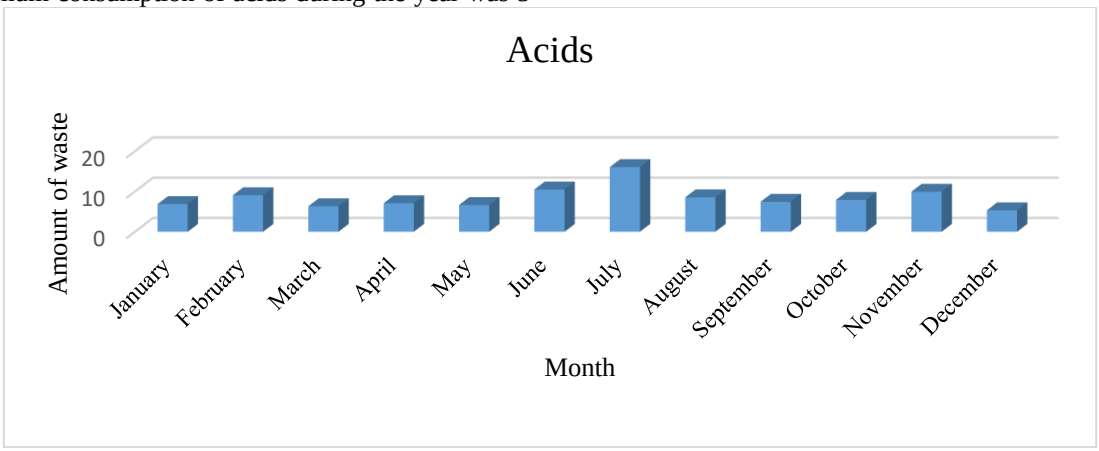

Fig. 1. Histogram of the distribution of the total amount of acids used in tests by months

Analysis of the data presented in Fig. 2 indicates that there is no regularity in alkali consumption by months. The minimum amount of alkalis (0.784 kg) was used in March, the maximum (8.133 kg) - in April. In other months, the amount of alkali consumed varied from 2.8 to 5.8 kg.

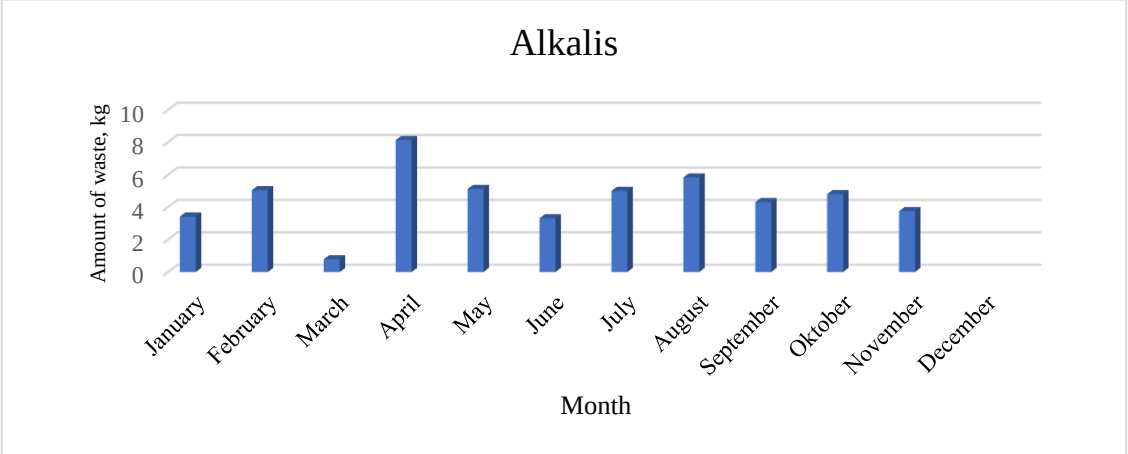

Fig. 2. Histogram of the distribution of the total amount of alkali used in tests by months

Fig. 3 shows that the main part of the organic solvents used in the testing laboratory is occupied by flammable liquids. The consumption of these reagents during the year was uneven: in July and December, flammable liquids were used in the minimum amount (slightly more than 5 kg), in the first, partially in the third and fourth quarters, their consumption ranged from 10.5 kg to 14.0 kg, the maximum amount was used in August (about 18.5 kg). The share of other solvents in the total consumption of organic solvents fluctuated in a wide range: from 1.2% to 17.3%, the maximum amount of these substances in the total consumption was recorded in July – 33.1%.

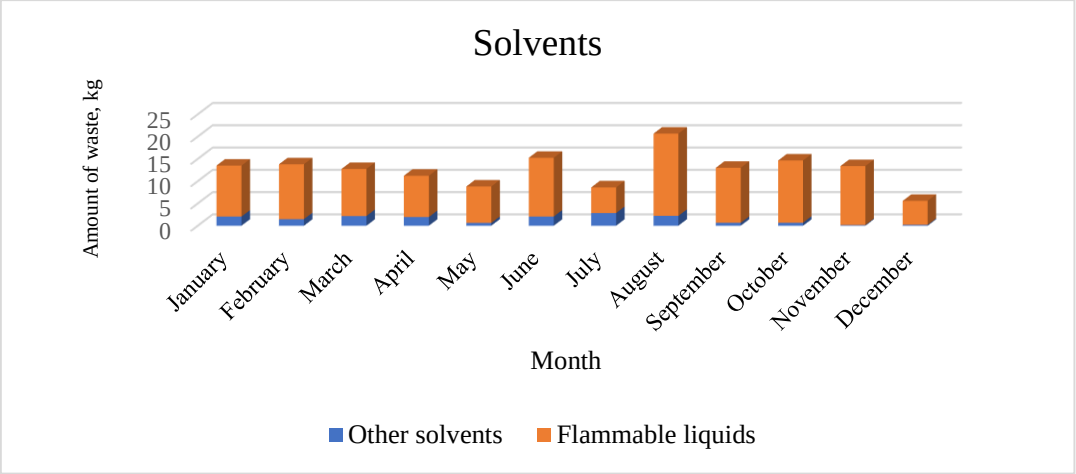

Fig. 3. Histogram of the distribution of the total amount of solvents used in tests by months

Comparison of data on the consumption of acids (Fig. 1), alkalis (Fig. 2) and salts (Fig. 4) showed that the need for inorganic and organic salts for testing during the year was insignificant: from 0.4 kg to 1. 2 kg, while the consumption of inorganic salts, as a rule, prevailed.

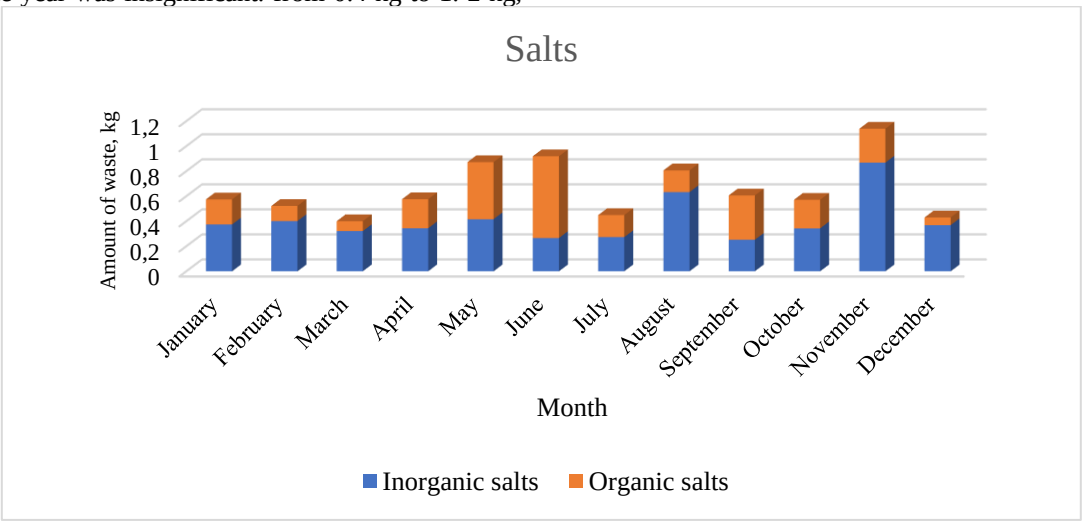

Fig. 4. Histogram of the distribution of the total amount of salts used in tests by months

Conclusions. Thus, our studies allow us to draw the following conclusions. In the testing laboratory, a significant amount of chemical waste is generated, belonging to substances of different chemical classes, having a different state of aggregation and degree of danger. The consumption of chemical reagents and waste generation during the year was uneven and depended on the test program. Most of the tests were carried out by chromatographic methods. To streamline work on accounting, methods of collection and storage, methods of disposal of the forming residues of laboratory chemicals, it is advisable to develop an appropriate standard operating procedure.

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