Methods for Acaricidal Solute Disinfection and Technical Means for their Implementation

Y.DZH. OSMONOV
Electrification and automation of agriculture
Kyrgyz National Agrarian University named after K.I. Scriabin
720005, Bishkek, Mederova str., 68
osmonov.ysman@mail.ru http://http://knau.kg
KYRGYZ REPUBLIC

B.S. TOKTONALIEV
Applied mechanics, physics and engineering pedagogy
Kyrgyz National Agrarian University named after K.I. Scriabin
720005, Bishkek, Mederova str., 68
ulpett@mail.ru http://http://knau.kg/
KYRGYZ REPUBLIC

N.Y. TEMIRBAEVA
Electrification and automation of agriculture
Kyrgyz National Agrarian University named after K.I. Scriabin
720005, Bishkek, Mederova str., 68
kissia2009@mail.ru http://http://knau.kg
KYRGYZ REPUBLIC

Z.T. ANDAEVA
Power Supply, State budgetary educational institution of higher education
"Osh technological University. M. after M. Adyshev"
zandaeva77@mail.ru https://oshtu.kg//
KYRGYZ REPUBLIC

M.S. NARYMBETOV
Electrification and automation of agriculture
Kyrgyz National Agrarian University named after K.I. Scriabin
720005, Bishkek, Mederova str., 68
maks_875@mail.ru http://http://knau.kg
KYRGYZ REPUBLIC

M.S. VOLKHONOV
Technical systems in the agro-industrial complex
Federal State Budgetary Educational Institution of Higher Education "Kostroma State Agricultural Academy" 156530, Kostroma Region, Karavaevo Village, Training Town, 34
vms72@mail.ru https://kgsxa.ru/
RUSSIA

I.I. MAKSIMOV
Transport Technological Machines and Complexes
Federal State Budgetary Educational Institution of Higher Education "Chuvash State Agricultural Academy", 428032, Cheboksary, K. Marx str., 29
maksimov48@inbox.ru http://www.academy21.ru/
RUSSIA

V.S. KUKHAR
International Scientific-Educational and Marketing Center
Federal State Budgetary Educational Institution of Higher Education «Ural state agrarian university
620075 Sverdlovsk region, Yekaterinburg, Karl Liebknecht str., 42
viktorurgau@mail.ru http://urgau.ru/
RUSSIA

Abstract:- The remains of acaricidal substances from the solutes used in the preventive treatment of sheep against infectious diseases by bathing them in special bathtubs fall into the environment without prior disinfection. The mass of the residues is about 30% of the initial mass of the acaricides used. In environmental objects such as soil, water, plants, etc. acaricidal substances being persistent pesticides are able to persist for a long time, migrate to adjacent objects, transpose into plants, deposite in the body of productive animals, excrete in milk, egg, transmit to the fruit, thereby contaminating feed and food of plants and animals. It is possible to use common analytical expressions to determine the constant time of detoxification of acaricidal substances in environmental objects and indicators of decrease in the initial content of acaricidal substances in the form of chemical decay periods. The authors use fundamental theory of chemical kinetics. This technique allows to trace the process of. The article provides a rationale for the disinfection methods of the acaricide solute residues based on the study of acaricidal solute detoxicants and the study of sorption properties of the brown coal (types B-2 and B-3) and a natural sorbent which is the mixture of rubber crumbs with powdered carbonaceous siliceous shale. The authors identified the needs of the brown coal and the natural sorbent for the decontamination of 1 ton of acaricidal fluid waste with residual acaricide - 0.2% neocidol, which is respectively 80 kg and 40-60 kg. Rational aggregate states of sorbents are recommended within 0.5-2 mm as well as the disinfection modes: such as filtration of acaricide solutes under vacuum through the crushed layer using brown coal as a sorbent; and static mode when using natural sorbent. The authors developed the technical means for implementing these methods during the disinfection of wastewater from the sheep bathtubs, combining with the pre-treatment of the solute from mechanical impurities, purification of the solute from the residues of acaricide substances and the combustion of the used sorbents not polluting the atmosphere. The methods and devices allow to carry out the disinfection of discharges from sheep bathtubs with a high content of acaricides - 150-300 mg/kg. The authors suggest the use of the new types of sorbents which have intense sorption properties of acaricides and a low cost as well, which are easy to prepare and to use and easy to recycle. Mobility and autonomy of the developed devices provide disinfection of the spent acaricide solutes and of the used sorbent at the locations of the sheep bathtubs.

Key-Words: - acaricidal substance, sorbent, detoxication, brown coals, natural sorbent, mobile unit.

1 Introduction

The productivity of sheep husbandry, along with breeding, feeding and keeping sheep, depend on the sheep preventive treatment against infectious diseases caused by ectoparasites. The diseases caused by ectoparasites, sarcoptosis, psoroptosis and charioptosis are most often found in sheep. They are united under the common name - scabies diseases that cause great damage to sheep breeding. With the intensive development of the disease, animals cause anxiety and itching, especially at night, as a result of which they lose weight, especially young, lag behind in growth and development, lose their mass by weight, the quality of the fiber deteriorates sharply, the normal vital activity of almost all of its organs gets impaired, that means the productivity of sheep decreases and the quality of their products [1]. In accordance with veterinary legislation, sheep farms must carry out preventive treatment of sheep twice a year - in the spring after shearing and in the autumn before wintering, sheep of all age and gender groups must be treated [2].

An effective method to prevent infectious diseases of sheep is their preventive bathing in special bathtubs filled with acaricidal solutes. This method, recommended as far back as 1884 by Mac Dugalley [3], is still used in many sheep-breeding countries. The advantage of this method is to ensure complete saturation of the coat - skin of sheep with acaricidal liquid during their bathing. It has been established that for complete saturation of the coat of skin of sheep immersed in acaricidal liquid, only hydrostatic pressure will require 240 s, and when bathing up to 60 s, depending on the breed of sheep. This is achieved by the fact that during the movement of the sheep in the liquid, the folds of the coat cover periodically open, passing the liquid to the greasy layer and, in addition, in this case, the hydrodynamic pressure is added to the hydrostatic pressure [4].

However, the sheep bathing method does not meet environmental requirements. Spent acaricidal solutions with acaricide residues — up to 30% of the initial mass — are discharged without preliminary disinfection into the environment with their subsequent migration to all objects of nature - to soil, water, plants, etc. on the food chain of animals and humans.

Acaricidal substances, being persistent pesticides, can persist for a long time in environmental objects, accumulate in the locations of bath tubs - create foci of persistent ill-being. The negative impact of acaricidal substances on all aspects of the life of biological objects was the basis for their regulation by approving the MPC of these acaricides in all environmental objects, as well as in feed and food products of plant and animal origin.

According to S.N. Nikolsky [1] sheep farms in the CIS countries annually emit about 3 million tons of spent acaricidal solutes into the environment. According to our data, sheep farms in Kyrgyzstan also annually throw out about 40 thousand tons of spent acaricidal solutions. This situation cannot continue for a long time, there will come a time when the discharge of spent acaricidal solutions will be strictly prohibited and the veterinary service will not be ready to switch to the technology of medical and preventive treatment of sheep, which excludes environmental pollution.

It should be noted that in the CIS countries, the use of drugs administered subcutaneously in order to treat sheep from scabies is practiced. Such drugs include ivomek, baimek, etc., which destroy internal and external parasites through a simple injection. However, in the fight against infectious diseases of sheep, prevention is of primary importance. It is known that the effects of acaricides and adverse environmental factors are most resistant to eggs and larvae of ticks, whose vital activity can last up to 60 days. Given that the drug administered by injection is excreted from the body within 8 hours, this method does not provide prophylaxis for scabies, but is used only for the treatment of sick animals. In addition, these drugs contain a large number of stabilizers with carcinogenic properties.

2 Problem Formulation

Due to the physicochemical properties, acaricidal substances - hexachlorocyclohexane (HCH), lindane, neocidol, butox, dursban, etc. are resistant to environmental factors. So, for example, preparations based on organochlorine compounds HCH and lindane in the soil lasts up to 10 years. It was established that after 3-4 years, lindane residues up to 36% of the initial amount remained in black earth soil, up to 18% in clay soil [5,6,7]. Acaricides can translocate from the soil to plants within 0.2 - 0.3 mg / kg. In some cases, the amount of residues received by plants due to translocation can reach 30 mg / kg [8,9,10].

The highest content of hazardous compounds are found in beets, potatoes and corn. Residues of acaricides were found not only in cultivated crops, but also in wild fruit trees: in burdock - 0.70 mg / kg, wormwood - 0.60 mg / kg, rosehip - 0.60 mg / kg and licorice - 0.56 mg / kg [11,12].

Residues of acaricides from the soil fall into water bodies and have a harmful effect on the beneficial fauna. Lindane residues were found in carp - 0.05 mg / kg, in trout - 0.0125 mg / kg [13,14,15].

Acaricides in animals are not evenly distributed and excrete through the mammary gland [16]. The amount of acaricides in the organs and tissues of sheep after bathing with an emulsion of 0.03% for lindane 154 days after treatment was to 0.54 mg / kg in muscle tissue and 2.7 mg / kg in fat [17.18].

The degree of contamination of soils, plants and water by the residues of acaricidal substances near the bathtubs showed that at a distance of 20-25 m from the bath, in a depth of 40 cm, the content of neocidol in the soil was from 8.1 to 11.2 mg / kg, in the structure of plants from 10 to 13 mg / kg [19]. The total water pollution amounted to 6.08% in spring, 50.4% in summer, 65.2% in autumn, and 38.4% in winter. Increased soil and water pollution in the autumn is associated with the discharge of acaricidal residues after anti-scabies treatments of sheep [20].

Residues of acaricidal substances were found in those places where they had never been used and could only be accessed through migration through adjacent natural objects. The formation of intermediates in the process of natural detoxification is a greater danger than their starting compounds. For example, in the process of lindane cometabolism the alpha-isomer of HCH with carcinogenic properties is formed, which is a potential environmental pollutant [21,22].

A brief analysis shows that the ability of acaricidal substances is retained in the soil, translocated into plants, deposited in the organs and tissues of animals, excreted in milk leads to contamination with residues of these substances in animal feed and plant and animal products [18].

Thus, the prospects for the development of sheep raising pose the problem of preserving the environment associated with the preventive treatment of sheep against infectious diseases. One of the ways to solve this problem is to develop methods for the disinfection of spent acaricidal solutions and appropriate technical means for their implementation.

2.1 Purpose and objectives of the study

The purpose of the study is to eliminate the anthropogenic effects of acaricidal residues on environmental objects.

To achieve the goal, the following tasks were set:

- to study the impact of existing technologies of zoo veterinary processing using acaricidal solutions on environmental pollution;
- to develop a methodology for calculating the detoxification of acaricidal substances in environmental objects without conducting expensive experiments;
- to develop effective methods for the disinfection of spent acaricidal solutions and technical means for their implementation.

2.2 Materials, methods and results of the study

Environmental pollution by acaricidal substances is a dynamic process. In this case, the object interacts with the acaricidal substance and then its complete or partial natural detoxification occurs. The remainder of the acaricidal substance continues to migrate to adjacent objects. This process can be expressed as a general dependence:

$$M = \sum_{i=1}^{n} x_i - \sum_{i=1}^{n} y_i, \quad (1)$$

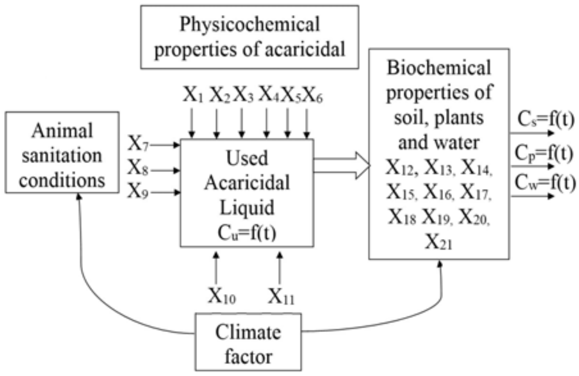
where M is the migratory part of the acaricidal substance;

$\sum_{i=1}^{n} x_i$ - is total mass of acaricidal substance in the environment;

$\sum_{i=1}^{n} y_i$ - is the total mass of a detoxified acaricidal substance as a result of interaction with an environmental object.

Quantitative and qualitative indicators of these total masses $\sum_{i=1}^{n} x_i - \sum_{i=1}^{n} y_i$ in environmental objects depend on factors characterizing the physicochemical properties of acaricidal substances, animal processing conditions against infectious diseases, biochemical properties of plants and soil, as well as climatic parameters. The influence of these factors on the detoxification process of an acaricidal substance is shown in the form of the system "acaricidal substance - environment" (Figure 1).

Figure 1 - The relationship of factors in the system "Acaricidal substance - Environment"



In the system "Acaricidal substance - Environment" the output variables are associated with the physicochemical properties of acaricidal substance (x_1 is the molecular weight, x_2 is the melting point (boiling point), x_3 is solubility in fats, x_4 is solubility in water, x_5 is resistance at pH 5-8, x_6 - volatility); animal treatment conditions (x_7 is the initial concentration of acaricidal substance in solution, x_8 is the pH of acaricidal liquid, x_9 is the residual concentration of acaricidal substance in solution); climatic parameters (x_{10} - average air temperature; x_{11} - relative air humidity). These input variables are measurable.

Output parameters - the content of acaricidal substance in environmental objects at any time: soil – C_s=f(t), plant C_p=f(t) and water C_w=f(t) depends on the residual concentration of acaricidal substance in the used solute and biochemical properties of the soil (x_{12} - moisture capacity, x_{13} - density, x_{14}- pH, x_{15}- mechanical composition, x_{16}- average temperature); plants (x_{17}- type, x_{18}- amount of water, x_{19}- amount of fat); water (x_{20}- pH, x_{21}- temperature).

In this system climatic factors (x_{10}, x_{11}) affect not only the properties of the used acaricidal liquid C_u=f(t), but also affect the biochemical properties of the soil, plants and water, as well as the conditions for treating animals.

In this physicochemical process, according to the laws of chemical kinetics, reactions of the first, second, and possibly higher orders take place [23].

To determine the dynamics of the processes of detoxification of acaricidal substances in environmental objects, it is necessary to determine the kinetics of their decay in the selected objects.

The decay kinetics of acaricidal substances can be determined using the first-order chemical reaction equation:

$$\frac{dC_0}{dt} = -KC_t . \quad (2)$$

By integrating differential equation (2), we have a solution of the following form:

$$C_t=C_r \cdot e^{-kt}, \quad (3)$$

where C_t is the amount of acaricidal substances in environmental objects at time t, mg / kg;

C_r- residual concentration of acaricidal substance in the spent liquid, mg / kg;

K is the rate constant of the detoxification reaction of acaricidal substances;

t is the time, sec.

From equation (3) it can be seen that the main parameter of the decay kinetics of acaricidal substances is the rate of the chemical reaction, which is characterized by the constant K. With a known value of the residual concentration of acaricidal substance in the used liquid C_0 from equation (3), we can determine K:

$$K=\frac{2{,}303}{t}\lg\frac{C_0}{C_t} \quad (4)$$

The value of K allows us to determine the half-life of $T_{0,5}$, which shows the period of time during which the residual concentration of C_0 is halved:

$$T_{0,5} = \frac{0{,}693}{K}, \text{ so } K = \frac{0{,}693}{T_{0,5}}. \quad (5)$$

Substituting the value of K in the formula (3) we have:

$$C_t=C_0 \cdot e^{-\frac{0{,}693}{T_{0,5}}}=C_0 \cdot e^{-x}. \quad (6)$$

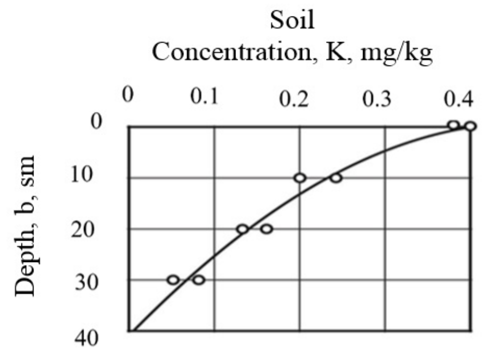
Equation (6) allows us to determine the generally accepted indicators for chemicals of the decrease in the initial content of acaricidal substances by 50.95 and 99% and, accordingly, the decay periods: $T_{0,5}$, $T_{0,95}$ and $T_{0,99}$. A negative value of the constant K (K <0) indicates a decrease in the content of acaricidal substances in environmental objects as a result of natural detoxification. In this case, it is rational to replace the rate constant K by an inverse proportional value τ = - 1 / k. Character τ is the time constant of the detoxification of acaricidal substances.

The possibility of using analytical expressions to study experimental data was carried out on the following relationships [24]:

- dependence of the concentration level of acaricidal substance on the depth of the soil (at a distance of 100 m from the bathtub) (Figure 2a);
- dependence of the level of concentration of acaricidal substance in the structure of plants (at a distance up to 2 m from the bathtub) (Figure 2b).

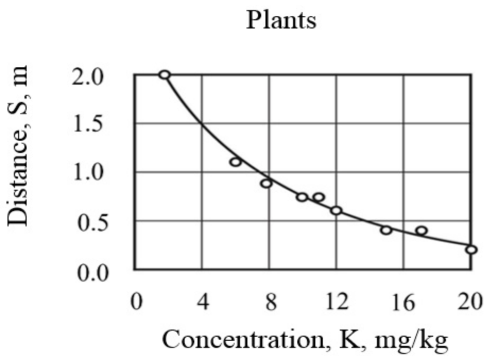
Chemical analysis of samples of soil and plant samples was performed by thin layer chromatography [25].

Figure 2 - Dependence of the level of concentration of acaricidal substances on soil depth (a) and in the structure of plants (b) near the bathtub



a) K = 0,381-0,015b+1,54×10⁻⁴ b²;

R^2=0,967; F = 128,7>$F_{0.05}$(3,6) = 4,757



б) K=24,033-22,541S+5,745S^2;

R^2=0,983; F=263,8> $F_{0.05}$(3,7) = 4,347

The approximation of the experimental curves (Figs. 2a, 2b) can be carried out by logarithm of equation (6):

$$\ln C(t) = \ln C_0 - x = \ln C_0 - kt. \quad (7)$$

Dependence (7) can be represented as a regression equation for two variables:

$$y = a + в \cdot x, \quad (8)$$

where $y = \ln C(t)$, $a = \ln C_0$, $в = -к$; $x = t$.

Equation (8) allows us to determine the coefficients a and b according to the well-known known method of least squares [26]

$$a = \frac{\sum_{i=0}^{n} y - в \cdot \sum_{i=0}^{n} x}{n};$$

$$в = \frac{\sum_{i=0}^{n} x \cdot \sum_{i=0}^{n} y - n \cdot \sum_{i=0}^{n} xy}{n \sum_{i=0}^{n} x^2 - (\sum_{i=0}^{n} x)^2}.$$

The values of the variables for determining the coefficients a and b (Fig. 2a and 2b) are determined experimentally. In this case, the coefficients were obtained: a = -3.729, b = -k = - 0.00614, τ = 162.86 for the dependence (Fig.2a) and a = - 16.892, b = - k = - 0.983, τ = 1 , 01 for the dependence (Fig. 2b).

According to the detoxification rate of constant K, it is possible to determine the half-lives of the acaricidal substance T0.5 = 0.693 / 0.983 = 0.705 (-1).

The detoxification time constant τ of the acaricidal substance equal to τ = 113 for the soil indicates that during this time the concentration of the acaricidal substance will decrease from 0.4 mg / kg to 0.2 mg / kg. Accordingly, to reduce the concentration from 0.2 to 0.1 mg / kg, another τ = 113 will be required, to reduce it from 0.1 to 0.05 another τ = 113 will be required also that means that the process of detoxification of acaricidal substances in the soil is a long process.

A time constant equal to τ = 1.01 for a plant indicates a high degree of translocation of acaricidal substance into plants due to biological and physiological processes. As a result, plants intended as animal feed get contaminated.

The calculated regression statistics show that the concentration level of acaricidal substances is well described in the experimental area by quadratic dependences on the soil depth and the distance from the bathtubs. The values of the determination coefficient R2 indicate a close relationship between the obtained dependences and the observed data.

Thus, the use of analytical expressions for the study of experimental data confirms that there is a complete or partial detection of acaricidal substances in environmental objects. Since the process of natural detoxification is protracted and covers new periods of treatment of animals accompanied by the discharge of new portions of spent acaricidal solutions, this process does not have time to eliminate the foci of pollution. The process of translocation of acaricidal substances from soil to plants is a source of forage crop pollution.

The search for detoxicants of acaricidal substances was conducted by model experiments. The following chemicals and simple substances were tested as detoxicants: 0.2 and 0.5% sodium hydroxide (NaOH) solution, quicklime and milk of lime, as well as mineral fertilizers: potassium chloride, superphosphate, ammonium sulfate and carbamide. An emulsion with a neocidol concentration of 0.01 to 0.2% was used as acaricidal liquid.

The inactivation of acaricidal substances in the emulsion according to the chemical analysis (Fig. 3a, 3b) showed that of the simple substances, quicklime and milk of lime have an inactivation ability. These substances are able to disinfect used acaricidal liquid with a neocidol concentration of up to 0.2% for 30-35 days. Carbamide, ammonium sulfate and potassium chloride showed inactivation ability and are also able to bring the concentration of acaricidal substance to the maximum allowable limit within 24-25 days.

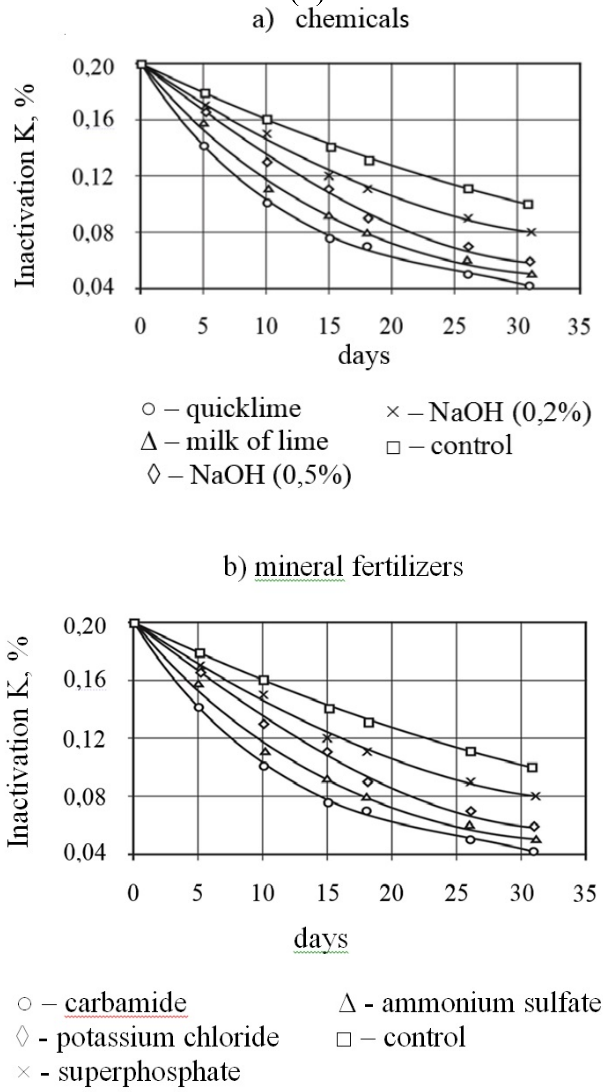
The greater the mass of these substances and mineral fertilizers is introduced into the emulsion, the more intensively their inactivation ability is manifested. Figure 3 shows the results of inactivation of acaricidal liquid at a concentration of chemical and simple substances and mineral fertilizers of 10% of the total mass of the emulsion.

Thus, the tested chemical and simple substances and mineral fertilizers have inactivation abilities and can be used to disinfect used acaricidal solutes. However, the duration of the disinfection process from 24 to 35 days makes it difficult to use these methods in a production environment, as in the process of sheep bathing the acaricidal liquid in the bathtub is replaced daily with a fresh one. Moreover, these 24-35 days are accompanied with an intensive sublimation of acaricidal substances which pollute the atmosphere.

The search for disinfection sorbents of used acaricidal solutes was also carried out in model experiments. Activated carbons of EPAC label of 52244 grade (manufactured by Futamara Chemical Japon) and activated carbon iodine (obtained from coal semicoke by paraphase activation, particle size 3-5 mm) were tested as sorbents. A neocidol water emulsion with a concentration of 0.03% was used. This concentration of neocidol corresponds to the rate of the used acaricidal neocidol solute.

The results of the sorption properties of activated carbons (Figure 4) showed that they are good sorbents for acaricidal substances. The sorption properties of activated carbon depend on their mass (concentration) in the emulsion, particle size, contact time and sorption mode.

Figure 3 - Inactivation of acaricidal substances in solutes under the influence of chemicals (a) and mineral fertilizers (b)



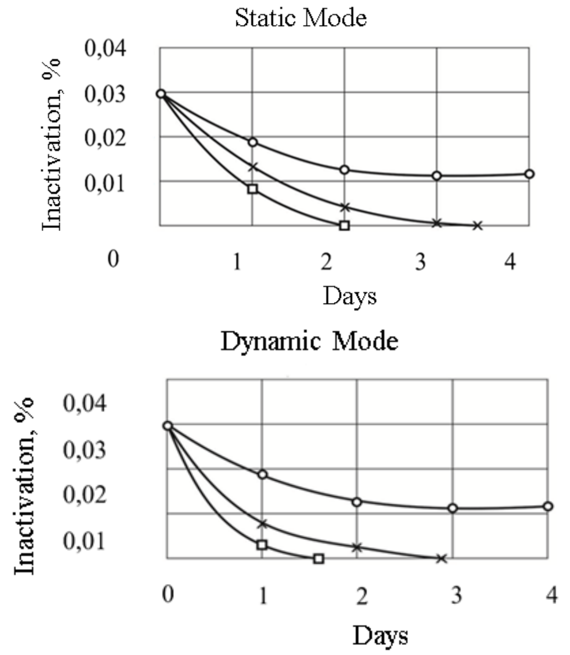
At a concentration of 0.3% of activated carbon 52244 of EPAC label, the sorption process lasts up to 2 days in a static mode and then stabilizes. The contact of coal with the emulsion the next day did not lead to an increase in the degree of neocidol absorption. At a concentration of 0.5% and 0.7% of coal, the sorption process is completed within 2 and 3.5 days respectively. The emulsion is completely freed from neocidol (Figure 4a).

Dynamic mode increases the sorption ability of activated carbon when periodic mixing of samples is carried out using a shuttle apparatus. At a coal concentration in the emulsion of activated carbon EPAC - 52244 of 0.5% and

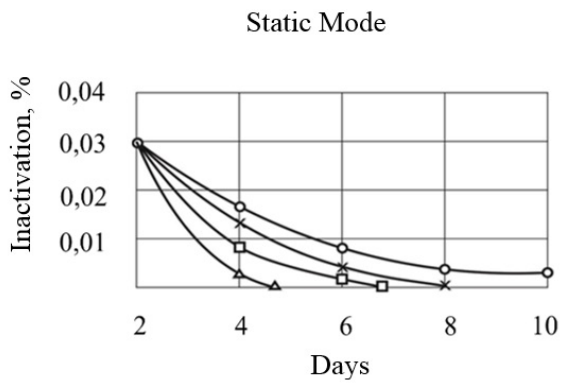
0.7% the sorption process is accelerated and takes from 1.5 to 2.9 days (Figure 4a).

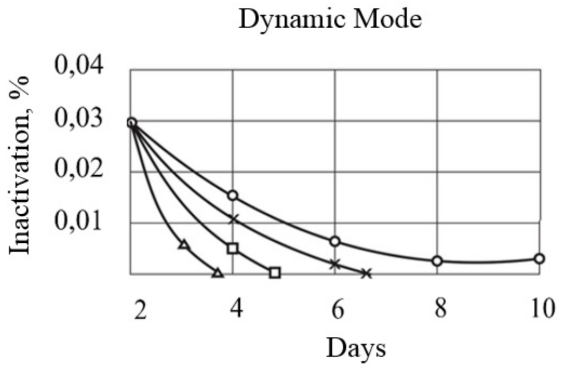
Activated carbon iodine showed a less active sorption ability, which manifests itself only after the fourth day, and at higher concentrations of coal in the emulsion. So, for example, at a 3% concentration of coal, the sorption process lasts up to 8 days, then stabilizes and the emulsion is not completely freed from neocidol (Figure 4b).

Figure 4 - Inactivation of acaricidal substances in solutions under the influence of activated carbons: EPAC 52244 (a) and activated carbon iodine (b)



a) Concentration EPAC – 52244 ○ – 0,3%, X - 0,5%, □ – 0,7%





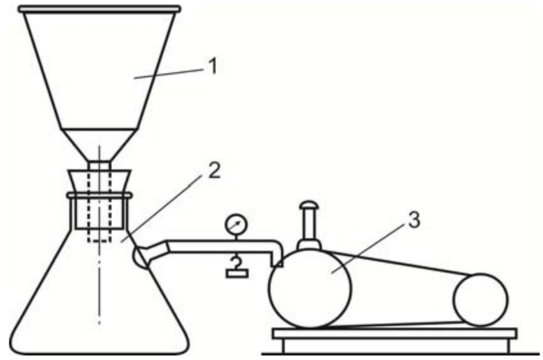
b) Concentration of activated carbon iodine: o - 3%, x - 5%, □ - 7%, Δ - 10%

Only at higher concentrations of activated carbon iodine 5%, 7%, and 10% the sorption process is completed within 3.7 to 8 days, both in static and dynamic modes. In addition, the particle size of activated carbon iodine 3-5 mm also affects the sorption process, namely, increases the sorption time.

To determine the degree of absorption of acaricidal substances by activated carbons EPAC - 52244 and activated carbon iodine, the obtained adsorbents were dried and subjected to desorption with hexane. The results showed that in the desorbed samples acaricidal substances were found in an amount equal to the initial content which confirms the high sorption ability of the tested activated carbons.

Considering the high cost of activated carbons and the economic inappropriateness of their use for disinfecting used acaricidal liquids the work was continued to find cheaper and more affordable sorbents. Natural brown coals B-2 and B-3 of low grade coal were tested. Coal samples were crushed to particles with a size of 0.5 mm, sequentially passing them through sieves with cells of 0.5x0.5; 1x1; 2x2; 3x3; 4x4; 5x5 and 6x6 mm2 in order to form carbon filters of the same size. Model experiments were carried out with a neocidol emulsion with a residual neocidol concentration of 0.03% in a static mode in order to determine the rational mass of brown coal for acaricide inactivation in the emulsion. Brown coals B-2 and B-3 were tested with a concentration of 2%, 4.6.8 and 10% of the total mass of the emulsion. The dependence of the filter capacity and the residual acaricide content in the filtrate on the particle size of coal was determined with free flow of liquid through sorbent filters and under vacuum. Using a vacuum installation (Figure 5) the filtration process significantly speeded up, created the possibility of sampling for analysis and visual assessment of the quality of the obtained filtrate. Samplings for chemical analysis were taken from the filtrate every 10 minutes during the filtration process and at the end of the filtration.

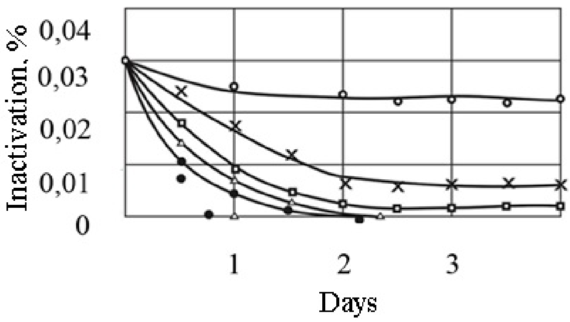
Figure 5 - Vacuum installation for filtering acaricidal liquid 1 - loading hopper; 2 - bunsen vessel; 3 - vacuum pump



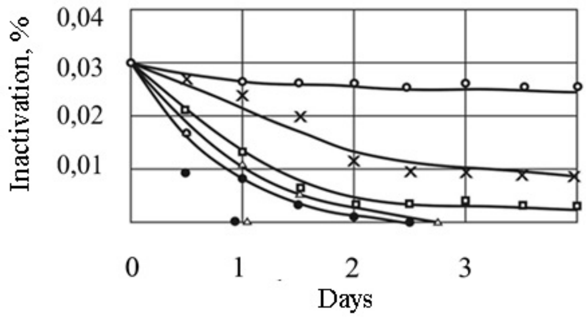
The results of the experiments on the inactivation of acaricidal solutes using brown coals B-2 and B-3 crushed to 0.5 mm are presented in Fig. 6.

The process of inactivation of acaricidal substances in the solutes with brown coals B-2 and B-3 proceeds almost identically. A more intense inactivation is shown by B-2 coal. At concentrations of 8 and 10% after 2.5 days the solution became transparent and odorless. In other samples with a coal concentration of 2, 4, 6%, the milky color of the solution remained unchanged. Chemical analysis showed that residues of neocidol were found in samples with a concentration of brown coal of 2, 4, 6% and the acaricide was not found in samples with a concentration of brown coal of 8 and 10%. The next day in samples with a concentration of brown coal of 2, 4 and 6% the content of neocidol in the solution did not change.

Figure 6. - Inactivation of acaricidal substances in solutes under the influence of brown coals of grade B-2 (a) and B-3 (b)



a) Concentration of B-2 coal
0–2%, x–4%, □–6%, Δ–8%, •-10%



б) Concentration of B-3 coal
0–2%, x–4%, □–6%, Δ–8%, •-10%

Thus, it is recommended to use brown coals of grade B-2 and B-3, crushed to 0.5 mm, at a concentration of coal in an acaricidal solution of 8 percent or more, as a sorbent for disinfecting spent acaricidal solutions.

In order to disinfect production discharges of the bathtubs, it is necessary to determine the rational particle size of brown coals, to choose methods for filtering used acaricidal solutes through a sorbent, and to develop appropriate technical means.

The results of filtering acaricidal liquid through crushed layers of brown coal with free flow of liquid and under vacuum are shown in table 1.

The filtration results (table 1) show that the quality of the filtrate — the residual content of acaricide and the throughput of the filter sorbent depend on the state of the coal aggregation. Coals B-2 and B-3 with particle sizes from 0.5 to 2.0 mm can be used as sorbents for the disinfection of used acaricidal solutes, in particular, a neocidol solution with a neocidol concentration of up to 0.03%. The filtrate does not contain residues of acaricidal substances.

Table 1 - The results of filtration of acaricidal liquid through crushed layers of brown coal B-2 and B-3 (free flow C / under vacuum, B). Mass of acaricidal liquid - 10 kg

Coal Label / Mass, kg (%)	The particle size of coal, mm	Filtration time C / V, min	The capacity of the filter (sorbent) C / V, kg / min	The residual content of acaricide in the filtrate
B – 2 / 0,8 (8)	0,5	57/5,8	0,18/1,72	
	1,0	52/5,1	0,19/1,96	Not found
	2,0	40/4,2	0,25/2,38	
	3,0	33/3,4	0,30/2,94	Found
	4,0	25/2,2	0,40/4,54	Traces
	5,0	18/1,9	0,56/5,26	
	6,0	11/1,0	0,91/10,0	Found
B – 3 / 0,8 (8)	0,5	63/6,4	0,16/1,56	
	1,0	57/5,6	0,18/1,78	Not found
	2,0	40/4,1	0,25/2,44	
	3,0	31/3,0	0,32/3,33	
	4,0	26/2,5	0,38/4,00	
	5,0	20/1,8	0,50/5,55	Found
	6,0	12/1,1	0,83/9,09	

With a coal size of 3.0 - 6.0 mm or more, the filter capacity increases, but acaricidal substances remain in the filtrate. When the aggregate state of coal is less than 0.5 mm, dust removal through a 100 mkm sieve is required, which increases the complexity and worsens the working conditions and the filter capacity gets significantly reduced. Therefore, it is rational to use brown coals of grades B-2 and B-3 with particle sizes of 0.5 - 2.0 mm as filtering agents of acaricidal substances.

This recommendation satisfies both filtration modes for filtrate quality. However, the filter capacity for free flow of liquid is of a protracted nature. According to the experiment, with free flow of liquid, the filter capacity for coal particles of 2.0 and 0.5 mm is only 15.0 kg / h and 10.5 kg / h, which makes them difficult to use in a production environment.

Filtration under vacuum of 5-6 kPa on filters with the same particle sizes increases the throughput by 10 times and is 142.8 kg / h and 103.2 kg / h, which creates the prerequisites for their use in production conditions.

Basing on the concentration of neocidol in the used acaricidal solute - 0.03%, the estimated mass of brown coal B-2 and B-3 for disinfection of 1 ton of solution is 80 kg. At lower concentrations of acaricide in the used solutions the need for coal decreases accordingly.

A study of the sorption properties of another natural sorbent which is a mixture of rubber crumb with powdery carbon siliceous shale was also carried out in model experiments. Shale is found in large quantities in carbon-siliceous rocks. Natural sorbent was prepared by thorough mixing in the form of a mixture of rubber crumb with slate in proportions of 1:40 respectively. The particle size of the natural sorbent was 1-2 mm.

In the experiments a neocidol emulsion with a concentration of 0.03% was poured into chemical flasks of 100 ml each and a natural sorbent with a weight of 0.5 g; 2.0 g; 4.0g; 6.0g was introduced. Samples for analysis were taken after 5, 10, 15, 20, 25, 30, 35, 40 hours. As a result it was found (Figure 7) that in static mode the complete absorption of acaricide from the emulsion occurs after 28 hours of contact with the natural sorbent at a concentration of natural sorbent in the emulsion of 4-6%. The particle sizes of the natural sorbent 1 and 2 mm give the same results. The consumption of a natural sorbent for detoxification of 1 ton of emulsion with a content of 0.03% neocidol is 40-60 kg.

A general structural and technological scheme of a mobile installation for disinfecting the remains of acaricidal solutions was developed (Figure 8) [27].

Figure 7 - Inactivation of acaricidal substances in solutions under the action of a natural sorbent

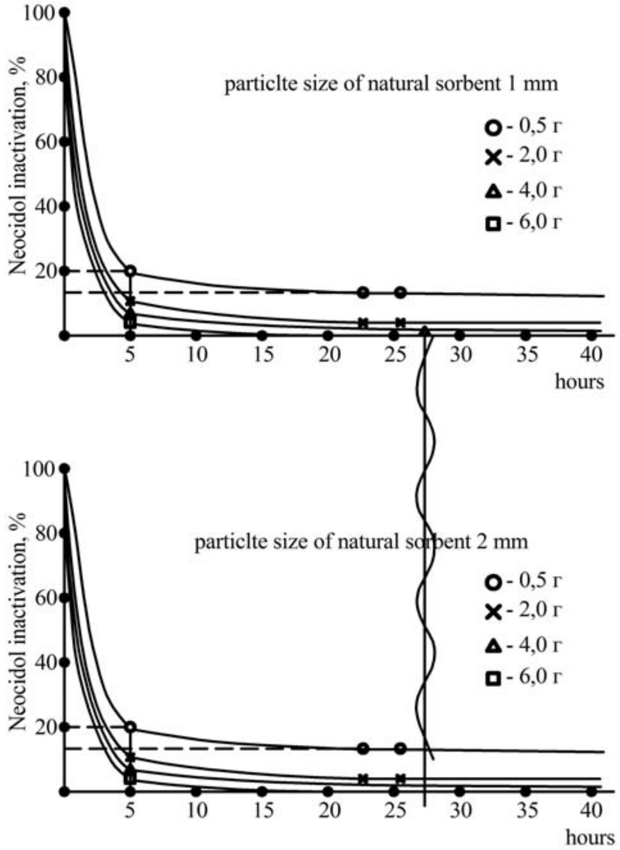
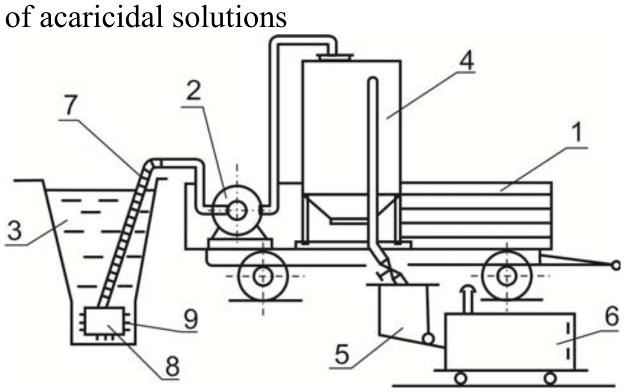


Figure 8 – Structural technological scheme of a mobile installation for disinfection of residues of acaricidal solutions

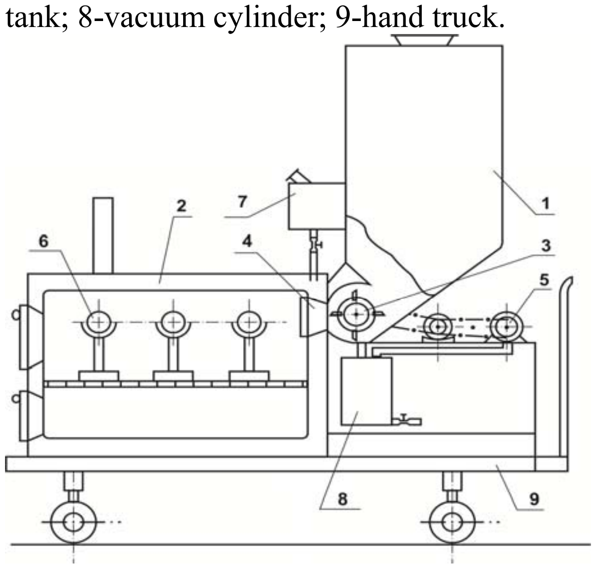


1 - tractor trailer; 2 - centrifugal pump; 3 - bathtub; 4 - filter sump; 5 - hopper for the sorbent; 6 - stove; 7 - a flexible hose; 8 - filter; 9 - frame.

The mobile unit consists of a tractor trailer 1, on which a centrifugal pump 2 is installed for pumping the used acaricidal liquid from the bathtub 3 to the sump filter 4. The liquid purified from mechanical impurities flows by gravity into the hopper 5, filled with sorbent from brown coal B-2 and B -3, where the sorption process is carried out. The hopper and a special stove 6 (Figure 9) [28] are separately mounted on the platform of the hand truck and are placed on the tractor trailer during transportation. The suction nozzle 7 of the pump is equipped with a filter 8 with a special frame 9. The preliminary cleaning of the spent solution from mechanical impurities using the filter 8 and filter sump 4 is a preparatory step for its disinfection. Without such cleaning, the sorbent in the hopper becomes clogged with dirt and the disinfection process gets difficult. The design of the hopper ensures uniform distribution of fluid throughout the volume, and the vacuum unit 5 (Figure 9) ensures the necessary rate of its outflow.

After the disinfection process is completed, the used sorbent is burned in an oven at a temperature of 800-850 C^0. At lower temperatures, acaricidal substances are sublimated to the atmosphere [28].

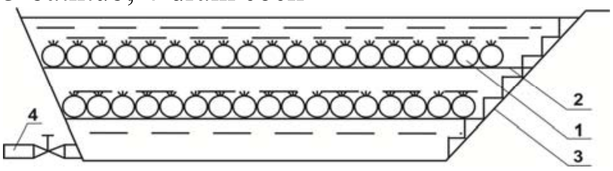
Figure 9 - Device for burning sorbent: 1-hopper; 2-oven; 3-spreader; 4 lower hatch; 5-vacuum installation; 6-burner battery; 7-fuel tank; 8-vacuum cylinder; 9-hand truck.



To supply the used sorbent to the furnace, the hopper in the lower elongated part is equipped with a spreader 3 and through the lower hatch 4 is connected to the furnace 2. To ensure the operating temperature of 800 - 850 C^0 for burning the sorbent in the furnace, we first need to supply the fuel from the tank 7 to the burner batteries 6 and to ignite it. The heat generated during the combustion of the sorbent can be used to heat water in the bath tub and for other domestic needs.

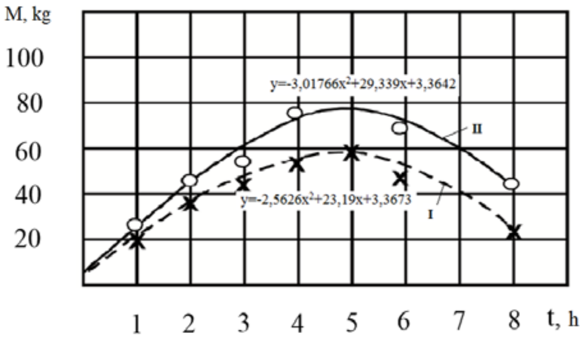
When using a natural sorbent, we also use a device (Figure 10 [29]), which provides for preliminary packing of the sorbent in bags 1 from the burlap and placing them in removable tiers 2 in the bathtub 3 after the completion of sheep bathing. After a certain time, the liquid is drained from the bath, and the natural sorbent is burned in the furnace.

Figure 10 - A bathtub with a natural sorbent. 1 - bags with a natural sorbent; 2-tiers; 3-bathtub; 4-drain cock



Experimental studies have established the dynamics of the flow of mechanical impurities into the sump under the bathtub during the sheep bathing shift (Figure 11)

Figure 11 - Dynamics of receipt of mechanical impurities in the sump under the bathtub during the shift: I-bathing sheared sheep; II-bathing unshorn sheep.



The Lagrange formula is used to expand the time series of the flow of mechanical impurities into the sump during the shift to the deterministic component:

$$l_n(x)=\sum_{i=0}^{n} y_i \frac{(x-x_0)(x-x_1)\ldots}{(x_i-x_0)(x_i-x_1)\ldots} \cdot \frac{\ldots(x-x_{i-1})(x-x_{i+1})\ldots(x-x_n)}{\ldots(x_i-x_{i-1})(x_i+x_{i+1})\ldots(x_i-x_n)}. \quad (9)$$

equations of the following types were selected to describe the dynamics of the flow of mechanical impurities into the sump when bathing sheared sheep during one shift

$$m_s^t = -2{,}62 \cdot t^2 + 24{,}72 \cdot t - 2{,}23, \quad (10)$$

when bathing unshorn sheep

$$m_u^t = -3{,}42 \cdot t^2 + 32{,}75 \cdot t + 0{,}67. \quad (11)$$

The determination coefficients were $R_s^2 = 0{,}941$ and $R_u^2 = 0{,}943$, respectively, which confirms the adequacy of empirical curves with the theoretical ones.

The maximum intake of mechanical impurities in the sump is observed at 4-6 hours of the operation and is $m^s = 44{,}32 \pm \Delta_m^s$ kg per hour when bathing sheared sheep and $m^u = 61{,}65 \pm \Delta_m^u$ kg per hour when bathing unshorn sheep. In the initial and final periods (the first 1-2 hours and the last 7-8 hours of work of the installation) the receipt is from 20 to 42 kg per hour.

This nature of the flow of mechanical impurities into the sump is explained by the corresponding nature of the sheep flow.

Based on the dynamics of the flow of mechanical impurities into the sump during the sheep bathing process, the capacity of the sump is determined:

$$V_s = \frac{M_u^t}{c_m}, \quad (12)$$

where c_m is the density of mechanical mixtures, kg / m3,

as well as the mass of mechanical impurities entering the sump per one sheep

when bathing sheared sheep

$$m_o^s = \frac{(m^s \pm \Delta_m^s) \cdot 1000}{n_{bs} \cdot t_p}, \quad (13)$$

when bathing unshorn sheep

$$m_o^u = \frac{(m^u \pm \Delta_m^u) \cdot 1000}{n_{bs} \cdot t_p}, \quad (14)$$

where n_{bs} - the productivity of bathing sheep, sheep / h;

t_p – processing time, h

The calculation of these parameters using formulas (12), (13) and (14) respectively gave the following results: the volume of the filter sump V_s = 0.0647 m^3, the mass of mechanical impurities brought by one sheared sheep is m_0^s = 109 , 62 ... 235.92 g and by one unshorn sheep m_0^u = 143.51 ... 334.72 g.

In accordance with the dynamics of the flow of mechanical impurities into the sump under the bathtub 3, the number of centrifugal pump starts during the shift will be up to 4 times when bathing sheared sheep and up to 5 times when bathing unshorn sheep with a duration of 2 ... 3 min.

3 Problem Solution

The prospects for the sheep raising development poses new challenges in the environment preservation by developing environmentally friendly methods of treating animals against infectious diseases and technical means for their implementation.

Residues of acaricidal substances can persist and migrate in the environment, translocate into plants, deposit in animals, excrete in milk, eggs and transfer to the fetus.

The results of studies on the possibility of using analytical expressions to determine the time constant of detoxification of acaricidal substances (τ = 113 for soil, τ = 1.01 for plants) show that the process of natural detoxification of acaricide has a long period and is accompanied by migration to adjacent objects of nature. Also it has a high degree of translocation to plants due to biological and physiological processes.

Simple and chemical substances, mineral fertilizers have inactivation capabilities due to destructive actions. They can disinfect used acaricidal liquid with a neocidol concentration of up to 0.2% for 24-35 days. However, these substances are not environmental pollutants. So, mineral fertilizers are specially introduced into the soil for its enrichment with nutrients, and therefore their optimal doses do not belong to environmental pollutants.

Sorption methods of water purification are widely used to remove pesticides and other compounds that are hazardous to human and animal health. The activated carbon was most widely used as a sorbent. We used this prerequisite for the purification of used solutions from the remains of acaricidal substances. Work on cleaning the water environment from pesticides with a content of 150-300 mg / l, which is the concentration contained in batch fluids, could not be found in the known literature. Therefore, the research on the disinfection of spent acaricidal solutions had their own characteristics. The activated carbons EPAC - 52244 and activated carbon iodine have shown high sorption properties as sorbents of acaricidal substances from the water environment. However, it is not economically feasible to use them for cleaning the used solutes. The search for cheaper and affordable sorbents led to natural brown coals with a low degree of coalification, that is, to the objects from which activated carbon is made. Of the many types of coals, brown coals of B-2 and B-3 types have the best sorption properties of acaricidal substances from the emulsion. The intensity of this property depends on the coal concentration in the emulsion, the particle size, the state of aggregation, the contact time with acaricide and the sorption mode.

In addition to brown coals, it is possible to use a natural sorbent which is a mixture of rubber crumb with powdery carbon siliceous slate for disinfecting used acaricidal solutes, as an affordable, easily made and convenient sorbent to use.

The engineering study of sorption methods with the aim of using them in veterinary practice is carried out by special three stage devices: 1 – preliminary cleaning of the solution from mechanical impurities; 2 - purification of residues of acaricidal substances contained in used liquids; 3 - burning of the used sorbent.

4 Conclusion

The authors studied the degree of soil contamination with acaricidal substance near the bathtub and the translocation of acaricide from soil to plants. At a distance of 20-100 m from the bathtub and in a depth of 40 cm, the content of neocidol in the soil is from 0.4 to 12 mg / kg. In the structure of plants it is up to 20 mg / kg at a distance of 2 m from the bath. The concentration of acaricide in these objects increases with decreasing distance of their location from the bath.

The study of the relationship of factors in the system "acaricidal substance - environment" using the laws of chemical kinetics allowed us to determine the time constant of detoxification of acaricidal substance (τ) in environmental objects with determination of the decrease in the initial content of acaricidal substances and decay periods generally accepted for chemicals ($T_{0,5}$, $T_{0,95}$, и $T_{0,99}$). This technique allows us to track the process of detoxification of acaricidal substances in environmental objects without conducting expensive experiments. It is enough to have data on the initial concentration of acaricide in the water environment.

Effective and economically feasible methods have been developed for the disinfection of used acaricidal solutes as well as the technical means for their implementation, which ensure that the solution is cleaned of mechanical impurities and acaricidal residues and the used sorbents are burnt without polluting the atmosphere. Brown coals (B-2, B-3) and the natural sorbent which is a mixture of rubber crumb with powdered carbon-siliceous shale, in a static sorption mode possess the intense sorption ability of acaricidal substances from used solutes. The need in brown coal for disinfection of 1 ton of the used acaricidal liquid with a residual neocidol content of 0.2% is 80 kg, and in the natural sorbent is 40-60 kg.

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