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Eichhornia crassipes in detoxification of heavy metal salts: Cadmium and lead salts as a case study

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ABSTRACT

Heavy metal salts, even in small quantities, accumulate in organisms, disrupt their cellular structures, and negatively affect growth and development processes. The situation requires in-depth research into methods and means that mitigate the effects of heavy metal salts on living organisms. In this study, the detoxification capabilities of the algae *Eichhornia crassipes* against the effects of cadmium and lead salts were evaluated using the example of *Oryctolagus cuniculus*. In experiments, biometric, physiological, and histological indicators in rabbits fed with $Cd(CH_3COO)_2$, $Pb(C_2H_3O_2)_2$ in the feed ration were stabilized as a result of the addition of dry biomass of *E. crassipes*. The primary data obtained on the detoxification properties of the algae *E. crassipes* for heavy metals are shown for the first time in the current study type, and the obtained data will serve to develop environmental recommendations for reducing the risk of Cd and Pb.

Keywords: *Eichhornia crassipes*, cadmium, lead, detoxification, *Oryctolagus cuniculus*, physiological, hematological, histological indicators.

INTRODUCTION

In recent years, along with the constant growth of the population, production has been developing rapidly, and the number of vehicles has increased sharply. The seriousness of the situation is clearly visible in the form of emissions into the environment from vehicles, ash and gases, heavy industrial enterprises, machine building, coal combustion, heat and power plant waste, as well as agricultural herbicides and insecticides (Hope et al., 2023; Ergasheva et al., 2024). Among the wastes harmful to living organisms, heavy metals occupy one of the leading places. They accumulate in the environment under the influence of anthropogenic factors and enter the food chain of living organisms (Chang et al., 2019; Akramov et al., 2025).

Heavy metals are commonly found in wastewater from mining, metal processing and smelting, and battery production, and are mostly composed of Co^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, and Zn^{2+} ions. The presence of these metals in wastewater is of public concern due to their toxic effects on terrestrial and aquatic organisms (Oladimeji et al., 2024). Heavy metals are non-biodegradable and persistent in the environment. Metal salts have a negative impact on living organisms in the environment, mainly through water and soil contamination (Das et al., 2023).

Cadmium (Cd) is classified as a Group II carcinogen by the International Agency for Research on Cancer, and the main sources of exposure are food, air, and soil contamination (Genchi et al., 2020). Once absorbed, cadmium accumulates in the body for many years. Even low concentrations of cadmium have a negative impact on metabolic processes in the body. Cadmium poisoning has been reported to cause damage to the kidneys, bones, and lungs, and to the liver, lungs, testicles, and blood formation (Bhardwaj et al., 2021).

According to official statistics, lead poisoning is the leading cause of occupational poisoning. According to the Institute for Health Metrics and Evaluation, since 2017, lead poisoning has caused an estimated 1.06 million deaths and 24.4 million serious health problems (https://www.niehs.nih.gov/health/topics/agents/lead). Lead is absorbed by red blood cells in the blood and, depending on age, 75–94% of the lead ingested by the body is deposited in the bones in the form of insoluble phosphates. Lead accumulated in the bones does not have a direct toxic effect. However, under certain conditions, its reserves in the bones become mobile, and lead passes into the blood and causes acute poisoning (Sachdeva et al., 2018). Factors contributing to the mobilization of lead include increased acidity, calcium and iron deficiency. Lead has a strong effect on the cardiovascular system, as well as the nervous system. Even low levels of lead in young children can lead to negative consequences (Lidsky et al., 2023).

In recent years, special attention has been paid to research aimed at using various sources for the detoxification of heavy metal dust. One of the plant groups with this property is higher algae (Ankit et al., 2022).

Eichhornia crassipes is a perennial aquatic plant that grows on the surface of the water and is widely distributed in tropical and subtropical regions. Currently, these plants have been successfully introduced to the conditions of Uzbekistan (Abduraimov et al., 2023; Khojakulov et al., 2024). The biomass of the plant naturally absorbs pollutants, including heavy metals such as Pb, Hg, Zn, Co, Cd and Cu, and has been reported to be used for wastewater treatment (Alengebawy et al., 2021). According to experts, *E. crassipes* a large amount of Cu (561 mg/kg dry matter) in its biomass. The level of Zn absorption is lower in the roots (84 mg/kg dry matter), as well as in the stems and leaves (51 mg/kg dry matter) (Ochekwu et al., 2013).

Based on the above, the aim of this study is to evaluate the detoxification potential of the algae *E. crassipes* for Cd and Pb dust using the example of *O. cuniculus* and to develop recommendations for its application.

MATERIALS AND METHODS

Research object, conditions and design

Male individuals of the Hikol hybrid breed of rabbits aged 60 days, with an average mass of 1600 g, were selected as the research object (Figure 1). Animal experiments were conducted in accordance with the Ethical Guidelines for the Use of Animals in Research (https://www.forskningsetikk.no/en/guidelines/science-and-technology/ethical-guidelines-for-the-use-of-animals-in-research/).

Rabbits were kept on a farm specializing in the cultivation and breeding of rabbit products called "Tarnov sabzovotlari" in the Akdaryo district of the Samarkand region (39°50'56.1"N 66°50'40.1"E).

In the study, the animals were fed a diet containing heavy metal salts and dry biomass of E. crassipes for 60 days (Table 1). The experimental groups were formed by increasing the amount of heavy metal salts added to the diet by five times the permissible standard amount for the animal body (5 mg/kg $Cd(CH_3COO)_2$, 25 mg/kg $Pb(C_2H_3O_2)_2$). After 60 days, the studied indicators were studied.

Determination of digestibility and amount of nutrients consumed

The digestibility of dry matter is determined by determining the difference between the part of the feed ingested by the body and the undigested part in the feces (Rajamuradova et al., 2022):

$$D\ (\%) = (ASC - ASM) \times 100 \tag{1}$$

where: D – digestibility; ASC – amount of substance consumed; ASM – amount of substance in manure.

Total nitrogen in the consumed feed and manure was determined by the Keldal method, the amount of protein, fat, fiber, and nitrogen-free extracts were determined using trilonometric and photocolorimetric methods, and their values were determined based on the formula above.

Assessment of the state of thermoregulation in rabbits

The body temperature of rabbits was determined using a mercury thermometer inserted through the posterior ostium of the rabbits (at a depth of 3 cm). Respiratory movements were measured by counting the contraction and expansion movements of the nostrils. The number of heart contractions was determined by counting the number of heartbeats beating against the chest with the rabbits held between the palms of both hands (Cranston et al., 1976).

Determination of live weight of animals

Live weight was determined by weighing on a scale. The absolute average daily growth rate in live weight was calculated according to the following formula (Guvenoglu. 2023):

$$D\ (\%) = (ASC - ASM) \times 100 \quad (2)$$

where: D – average daily growth rate, g; WO – initial live weight, kg; $W1$ – final live weight, kg; t – time (days).

Determination morphological composition of the blood

The method of Khayitov (2023) was used to determine morphological indicators of blood (Khayitov et al., 2024). The obtained blood samples were analyzed on the YeCL 760 Filly automatic Haemostasis analyzer. Hemoglobin was determined by the calorimetric method, red blood cells by flow laser cytometry, and platelets by the electron impedance method. The amount of lymphocytes was determined by separating and separating the mononuclear leukocyte fraction of the circulating blood by gradient centrifugation.

Preparation of histological preparations

Preparations for histological examinations were carried out using the following technology: 1) material collection; 2) fixation; 3) washing; 4) dehydration-compression; 5) casting; 6) cutting; 7) deparaffinization; 8) staining; 9) illumination; 10) finishing.

In the experiments, sections from the small intestine were fixed in 12% formalin for 24 hours. After fixation, the fixative was poured out, and the sections were washed in water. After washing,

Figure 1. Research object (Hikol hybrid breed)

Table 1. Feed ration used in the study

Control	Experience			
	I	II	III	IV
*Traditional farm diet -(TFD)	TFD + 5 mg/kg $Cd(CH_3COO)_2$	TFD + 25 mg/kg $Pb(C_2H_3O_2)_2$	TFD + 5 mg/kg $Cd(CH_3COO)_2$ + 25 mg/kg $Pb(C_2H_3O_2)_2$	TFD + 5 mg/kg $Cd(CH_3COO)_2$ + 25 mg/kg $Pb(C_2H_3O_2)_2$ + dry biomass *E. crassipes* (9:1 ratio)

Note: *Traditional farm diet – (TFD): Various plant flours – 27.3%; Wheat grain – 18.5%; Wheat bran – 17.4%; Corn grain – 13.8%; Oat grain – 10.2%; Sunflower meal – 10.4%; Tricalcium phosphate – 2.0%; NaCl – 0.4%.

the sections were placed in alcohols of increasing concentration: 50%, 60%, 70%, 80%, 90%, 96% and 100%, that is, absolute alcohols. Despite the fact that the sections were concentrated to a certain extent in alcohols, they were not hard enough to obtain thin sections, so at the next stage they were embedded in paraffin. Paraffin-embedded sections were cut into 5–7 μm thick sections using a microtome. Special steel blades were used for this. Excess paraffin in the sections was removed using organic solvents (chloroform, xylene, toluene). The preparations were stained with hematoxylin-eosin. After the sections were dehydrated, they needed to be illuminated so that light rays could pass through them well or become clear. Toluene was used as an illuminating agent. The sections were kept in the illuminating agent for 0.5–1 minute (Suzuki et al., 2012; Mukhtorova et al., 2024).

Statistical processing of the obtained results

Statistical processing of the obtained results was performed according to the method of Lakin (1990), and the figures were drawn using the Excel (Microsoft, USA) computer program. The results obtained were determined by Student's t-test (Lakin. 1990; Rayimova et al., 2024).

RESULTS

The fact that the amount of feed consumed by rabbits in all experimental groups, except the control group, was lower than the standard level indicates that feeding a diet containing heavy metal salts led to a certain reduction in feed consumption (Table 2).

Since feeding the feed in a granulated form is more effective than feeding it in its natural state, all the feed was crushed and fed in a granulated form after adding heavy metal salts to the diet. The data obtained on the feed consumption showed that the rabbits of the experimental group that received heavy metal salts in their diet consumed less food than the rabbits of the control group that were fed a natural farm diet.

The amount of feed actually consumed by rabbits in the comparison groups per day was found to be 163.8 g on average in the control group, while in the experimental groups it was 149.2, 154 and 142.1 g, respectively. According to the data in Table 2, the complex consumption of heavy metal salts also had a negative effect on the digestibility of feed. As a result, a negative effect was noted both on the amount of feed actually consumed and on the digestibility coefficient of substances. The digestibility of the experimental groups in which cadmium and lead salts were added to the feed separately and together was observed to be 6%, 4.6% and 10.2% lower than that of the control group (control 72.0%, I-66.02%, II-67.4%, III-61.8% in the experimental group). In the experimental group in which heavy metal salts and additional *E. crassipes* biomass were added, the amount of feed actually consumed was 162.4 g per day on average, which was 0.8% different from the control group. It can be concluded that although the rabbits in this experimental group consumed both salts in combination, the *E. crassipes* biomass added to the feed prevented the negative effects on the palatability, digestibility and assimilation of the feed.

During the research, it was found that in experimental groups, heavy metal salts were included in the diet, which may reduce the intake of nutrients in the diet (Table 3).

According to the data presented in Table 3, rabbits in the experimental groups, to which cadmium and lead salts were added separately and together, consumed 4.2%, 3%, and 13% less dry matter than rabbits in the control group. The percentage of nutrients digested in the gastrointestinal tract of rabbits in the group that received *E. crassipes* as a supplement was close to or equal to the indicators of control rabbits.

During the study, the general physiological and clinical indicators of rabbits of the control and experimental groups were studied (Figure 2).

As can be seen from Figure 2, the body temperature of rabbits in all experimental groups, except for experimental group IV, decreased by 0.8–3.3% compared to rabbits in the control group. This may be due to the process of actively removing heat generated in the body. In experimental group I, rabbits that received cadmium acetate, a 2.7% decrease in body temperature was observed compared to the control group, while in experimental group II, that is, in the group that consumed lead acetate, a 2.53% decrease was recorded. In experimental group III, rabbits that received both types of heavy metals, the decrease compared to the control group was 3.29%.

Heart rate is one of the important clinical and physiological signs characterizing cardiac activity. The data obtained from our experiments show that the heart rate of the rabbits of the remaining 3

Table 2. Effect of Cd and Pb dust detoxification by E. crassipes algae on dry matter intake and digestibility in the diet, g (n=5)

Indicators	Groups				
	Control	Experience			
		I	II	III	IV
Given in the diet	199.7±1.7	198.5±1.2	198.9±0.9	198.7±1.0	198.6±0.7
Unused portion	35.9±0.8	49.3±0.9	44.9±1.0*	56.6±0.9	36.2±0.6
Actually consumed	163.8±3.8	149.2±2.2	154.0±2.3	142.1±2.2	162.4±2.9*
Excreted in feces	46.2±0.6	50.7±1.02	50.2±0.9	54.3±1.0	47.8±1.03
Digested portion	117.5±1.9	98.5±0.4	103.8±1.0	87.8±0.7*	114.6±1.8
Digestion coefficient, %	72.0±1.3	66.02±1.3	67.4±1.1	61.8±1.2	71.0±0.9

Note: *p < 0.05.

Table 3. Detoxification of Cd and Pb dust by E. crassipes algae as reflected in the amount of nutrients consumed, g (n=5)

Indicators	Groups				
	Control	Experience			
		II	III	IV	IV
Consumption	163.78±2.4	149.2±3.1	153.9±2.9	142.12±4.1*	162.44±1.8
Dry matter	146.6±1.8	140.7±1.1	142.3±1.2	127.2±1.3	145.4±1.0
Organic matter	117.7±1.6	107.9±1.6	111.0±1.2	102.1±1.1	116.7±1.1
Crude protein	19.6±0.8	18.7±0.7	18.9±0.2*	17.3±0.7	19.45±0.6
Crude fat	4.7±0.1	4.5±0.1	4.6±0.2	4.2±0.1	4.6±0.1
Flour	31.5±0.2	28.8±0.3	29.7±0.3*	27.2±0.2	31.3±0.4
Non-nitrogenous extractives	57.6±0.8	48.5±0.6	50.05±1.1	46.5±0.9	57.1 ±0.4

Note: *p < 0.05.

experimental groups was 5.7%; 4.2%; and 6.44% lower than that of the control group compared to the IV-experiment and control groups. We believe that this phenomenon is caused by the control systems formed outside the heart that control the work of the heart, which are usually performed by the vagus or parasympathetic nervous system of the spinal cord (Gordon et al., 2015).

To monitor the dynamics of changes in the live weight of rabbits, the change in their live weight was measured by weighing each of them on separate scales every 15 days (Figure 3).

The addition of *E. crassipes* to the traditional farm diet of rabbits in the experiments allowed us to obtain important information.

It can be noted that before the start of the experiments, the body mass of all rabbits was practically the same and ranged from 1597 g to 1610 g. After 60 days of the experiment, the results showed that the body mass of rabbits in experimental groups I, II, and III was 11.5%; 10.1%; 14.8% lower, respectively.

We observed that the daily growth dynamics of rabbits in experimental group IV, to which the nutritional supplement of *E. crassipes* was added to the traditional diet, was very close (0.9% difference) to that of rabbits in the control group without the addition of heavy metal salts. Since the addition of *E. crassipes*, which has a corrective effect, to the rabbits of the IV experimental group acted as a factor ensuring the activation of enzyme activity in the digestive tract of rabbits, an increase in the number of beneficial microorganisms, we observed that the daily growth dynamics of rabbits of this group was moderate, in addition, it is known from scientific sources that two salts with ecotoxic properties can act as antagonists to each other. In our opinion, *E. crassipes* may have shown its corrective properties here as well.

According to experts, stress factors, including heavy metal pollution, also negatively affect the stability of the internal fluids of living organisms. Therefore, during our studies, the effect of feeding feed with cadmium and lead salts on the

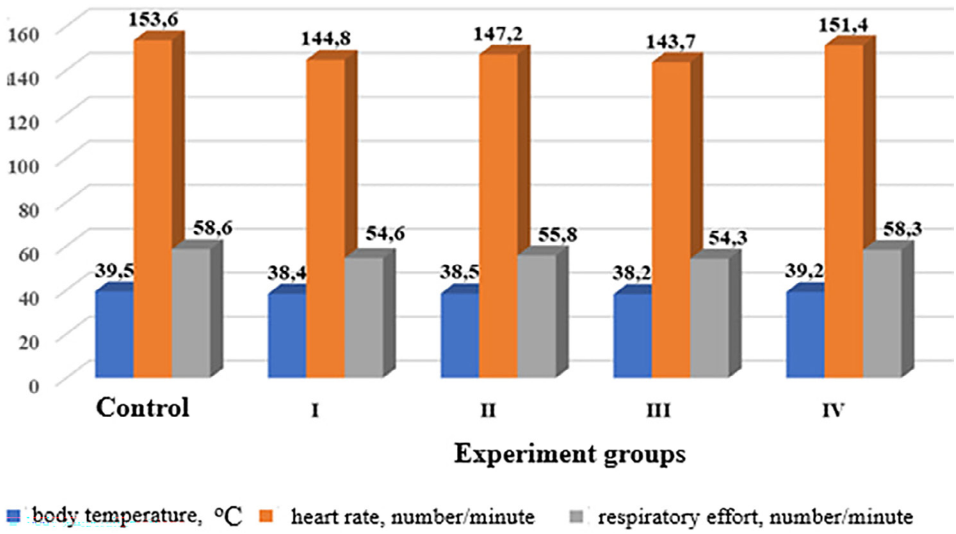

Figure 2. Effect of Cd and Pb dust detoxification by *E. crassipes* algae on the dynamics of physiological status indicators in rabbits (n=5)

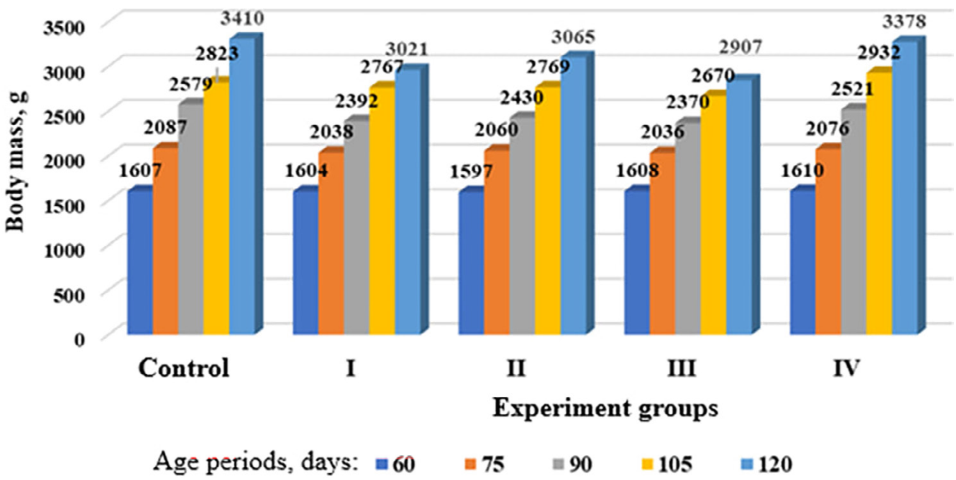

Figure 3. Effect of *E. crassipes* algae detoxification of Cd and Pb dust on daily growth rates of rabbits, g (n=5)

morphological parameters of the blood of rabbits and the role of E. crassipes in mitigating the effect were assessed (Figure 4).

The results obtained in the experiments showed that the addition of cadmium and lead salts to the diet separately and in combination negatively affects the hematological parameters of their blood, and the addition of *E. crassipes* biomass to the diet normalizes the parameters.

As can be seen from Figure 4, the number of erythrocytes in the blood of rabbits in the experimental groups to which cadmium and lead salts were added separately and together decreased by 14.04%, 10.5%, and 17.5%, respectively, compared to the control group. In the experimental groups to which cadmium and lead salts were added separately and together, along with a decrease in the number of erythrocytes and hemoglobin in the blood of rabbits, a slowdown in metabolic processes and hypoxia were noted in the body. The data obtained on the total number of leukocytes showed that in the experimental groups to which cadmium and lead salts were added separately and together, they decreased by 13.3%; 10.1%, and 16.9%, respectively, compared to the control groups, while the number of eosinophils and lymphocytes increased.

The results of the studies showed that the concentration of erythrocytes, hemoglobin, and leukocytes in the blood of rabbits in the control group and the group receiving *E. crassipes* as a supplemental feed were within normal limits.

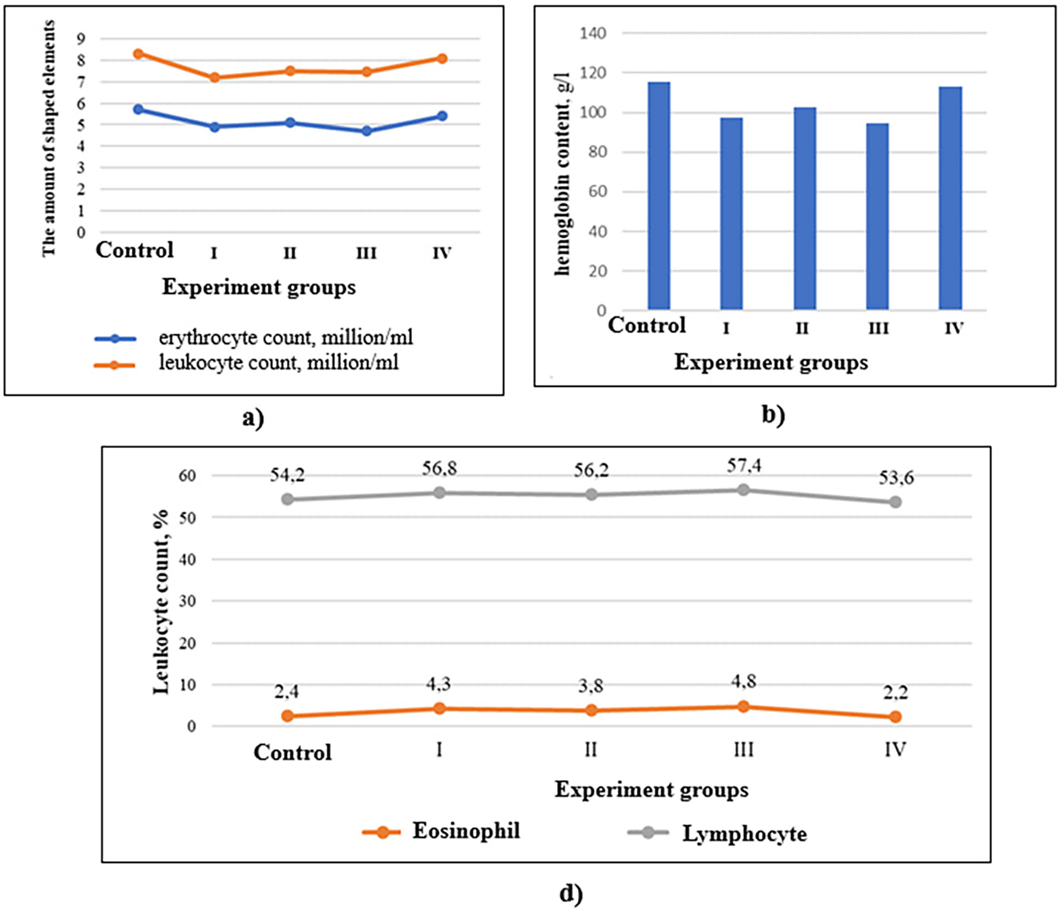

Figure 4. Detoxification of Cd and Pb dust by *E. crassipes* algae in the morphological parameters of rabbit blood (a) erythrocytes and leukocytes; b) hemoglobin; d) leukocyte groups), (n=5)

The nutrients included in the diet consumed by animals and various biological substances and additives added to the diet primarily affect the structural structures and moderate activity of the tissues that form the walls of the intestines, which are actively involved in metabolic processes, and the glandular cells with digestive properties located in their surface and intermediate layers. All of the above, during our research work, regardless of the consumption, digestion, and assimilation of digested nutrients by rabbits, we also studied information about the state of the epithelial tissues that form the walls of the intestines, the structural structures of the villi located on their surface (Figure 5).

The serous membrane is composed of a single-layered squamous epithelium (mesothelioma), which, if functionally normal, actively participate in the absorption, digestion and assimilation by the body of nutrients contained in the consumed diet. However, the maintenance of the normality of the suckers located on the walls of the duodenum, which is presented, indicates the normal course of digestion and other metabolic processes there. We recognize that the addition of a prophylactic and high-energy nutritional supplement containing a high amount of protein from *E. crassipes* to a diet containing both heavy metal salts, as shown by histopreparations prepared from the duodenum of rabbits of the IV experimental group, gave results in which the suckers on the walls of the intestines functionally did not differ from those of rabbits of the control group. It can be noted that when feeding any type of heavy metal salt-containing diets used in agro-industrial production enterprises, the addition of *E. crassipes* in the amount of 10% of the dry matter in the diet can be considered as a supplementary feed that enriches the rabbits' body with high-value proteins, while having a certain preventive effect.

DISCUSSION

The biological role of each mineral element in the animal body is unique and its presence is determined by a threshold concentration, the

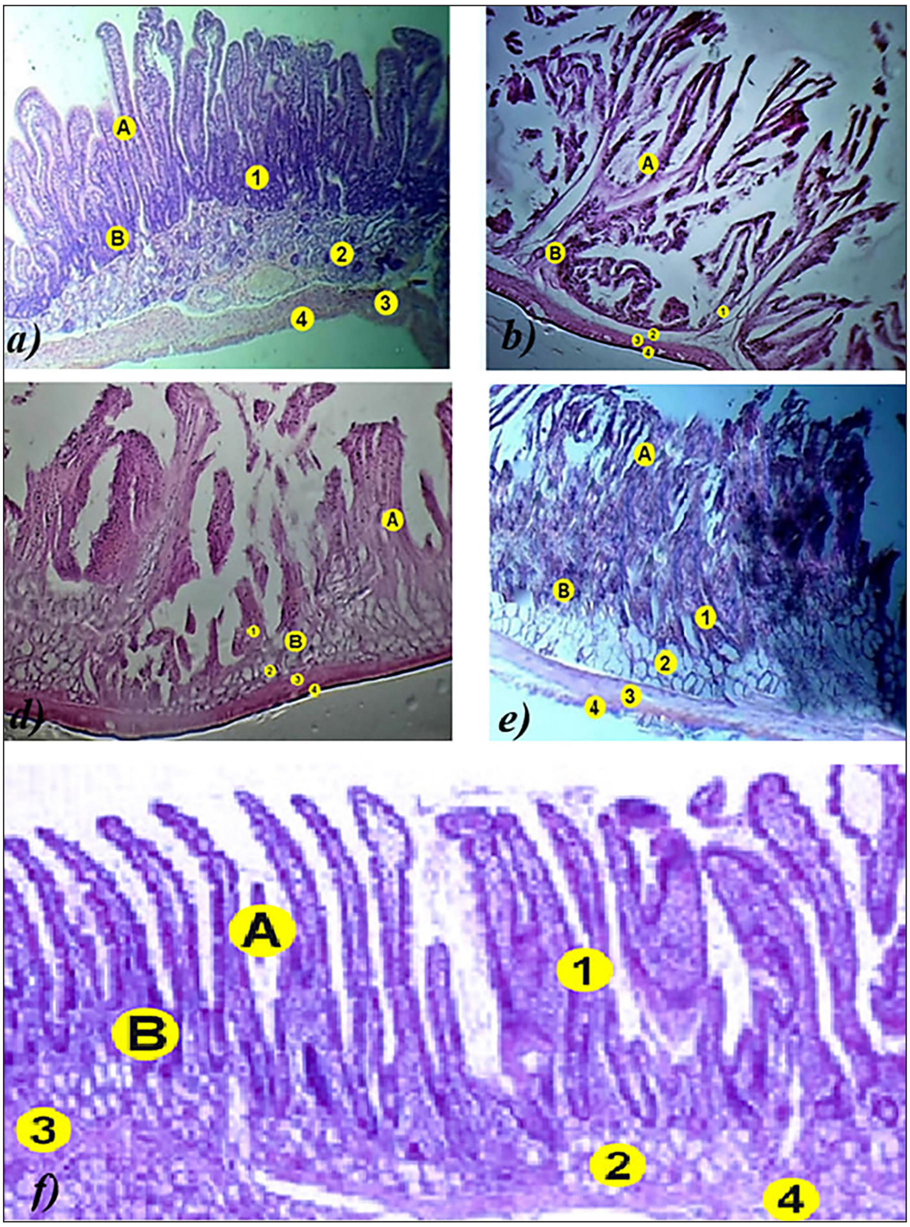

Figure 5. Detoxification of Cd and Pb dust by *E. crassipes* algae in the structure of the duodenum: (a)Traditional farm diet -(TFD); b) TFD + 5 mg/kg $Cd(CH_3COO)_2$; d) TFD + 25 mg/kg $Pb(C_2H_3O_2)_2$; e) TFD + 5 mg/kg $Cd(CH_3COO)_2$ + 25 mg/kg $Pb(C_2H_3O_2)_2$; f) TFD + 5 mg/kg $Cd(CH_3COO)_2$ + 25 mg/kg $Pb(C_2H_3O_2)_2$ + dry biomass *E. crassipes* (9:1 ratio); 1-mucosa; 2-submucosa; 3-muscular layer; 4-serosa layer. A-Villi. B-crypts)

increase of which leads to disruption of regular processes in biological reactions, which is manifested in the form of biochemical changes in metabolic processes (Kostova et al., 2023). An excess of cadmium, chromium, nickel, lead, copper, iron in food leads to the development of diseases such as disruption of enzyme systems, blindness, saturism, bilirubinemia. As a result, the country's economy loses about 250 thousand animals annually (Balali-Mood et al., 2021).

The main routes of cadmium entry into the body are the gastrointestinal tract and respiratory organs. Cadmium metabolism is characterized by the following main features: long-term retention in the body, accumulation in the liver and kidneys (Qu et al., 2024). Cadmium absorption occurs in the small intestine; The absorption value for cadmium is much higher than that of copper and zinc, which share a common transport mechanism. Cadmium can be considered a kind of zinc antimetabolite. With an increase in cadmium, copper in the body of animals decreases. Experiments show that with a lack of calcium and iron in animal feed, the absorption of lead into the body increases, which is associated with an increase in its absorption in the intestine (Ohta et al., 2024). The normal presence of iron in the body reduces lead absorption by 5 times, and calcium by 2 times. Therefore, it is advisable to enrich the diet with iron, calcium, pectin. Another physiological antagonist of lead is zinc, which reduces its toxic effect. Of the total amount of lead entering the human body, 30–45% comes from food, 30–35% from air, and 20–25% from drinking water (Lönnerdal, 2010). In newborn animals, the level of cadmium absorption in the intestine is much higher than in adults. During pregnancy and lactation, cadmium deposition in the kidneys, duodenum, and mammary glands increases. It has been proven that long-term exposure to cadmium at a dose of 1 mg/kg body weight reduces sperm resistance. Cadmium has a negative effect on the reproductive system. During pregnancy in animals, cadmium crosses the placental barrier and affects the offspring (Petersson et al., 2000). Cadmium also has the ability to cross the placenta, since at certain doses this element has a pronounced teratogenic effect, disrupting the penetration of other important elements into the fetus. The level of cadmium in the blood of newborns is approximately 2 times lower than in the mother's blood (Iman et al., 2011). The embryotoxic and teratogenic effects of cadmium, as well as the ability to cause degeneration of bone marrow and bone tissue, have been established. In addition, Cd poisoning affects blood sugar levels, contributing to the development of diabetes mellitus (Genchi et al., 2020).

Another physiological antagonist of lead is zinc, which weakens the toxic effect of lead and reduces its content in animal tissues. In addition, zinc changes the nature of the distribution of lead between organs and tissues, reducing its content in the skeleton and increasing it in the kidneys and liver. Lead compounds belong to the group of thiol poisons, which, once in the body, enter into chemical interactions with sulfhydryl groups of various macromolecules, primarily enzymes. More than 100 enzymes are known, the activity of which can be inhibited by blocking sulfhydryl groups in their molecules (Saikat et al., 2022).

Recently, feed contamination with two or more representatives of heavy metals has become increasingly common. At the same time, the toxic effect of the combined entry of metals into the animal body has not been sufficiently studied. The impact of these factors often affects the metabolic processes of the organism, their productivity, reproductive ability and the biological value of animal products. As a result of this deterioration of the ecological situation, animal morbidity and mortality increase, productivity decreases, and reproductive functions are impaired (Tchounwou et al., 2012). Cadmium is close to zinc in physical and chemical properties and occurs naturally with it, is its antagonist and chemical analogue, and can replace zinc in the active centers of enzymes containing cadmium metal, which leads to a sharp disruption of enzymatic processes (Tavarez et al., 2023).

In studies by a number of scientists, chronic poisoning of rats with cadmium, lead and copper salts led to a decrease in hemoglobin, erythrocytes, leukocytes, total protein and albumin in the blood. At the same time, the activity of ACT, ALT increased. The noted changes were accompanied by a decrease in the activity of lysozyme, phagocytes, the concentration of T-lymphocytes and B-lymphocytes. In general, there was a significant detrimental effect on the immune system of animals (Andjelkovic et al., 2019). Hematological results show that Pb developed hyperchromic macrocytic anemia in rabbits. Increased AST and ALT activity indicates pathophysiological changes in the liver parenchyma. Due to the toxic effect of Cd on the kidneys, changes in kidney function were observed. The toxic effects of Cd, Pb and Hg on the pancreas were explained by the decrease in amylase, trypsin, protease and lipase activities (Melillo, 2007).

The results obtained in the current study support the idea that the addition of E. crassipes biomass to the diet detoxifies the effects of cadmium and lead dust. The detoxification process can occur through a number of mechanisms. In particular, the mechanisms of dust detoxification are studied: cadmium and lead ions form chemical bonds with carboxyl (COOH), hydroxyl (-OH), and sulfide (-SH) groups in *E. crassipes*; phenolic compounds and flavonoids in plant biomass neutralize free radicals generated by heavy metals, reduce oxidative stress, block their toxic effects at the cellular level; and organic and inorganic acids (e.g., oxalate, citrate, carbonate) react with Cd^{2+} and Pb^{2+} ions, converting them into biologically inactive forms (Jianbo et al., 2008).

CONCLUSION

In rabbits fed with *E. crassipes* dry biomass, the consumption and digestion of dry matter in the diet, the amount of nutrients consumed, physiological status indicators, productivity, and morphological blood indicators were close to those in the control variant, and had a positive characteristic compared to these indicators in rabbits fed with $Cd(CH_3COO)_2$ and $Pb(C_2H_3O_2)_2$. Histological analysis of the structure of the duodenum showed that the structure and function of the villi were normalized by adding E. crassipes biomass to the diet. Based on the results obtained, it is recommended to use *E. crassipes* algae in the detoxification of heavy metal salts, including Cd and Pb salts.

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