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# The Assessment of the Sorption Capacity of Enterosorbents at the Risk of Heavy Metal Poisoning

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**ABSTRACT**

It was carried out a comparative determination of the effectiveness of the detoxification activity of sorbents about heavy metals. It was found that the half-adsorption period is approximately 30 minutes and it does not depend on the type of sorbent. The maximum sorption capacity for sorbents relative to heavy metals was determined. Rows of sorbent activity about heavy metals were constructed. The influence of the pH of the medium on the value of the specific adsorption of sorbents was studied. The assessment of desorption processes in conditions close to physiological in the environment of "artificial" intestinal juice was carried out to establish the possibility of secondary metal intoxication. The results can be used to select the optimal detoxifying agent and correct the elimination of the consequences of heavy metal poisoning.

**Keywords:** *heavy metals, enterosorbents.*

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## INTRODUCTION

The problem of heavy metals in modern conditions is global and is associated with contamination of soil and water with rare and scattered elements that have a biocidal effect. This leads to the accumulation of heavy metals along the food chain leading to severe human diseases [1]. The sorption deoxidation occupies an important place among other methods of treatment [2] including the clinical practice [3]. There is a wide range of sorbents and the most famous which are: "POLYSORB" [4], "Enterosgel" [5], alginates [6], pectin [7] and peat sorbents [8]. Publications on their comparative characteristics are devoted to sorption preparations [9]. But despite these issues related to the study of sorbents are relevant. So, there is a question of studying the boundary between the therapeutic and toxic effects of sorbents that include certain chemical structures in their composition and it is also important to determine the relationship between the chemical structure of a substance and its pharmacological action. A specific quality indicator for all drugs of the enterosorbent class is the adsorption activity [10].

The relevance of this work is determined by a wide range of proposed synthetic, semi-synthetic and natural sorbents and cases of heavy metal poisoning, leading to intoxication and accumulation in the internal organs. Heavy metals are dangerous because they possess the ability for bioaccumulation, i.e. they can concentrate in the tissues of living beings and when excessive, they can be toxic [11]. All over the world, heavy metal pollution is one of the most dangerous problems, especially for wastewater considering this, they can also be useful [12, 13]. In this regard, the study of the effectiveness of various sorbents about heavy metals in their overdose is an important medical task.

The purpose of the study is to compare the effectiveness of the detoxification activity of popular medical sorbents about heavy metals.

## MATERIALS AND METHODS

Sorption of metal ions was performed under static conditions from solutions of $CuCl_2{\cdot}2H_2O$, $ZnSO_4$, PbCl2, NiCl of the "clean for analysis" brand. The quantitative determination of lead, nickel, and zinc was performed by the method of complexometry and the quantitative determination of copper was done with the help of iodometry [14].

To determine the sorption capacity of the sorbent we took samples of sorbents weighing 1 g on analytical electronic scales scale series EVA model SKA–220V, after that we placed it in a glass beaker introduced 30 ml of the solution of the metal salt understudy with different concentrations, then we mixed it on the device LAB–PU–01 at 150 rpm at a temperature of 25 ° C for 60 minutes. After that, the solution was centrifuged on the ELMI SkyLine CENTRIFUGECM–6M (1000 rpm, 3 min) and the equilibrium concentration was determined metal in the centrifuge. During the experimental determination of the adsorption of each metal 5 measurements were performed. The obtained data were subjected to statistical processing. The relative uncertainty was less than 5 %. The concentration of metal remaining in the solution after applying the sorbent was calculated using the formula:

$$Ssp = \frac{(\mathrm{Ccor} - \mathrm{Ccom}) \cdot \mathrm{V}}{\mathrm{m}}$$

Where we take – m- as the mass of the enterosorbent suspension; Ssp- is the specific adsorption mg / g of the sorbent; V- is the volume of the solution in ml; Ccor and Ccom - is the initial and equilibrium metal concentrations in mg/ml [15].

To study the effect of different pH values of the medium "artificial" gastric and intestinal juice was prepared. After that 7.0 ml of concentrated hydrochloric acid was quantitatively transferred to a 1000 ml flask. Then 2.0 grams of sodium chloride were dissolved in it and the volume of the solution was brought to the pH 2.0 $\pm$ 0.05 mark with distilled water. The pH value was determined on the pH meter pH-150M. The sorbent located in the glass with a bound metal were filled with a pipette of 3 cubic centimeters of "artificial" gastric juice and mixed at 150 rpm for 60 minutes at a temperature of 37 C. After that, the solution was centrifuged (1000 rpm for 3 min) and the metal content in the centrifuge was determined [16].

To study the desorption processes, a solution of "artificial" intestinal juice was prepared. It was made with the help of 1 g of sodium chloride which was quantitatively transferred to a flask with a capacity of 500 cm3 and brought to the mark with distilled water. A solution of sodium bicarbonate was added drop by drop to a pH of 7.5 $\pm$ 0.05. To determine the amount of desorption, the studied sorbent was taken after sorption at pH 2 with sorbed metals filled with 3 cm3 of "artificial" intestinal juice and mixed at 150 rpm for 60 minutes at a temperature of 37 C. After that, the solution was centrifuged (1000 rpm, for 3 min) and the metal content in the centrifuge was determined [16].

The percentage of desorbed substance about the adsorbed one was determined by the formula:

$$\%\ desorption = \frac{\mathrm{C\ substance} \cdot 100}{(Cinitial - Cequilibrium)}$$

Where we take -Ccon-as the concentration of the substance to be determined after desorption mol/l; Ccor and Ccom- is the initial and equilibrium concentration in mol/l.

## RESULTS AND ITS DISCUSSION

Since the most important characteristics of sorbents are the size of the sorption capacity and the time to achieve sorption equilibrium, the study of the effect of time on the specific adsorption of sorbents relative to heavy metals was conducted. The binding rate of metals was determined using sorbents such as white coal and enterosgel. The analysis was performed after 15, 30, 60 and 90 minutes. It was found out that the balance was established relatively quickly, after about 60 minutes. Thus, during the first 30 minutes, almost 50% of the metals from the maximum possible value are bound, i.e. the half-sorption period is approximately 30 minutes and it doesn't depend on the type of sorbent.

The influence of the sorption of heavy metals from mixing on the value of specific adsorption of medical sorbents was studied. The studies have shown that the amount of specific adsorption is practically not affected by mixing, which indicates that the process is determined by the internal diffusion of metals into the sorbent.

The sorption capacity of medical sorbents relative to heavy metals was determined. The sorption capacity about lead cations was 102.11 mg/g for POLYSORB, 49.18 mg/g for activated carbon and 150.28 mg/g for white coal. Thus, the sorption efficiency depends on the nature of the sorbent and its ability to complex, polarity (hydrophobicity, hydrophilicity) and porosity. Physical adsorption is observed on activated carbon and chemisorption is observed on POLYSORB and white coal.

The maximum sorption capacity about heavy metal ions was determined. It was the highest for the white coal sorbent and the lowest for activated carbon. The series of sorbent activities about heavy metals were constructed: "White coal" ≥ "POLYSORB" ≥ "Enterosgel" ≥ "Smekta" ≥ "Filtrum" ≥ "Activated carbon". Sorption efficiency was increased in the following series: $Cu^{2+}$< $Ni^{2+}$< $Zn^{2+}$< $Pb^{2+}$, which is explained by the size of the radii of metal ions increasing in the same row.

At the next stage, the influence of the pH of the medium on the value of specific adsorption was studied. The sorption activity of sorbents at pH simulating the stomach environment was studied. In this environment, the sorption values of all metals were slightly lower in comparison with the data obtained for a neutral pH. The influence of the medium can be explained by the changes in the volume of pores or surface structure available for sorption compared to the original sorbents.

Desorption processes were evaluated in conditions close to physiological in the environment of "artificial" intestinal juice to establish the possibility of secondary intoxication with heavy metals. The data obtained in most cases indicated slight desorption of metals except activated carbon, which can be explained by the physical mechanism of adsorption. In other cases, a strong sorbent-metal complex was formed due to chemisorption. In this regard, it is possible to exclude the possibility of repeated intoxication due to the desorption of heavy metals from the studied medical sorbents in the human body.

## CONCLUSIONS

A comparative analysis of the sorption capacity of widely used medical sorbents: enterosgel, polyphepane, activated carbon, white coal, smecta and filtrum concerning heavy metal ions $Cu^{2+}$, $Ni^{2+}$, $Pb^{2+}$и $Zn^{2+}$ in vitro experiments was performed which allowed us to determine the most effective sorbents. The influence of mixing and sorption time on the establishment of equilibrium in the enterosorbent-metal system was studied. The half-sorption period averaged 30 minutes regardless of the type of sorbent. The effect of heavy metal concentration on specific adsorption was studied. The sorbent white coal the main component of which is silicon dioxide has a higher adsorption capacity relative to heavy metals. Thus, its adsorption capacity for lead is 10 times greater than that of activated carbon and 1.5 times that of POLYSORB. We determined the maximum sorption capacity for each of the sorbents taken for the study relative to heavy metal ions. Rows of sorbent activity relative to metals were constructed: "White coal" ≥ "POLYSORB" ≥ "Enterosgel" ≥ "Smekta" ≥ "Filtrum" ≥ "Activated carbon", the cleaning efficiency increased in the row: $Cu^{2+}$< $Ni^{2+}$< $Zn^{2+}$< $Pb^{2+}$. The influence of the pH of the medium on the value of specific adsorption is studied. In a medium that simulates stomach conditions at pH 2.0 the sorption values of all heavy metals are lower compared to the values obtained for aqueous solutions with pH 7. Desorption processes were evaluated and in most cases, drug desorption was insignificant due to the formation of a strong complex sorbent –the metal.

The results of the study can be used to select the optimal detoxifying agent and adjust the treatment of the consequences of heavy metal poisoning.

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