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Influence of Nanomaterials on Biological Activity of Marine Pelagic Sediments (peloids)

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Influence of nanomaterials (based on bentonitic clays and calcium carbonate) in pelagic sediments of the Black Sea on their biologic activity has been investigated. It was shown that chemical composition, preliminary thermal treatment and concentration of nanomaterials in composition with pelagic sediments have a great influence to their medical properties. Based on obtained data for complex influence of nanocomposites to organism (behaviour, nervimuscular irritability, reflexes, vegetative effects, functional condition of lever and kidneys) a conclusion of substantially increasing the biological activity of pelagic sediments with the properties of medicinal mud (peloid), under the influence of bentonite and calcium carbonate that contain nanoparticles. A method for testing the pelagic sea and ocean sediments with nanodispersed components to predict the prospects of their use as medicinal muds (peloids) has been suggested.

Keywords: Nanomaterials, Bentonite, Calcium carbonate, Peloid, Biologic activity.

PACS numbers: 62.23.Pq, 87.85.Qr, 87.85.Rs, 82.70.Dd

1. INTRODUCTION

Pelagic sediments (PS), reserves of which in Ukraine are found mainly in the basin of the Black Sea, attracted attention of researchers as a source of minerals for a long time, and recently as a source of medical mud (peloids) [1-5]. The structure of PS consists of highly dispersed and nanodispersed clay minerals, feldspars, quartz, opal, diatomites, microorganisms and microalgae, biologically active organic substances, sulfur and other compounds. Therefore, PS are typical biocolloidal material, which can be converted in the processes of metamorphism not only in a sedimentary deposits of iron ore, nodules, clays, but in medical muds too. Indeed, the newly discovered deep-sea deposits of the Black Sea peloids have unique healing properties [5]. However, the impact of nanoadditives on them virtually not has been studied, and that was the basis for carrying out of this study.

2. EXPERIMENTAL

Samples of the Black Sea deep-water deposits of peloids have been used as the main object of studies, preparation of which was conducted in accordance with the recommendations [6]. Natural bentonitic clay from Dashukovka site of Cherkassy deposit and saponites were used as nanoadditives to peloids. They were processed to form nanoparticles (Fig. 1 and Table. 1) and injected into peloids in accordance with [6,7]. Cherkassy bentonite also were subjected to thermal treatment at 600 °C (Fig. 2) by the method [8]. Nanodispersed calcium carbonate, which was also used as an additive to peloids, was prepared by the methods described in [5 and 9]. The size of the formed nanoparticles was within 20-40 nm (Fig. 3, 4). Physiological studies using compositions of peloids with nanomaterials were performed according to recommendations [10]. They were defined by the response of various body systems of healthy animals (white Wistar's rats) on the action of the compositions.

3. RESULTS AND DISCUSSION

Data given on Fig. 5 shows skin-resorptive action of natural bentonite on functional state of liver of experimental laboratory animals. Thus, addition of 5 % and 10 % of bentonite to peloids almost has not influenced the time to fall asleep and sleeping duration at metabolic test with barbiturates. It have a reason to decide that it also has no negative influence of such composition on central nervous system (CNS) and liver. Raising concentration of bentonite up to 15 % or addition of 5 % of saponite into peloid composition decreases metabolic processes in liver that confirms with increasing of metabolic sleep of animals while thiopental test. In this case the functional state of central nervous system (CNS) remains at background levels.

Tests of renal function of experimental animals under the influence of skin-resorptive action of peloids with nanoadditives have shown that addition of 5% bentonitic clay leaves renal function virtually unchanged. Increasing of clay addition up to 10 % gives negative effects. They appear in decreasing of filtration rate of primary urine in the glomeruli of nephrons. This causes in decreasing of daily urine output 1.5 times as much, daily urinary excretion 1.2 times as much, and creatinine 1.6 times as much.

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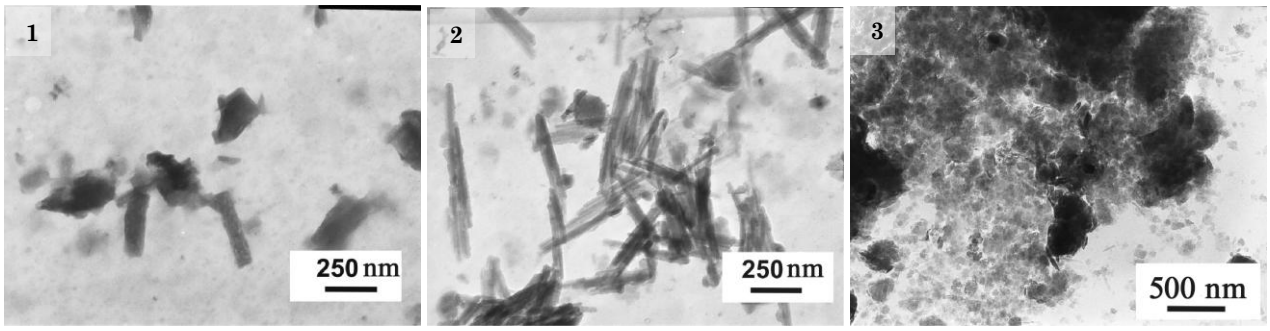

Fig. 1 – Electron microscope images of Cherkassy montmorillonite (1), palygorskite (2), hydromica (3)

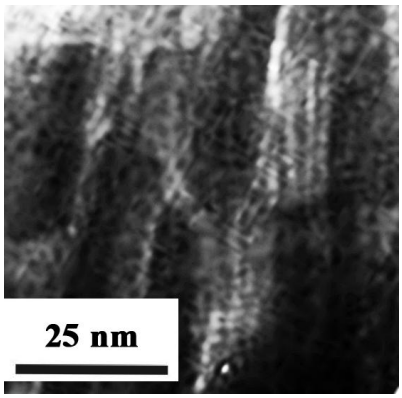

Fig. 2 – Electron microscope image of thermal treated clay mineral with organic matter

Fig. 3 – Electron microscope images of $CaCO_3$

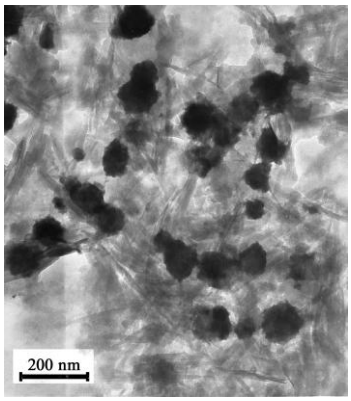

Fig. 4 – Electron microscope image of polymineral carbonate clay

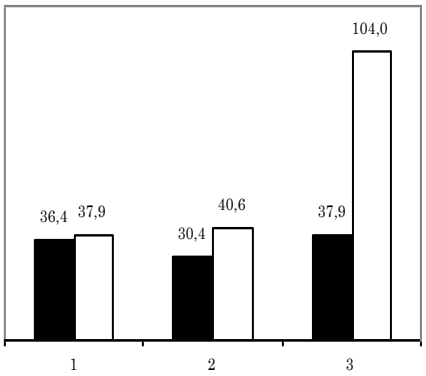

Fig. 5 – Sleep duration of test animal caused by addition of 5% (1), 10% (2) and 15% (3) of natural clay into peloid. ■ – check, □ – experiment

Table 1 – Distribution of particles by sizes in clay minerals

Fraction, nm	≤ 60	61-105	106-158	159-209	210-417	418-550	551-724
Montmorillonite, %	0.53	2.6	2.08	2.68	6.76	6.79	7.05
Palygorskite, %	0.17	0.34	0.38	1.96	4.17	3.24	3.83
Hydromica, %	0.26	0.35	1.57	1.95	8.64	5.37	2.91

Addition of 5 % of saponite clay into peloids stimulates exclusive processes of uropoiesis: filtering of the primary urine and water readsorption. In this case there is no change of the daily urine output and creatinine excretion increases 1.5 times, chlorides – 1.3 times. Daily excretion of chlorides and reaction of daily urine remains unchanged.

Thus, these studies provide a basis for conclusion that presence of 5-10 % of bentonite and not more than 5% of saponite clays in bottom peloids makes such deposit could be prospective for commercial production of biologically active peloids.

Testing of bentonitic clay influence thermodestructed at 600 °C on biologic activity of peloids has shown that its addition in quantities of 5 and 10 % changes previously shown readings. Antitoxic ability of liver increases which is confirmed by decreasing of medication sleep duration in 3 times (5 % of bentonite) and in

1.9 times (10 % of bentonite) – see Fig. 6.

As we can see from Table 2, uropoiesis of rats becomes better when 10% of burnt bentonite is added into peloids. Increasing of daily diuresis is caused by increase of filtration rate of primary urine with unchanged readsorption of water in kidney tubular structure.

Addition of calcium carbonate in quantities of 5, 10, 15 % by peloid mass has shown that functional condition of central nervous system (CNS) is not changing and antitoxic ability of liver is increasing. Skin-resorptive application of 5 and 10 % additive of calcium carbonate does not influence on functional condition of kidneys. Addition of 15 % of $CaCO_3$ to peloid influences on rising of filtering of the primary urine in nephron glomerulus in 1.5 times and decreasing of water readsorption in kidney tubular structure. In addition, excretive function of kidneys increases. That confirms with growth of creatinine excretion in 1.5 times, urea excretion in 1.12 times and more active chlorides excretion.

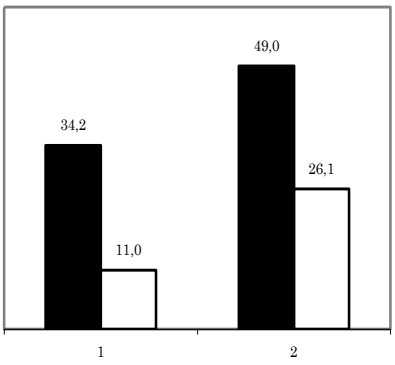

Fig. 6 – Influence of addition of heated by 600 °C bentonite to peloid on duration of medication sleep. 1 and 2 – 5% and 10% of bentonite correspondingly. ■ – check, □ – experiment

Table 2 – Skin-resorptive action of peloids with addition of 5 % (1) and 10 % (2) of bentonite burnt at 600 °C on renal function of white Wistar's rats

No.	Indexes	Check group	Experimental group	
			1	2
1	Daily diuresis, cm^3/cm^2 of body surface	1.39 ± 0.09	1.41 ± 0.45	1.91 ± 0.09
2	Nodule filtration, $cm^3/cm^2 \cdot min$	0.10 ± 0.01	0.09 ± 0.03	0.15 ± 0.01
3	Tubular readsorption, % to filtration	99.00 ± 0.09	98.73 ± 0.22	97.07 ± 0.18
4	Excretion of creatinine, mmole	0.011 ± 0.001	0.009 ± 0.003	0.16 ± 0.002
5	Excretion of urea, mmole	0.74 ± 0.04	0.70 ± 0.15	0.88 ± 0.14
6	Excretion of chlorides, mmole	0.60 ± 0.05	0.87 ± 0.08	0.81 ± 0.06
7	pH of uina, units of pH	6.40 ± 0.09	6.30 ± 0.15	6.00 ± 0.0001

4. CONCLUSIONS

Analysis of obtained data shows that addition of 5% of natural and burnt saponites to peloids decreases their biological activity. Similar effect is observed for 10 % of bentonites. Concentration of 15 % of burnt bentonites and $CaCO_3$ enhances biological activity of peloids.

These results indicate that increasing of quantity of nanoparticles in bentonites and calcium carbonate enhances biological activity of peloids. It happens likely due to the increased sorption and ion exchange capacity of nanomaterials [5, 7, 8, 11, 12].

The research allowed drawing up the method of bottom pelagic sediments testing in order to pre-assess their biological activity and assess a possibility of their use as a medicinal mud (peloid). The basis of this method is in testing of sediment dispersion and determination of quantity nanoparticles of bentonitic clays and calcium carbonate in it.

It seems reasonable to continue such investigations to find a connection between biological activity of peloids and colloid-chemical properties of nanomaterials and nanosorbents of different chemical nature.

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