

Usage of Worked Clay Absorbent as a Manifestation of an Ecologically Oriented Lifestyle

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ABSTRACT

The article deals with the development of new eco-innovative technologies, evaluation of their effectiveness and raising the widest possible awareness of those categories to the people who could effectively use the proposed technologies. It was found that the personal position of economic entities is the core of the structural organization of psychological readiness for ecologically oriented innovation and is manifested in the forms of free ecologically oriented will. The paper discusses the main methods of removal of nutrients from wastewater, as well as presents promising technologies and techniques. It contains the recommendations for optimal conditions for the precipitation of ammonia nitrogen from an ion exchange regenerator for further use as an ammonium fertilizer. The maximum efficiency of ammonium nitrogen removal was established. According to the results of the best options, the deposition of real ion exchange concentrates was carried out. The humidity level was set during the drying of mineral fertilizers. The moisture content determined the content of sediment, which is close to the number of water molecules to the formula of the fertilizer $MgNH_4PO_4 \cdot 5H_2O$. Complex phosphate fertilizer struvite was characterized. A comparative agronomic evaluation of synthetic struvite was performed. The influence of struvite on the processes of germination of cultivated plants was carried out. The results show that the method of obtaining struvite does not significantly affect the processes of wheat germination, and the determining factor in the effectiveness of fertilizers is the method of its application and dosage.

Keywords: natural clay sorbents, adsorption, bioindication, agroecological assessment.

INTRODUCTION

The general dynamics and intensity of changes taking place in the environment, puts forward new requirements for life in any industry. Particular attention should be paid to the connection and explanation of any economic activity from the standpoint of environmentally friendly lifestyle. Ecologically oriented way of life should gradually grow into a norm of everyday life, which provides a balanced approach to the human consumption of natural resources, concern for maintaining the cleanliness of the environment, and the use of new environmentally friendly treatment technologies (Palamarchuk, 2014).

The strategic direction of solving the problem of development of ecologically oriented

way of life encourages the development of new eco-innovative technologies, assessment of their effectiveness and the widest possible awareness of those categories of people who could use the proposed technologies. That is why, in this study it was considered appropriate to pay special attention to the detailed coverage of regeneration technologies and reuse of material resources. In particular, the use of ion exchange regenerate obtained during wastewater treatment in organic production of crop products was proposed, and also presented an agroecological assessment of the obtained mineral fertilizer.

Due to the inflow of nutrients to surface waters through leaching from the upper soil layer, precipitation, industrial and domestic wastewater,

runoff of agricultural lands and animal complexes, eutrophication of reservoirs occurs, their useless productivity increases, phytoplankton, algae, etc. develop. When the content of phosphorus and nitrogen in water exceeds the critical level, the vital processes of aquatic organisms are accelerated. As a result, the mass development of planktonic algae (“blooming” of water) begins. Water acquires an unpleasant odor and taste, its transparency decreases, color increases, while the content of dissolved and suspended organic substances increases as well. In the deep zone, anaerobic metabolism increases, hydrogen sulfide, ammonia, etc. accumulate. Such a eutrophicated reservoir loses the economic and biogeocenosis significance of water (G. Sakalova et al., 2018).

Decomposition of ammonium salts leads to the release of ammonia, which is toxic to flora and fauna. In addition, the oxidation of ammonium nitrogen reduces the oxygen content to 22–44% of the total amount of oxygen dissolved in water. Purification of water from nitrogen compounds by using classical methods requires expensive reagents and equipment, these methods are difficult to operate and inefficient. The wastewater from these industries is treated by conventional biological methods (in aeration tanks), but nitrogen compounds are practically not removed.

We believe that the solution to this problem lies not only in the development and evaluation of the effectiveness of new environmentally friendly treatment technologies, but also in the ability of economic entities to realize the practical significance of various innovations in the system of human-nature interaction, both professionally and on a personal level.

The purpose of the study was to develop the recommendations on the basis of experimental data on the optimal conditions for ammonium nitrogen deposition from ion exchange regenerate, to substantiate the suitability for use in organic production of crop products and to determine the

stages of implementation of the proposed innovative technology in environmental practice.

It is expected that the proposed environmentally friendly water treatment technology will take place in the life of modern businesses, subject to the introduction of a system-based methodology with a leading position of unity of consciousness and activity. The personal position of the business entity should be the core of the structural organization of psychological readiness for environmentally oriented innovation and manifest itself in the forms of free environmentally oriented expression of will, as opposed to the actions under the pressure from social coercion. The problems of effluent discharge into water bodies by businesses can be solved by developing the technological schemes of water purification, regeneration, and effective utilization of water treatment materials. Effective combination of the adsorption method of purification with the formation of ion exchange concentrate with further reagent precipitation results in a product which is beneficial for agriculture (Malovany et al. 2013, Tulaydan et al. 2017).

MATERIALS AND METHODS

The possibility of concentrating ammonium ions from effluents using ion exchange has been previously researched by several authors including the authors of this paper. In these studies, natural and synthetic adsorbents were saturated with NH_4^+ ions from both model and real effluents by method of displacement.

The initial model solution contained 40 mg/dm³ pH = 6 with a total cation content of 2.46 mg/dm³. The results of water purification from purification ions with KU-2-8 cation exchange resin and natural zeolite are presented in Table 1. The maximum saturation of the adsorbent is determined by the jump in the electrical conductivity of the solution at end of the column.

Table 1. The results of saturation with NH_4^+ cation exchange resin and zeolite

Indicator	The use of cation exchange resin KY-2-8	Use of natural zeolite
Volume consumption of the model district, dm ³ /s	0.342	0.27
The first traces of NH_4^+ in purified water, dm ³	2.76	2.10
Dynamic exchange capacity, mg NH_4^+ (N)/g	10.1	4
Volume consumption of the district for regeneration, 10 ⁻³ dm ³ /c	0.057	0.060
The volume of solution for regeneration, dm ³	0.36	0.33
Regeneration degree, %	98	90

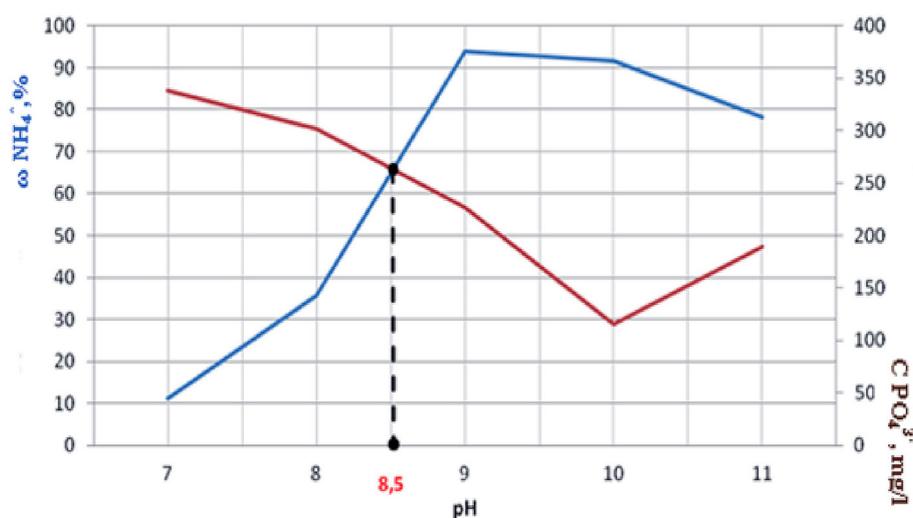


Figure 1. Conditions of ion deposition in solution at molar ratio $Mg^{2+}: NH_4^+: PO_4^{3-} = 1.5 : 1 : 1.5$

The optimal conditions for the deposition of ammonium nitrogen were determined at the initial concentration of $NH_4^+ - N - 550$ mg/l and of $NH_4^+ - N - 470$ mg/l. It was established that the maximum efficiency of ammonium nitrogen removal is reached within the range of pH 8.5–9 and at the ratio $Mg^{2+}: NH_4^+: PO_4^{3-} = 1.5 : 1 : 1.5$. Changing the ratios at the same pH reduces the removal efficiency of NH_4^+ ions. Similarly, the increase in pH decreases the efficiency of deposition of ammonium ions (Fig. 1).

The deposition of real ion exchange concentrates was also performed. The degree of precipitation of $NH_4^+ - N$ ions for the concentrate extracted from the cation exchange resin was 94.5%, and for the concentrate extracted from the zeolite 93.91%. Ultimately, the results are very similar to the values of the model concentrates.

The formula of the crystal hydrate $MgNH_4PO_4 \cdot 5H_2O$ was determined by examining the moisture content of products. Same as previously, the sediment was very similar to the mineral fertilizer struvite formula $MgNH_4PO_4 \cdot 6H_2O$ in terms of physical parameters.

RESULTS AND DISCUSSION

For the research purposes, two types of plants which belong to the monocotyledonous and dicotyledonous plants were selected. These were Sachs radish and soft winter wheat seeds.

The effectiveness of crystal hydrate magnesium-ammonium phosphate (MAP) was determined by examining the following agronomic indicators: the germination dynamics, wheat and radish seeds germination similarity and energy. The values of the pure fraction of seeds (10 pieces) were determined in the frequency of three and five times, respectively, using the following dosing regimens of synthesized struvite, g/ml of distilled water or citric acid solution:

1. Control (distilled water);
 - 1.1. 0.025 (distilled water);
 - 1.2. 0.068 (distilled water);
- 2.1. 0.025 (1% citric acid solution);
- 2.2. 0.068 (1% citric acid solution);
- 3.1. 0.025 (2% citric acid solution);
- 3.2. 0.068 (2% citric acid solution).

Table 2. Influence of MAP on radish seeds germination

No. of experiment	Seed germination, %	Deviation from control, %	Duration of germination, days	Germination energy, %
1. Control	90.0	-	1	90.0
1.1	93.3	3.3	2	93.3
1.2	93.3	3.3	2	93.3
2.1	90.0	0	2	90.0
2.2	86.7	-3.3	3	86.7
3.1	86.7	-3.3	3	86.7
3.2	80.0	-10	4	76.7

Table 3. Influence of MAP on wheat seeds germination

No. of experiment	Seed germination, %	Deviation from control, %
1. Control	93.3	-
1.1	93.3	0.0
1.2	93.0	-0.3
2.1	83.3	-10.0
2.2	76.7	-16.6
3.2	77.7	-15.7
3.3	80.0	-13.3

The results of *Raphanus sativus L* variety Sachs seeds germination are shown in Table 2. When germinating radish seeds, it was determined that the seeds germinated the fastest (in two days) in the control option. When the struvite was utilized, higher germination rates were typical for aqueous solutions but less so for citric acid solutions. In comparison to the control option, the dosage of MAP slows down the germination of seeds under experiment. Moreover, citric acid impairs the germination of radish seeds, i.e. acidic environment does not improve agronomic performance. This is confirmed by the seed moisture characteristics, as reducing the humidity of germinated seeds decreases the efficiency of its germination (Tymchuk et al. 2020).

The results of wheat seeds germination are presented in Table 3.

The results of the research indicate that citric acid reduces the effectiveness of struvite while

the speed of germination of wheat seeds increases. It was also observed that the aqueous solutions of MAP do not significantly change the processes of wheat germination; therefore, the use of synthetic struvite at the stage of seed germination is ineffective (Fig. 2).

The studies on the germination of wheat seeds in aqueous culture were performed by determining the growth of the root system for the solutions containing struvite (0.068 g/ml) obtained by the reagent method (Sr) and fertilizer from ion exchange concentrate during its precipitation (Sk). The research results are presented in Table 4.

While analyzing the results presented in table 4, it can be said that the presence of struvite contributes to the elongation of the root system. The average daily gain for control variants is 0.72 cm and 0.77–0.78 cm for the variants with struvite. The average length of the root system of plants in the variants with struvite is 5–6% longer.

The linear growth of the root system in the case of the control variant is observed the largest on the 5th day of germination. The same indicator is obtained when using the struvite obtained by means of the reagent method. At the same time, the use of struvite obtained from ion exchange concentrate gives the largest increase in the root system on day 3 and numerically this deviation is quite significant, compared with other options, reaching almost 35%. This change may be due to possible impurities of zeolite present in this fertilizer, as zeolite is also used as a nutrient medium.

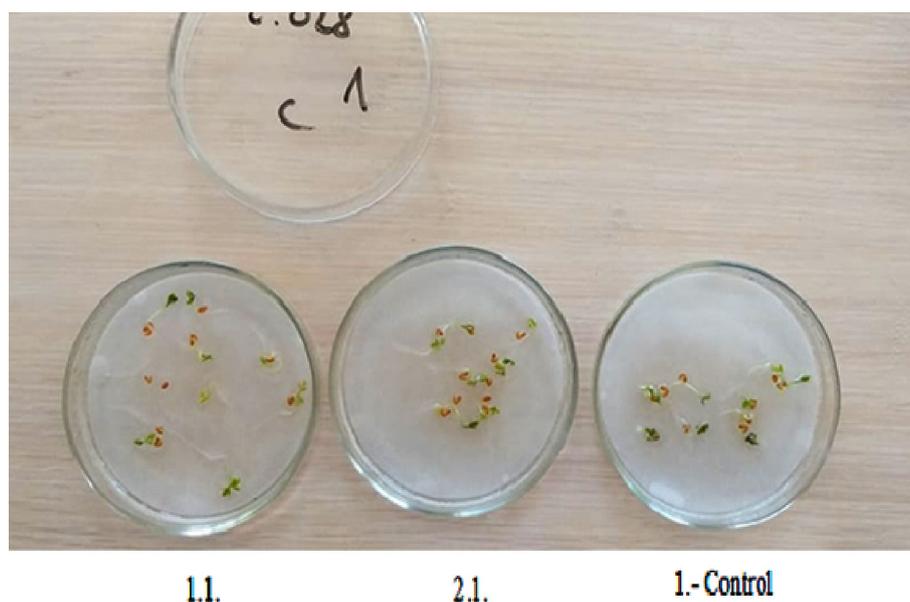
**Fig. 2.** Germinated wheat seeds (2nd day of the study)

Table 4. Influence of struvite on morphological changes of the root system

Version	I-day		II-day		III-day		IV-day		V-day		P _b
	D	P _i	d	P _i	D	P _i	d	P _i	d	P _i	
Control	1.4	1.4	1.8	0.4	2.3	0.5	2.9	0.5	3.6	0.7	0.72
Sr1	1.6		1.9	0.3	2.7	0.8	3.3	0.6	4.0	0.7	0.8
Sr2	1.8		1.9	0.1	2.4	0.5	3.1	0.6	3.8	0.7	0.76
Sr3	1.7		2.3	0.6	2.7	0.4	3.2	0.5	3.9	0.7	0.78
Sr4	1.8		2.1	0.3	2.6	0.5	3.0	0.4	3.8	0.8	0.76
Sr5	2.1		2.2	0.1	2.8	0.6	3.0	0.2	3.8	0.8	0.76
Average value	1.8	2.08	2.08	0.28	2.64	0.56	3.12	0.48	3.86	0.74	0.77
Sk	1.6		2	0.4	2.7	0.7	3.2	0.5	4.1	0.9	0.82
Sk	1.4		2.4	1.0	3.1	0.7	3.5	0.4	4.1	0.6	0.82
Sk	1.5		2.1	0.6	2.8	0.7	3.0	0.2	3.6	0.6	0.72
Sk	1.8		2.4	0.6	2.9	0.5	3.2	0.3	3.9	0.7	0.78
Sk	2.1		2.4	0.3	3.0	0.6	3.3	0.3	3.9	0.6	0.78
Average value	1.68	1.68	2.06	0.38	2.9	0.84	3.28	0.38	3.92	0.64	0.78

In general, the origin of MAP has little effect on the morphological changes of the wheat root system in aquaculture. As for the changes of the aboveground part, they are practically absent.

The studies to determine the effective amount of struvite required for application to the soil to increase the wheat yield were performed for 10 days. It was previously determined (Malovanyy et al. 2018) that in the case of the application rate of ammonium phosphate fertilizer above 150 kg/ha, the product cannot be considered environmentally safe for consumption.

The study was conducted in three ways:

- 1) Control – germination of wheat seeds in the soil without fertilizer dosing.
- 2) C80 – application of dry fertilizer to the soil together with seeds in the amount of 80 kg/ha.
- 3) C140 – application of dry fertilizer into the soil together with seeds in the amount of 140 kg/ha.

The results of the 10-day germination period were determined visually and by morphological parameters of the aboveground and root part (Table 5). While analyzing the results shown in the table, it can be said that the morphological structure when applying fertilizers does not change significantly, because the ratio of aboveground and underground part is close in value for all options. When making struvite increases, the raw mass of the roots with the densest structure of the root part is determined for option No. 3. In general, the application of fertilizer promotes growth processes, as evidenced by the greater value of the length of the aboveground and underground parts of plants

in terms of fertilizer application compared to the control. In general, the dosage of MAP in the amount of 80 kg/ha should provide sufficient wheat yield because this amount of fertilizer has a positive effect on the formation of root and aboveground parts of the plant.

The recommended application of fertilizer in the amount of 80 kg/ha required additional environmental testing using chemical methods to establish safe rates of fertilizer application. The results show that the use of struvite in a given amount increases the content of ammonium ions in the root system by 0.8%, and phosphates by 1.15% and such values are within the experimental error.

The proposed technology will be reflected in the life of business entities under the condition of widespread innovation of the environmental process, which involves compliance with the following stages:

1. The stage of birth (or emergence) of the idea of using spent sorbents in the production of mineral fertilizers.
2. The stage of the invention, i.e. the creation of an ecological innovation embodied in determining the effectiveness of fertilizers on the impact on crop yields.
3. The implementation phase at which the technology is developed and described should find practical application in the activities of a particular business entity.
4. The stage of obtaining a lasting effect from the application of the proposed technology to specific entities.

Table 5. Influence of struvite mineral fertilizer on the growth processes of soft winter wheat

Version	Number of leaves	The average length of the aboveground part, cm	The average length of the underground part, cm	Mass of the underground part, g	Conditional density of the root part, g/cm ³	The ratio of aboveground and underground part	
Control	1	4	23.85	8.5	0.019	0.0125	2.71:1
	2	5	28.9	10.5	0.01		
	3	6	28.12	7.5	0.015		
	4	5	23.44	9	0.012		
	5	5	25.1	12.3	0.017		
	\bar{x}	5	25.9	9.56	0.015		
No. 3 C140	6	4	28.5	14.2	0.032	0.0189	2.56:1
	7	6	30.3	12.45	0.02		
	8	5	29.7	11	0.035		
	9	6	29.6	8.8	0.019		
	10	5	32.6	12.33	0.036		
	\bar{x}	5,2	30.14	11.76	0.028		
No. 2 C80	11	5	29.82	13.12	0.037	0.0171	2.33:1
	12	5	29.2	12.37	0.04		
	13	4	30.3	14.5	0.024		
	14	5	31.7	13.5	0.028		
	15	6	30.9	11.8	0.02		
	\bar{x}	5	30.38	13.06	0.028		

5. The stage of dissemination of ecological innovation, which consists in the widespread implementation by economic entities of the proposed optimal conditions for the deposition of ammonium nitrogen from the regeneration of ion exchange and its use in organic production of crop products (Levkivs'ka et al. 2018).

Considering the described stages of implementing the developed technology of wastewater treatment from ammonium pollution and the use of ion exchange regenerate in organic production of crop products, it is worth emphasizing the first two stages and elaboration of ways to achieve the next three stages. The main means of forming the psychological readiness of business entities to implement the developed technology in their own activities is to stimulate the reflexive performance of personal auto transformations at different stages of environmental professionalization. It is especially important to understand this now, when it is still possible to avert environmental danger and reorient the mass consciousness to effective eco-philicity.

CONCLUSIONS

Ecologically oriented way of life is the result of ecological activity of economic entities, embodied in the application of wastewater treatment technologies and the possibility of utilization of isolated pollutants in industry and agriculture. At the same time, the personal position of business entities is the core of the structural organization of psychological readiness for environmentally oriented innovation (Shulyak et al. 2018). The reagent method will allow businesses to simultaneously remove up to 95% of ammonium ions and up to 98% of phosphate ions. It was established that the most optimal conditions of the process of reagent deposition of ammonium nitrogen are the stoichiometric ratio $Mg^{2+}: NH_4^+: PO_4^{3-} = 1.5:1:1.5$ and at the initial concentration $NH_4^+(N)$ 550 mg/g, pH = 9, and at the initial concentration $NH_4^+(N)$ – 470 mg/dm³ pH=8.5. The formula of the crystal hydrate was determined as $MgNH_4PO_4 \cdot 5H_2O$, which is close to the formula of the mineral fertilizer struvite (Sakalova et al., 2018).

The obtained fertilizer has a positive effect on the processes of plant germination, has a prolonged effect, while its production and use have a positive economic and environmental effect.

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