Journal homepage: www.fia.usv.ro/fiajournal
Journal of Faculty of Food Engineering,
Ştefan cel Mare University of Suceava, Romania
Volume XII, Issue 4 – 2014, pag. 368 - 374

THE APPLICATION OF BASALTIC TUFFS IN THE TECHNOLOGY OF CULTIVATION THE LIVE FEED FOR FISH – PRELIMINARY STUDY

Oleksii KHUDYI[1], *Igor KOBASA[1], Olga KUSHNIRYK[1], Lidiia KHUDA[1]

[1] Yuriy Fedkovych Chernivtsi National University, Ukraine,
imk-11@hotmail.com
* Corresponding author
Received November 24th 2015, accepted December 18th 2015

Abstract: *The research work is meant to investigate the possibility of using the zeolite-containing tuffs in the technology of live fish feed cultivation by example of Cladocera. It is shown that the use of natural and treated at the temperature of 150 °C basaltic tuffs from „Polytske-2" basalt deposit during Moina macrocopa cultivation leads to an increase of the culture density by 2 and 2.3 times, respectively. In the experiment with Simocephalus vetulus the increase of culture density has not been found, however basaltic tuffs allow to stabilize the culture growth and slow its extinction rate. Besides, it is observed the effective purification of cultural medium of dissolved nitrogen forms probably by adsorption. The use of basaltic tuffs, calcined at a temperature of 1000 °C, leads to the death of M. macrocopa and S. vetulus cultures in 6 days. This circumstance makes the use of calcined tuffs impractical.*

Keywords: *zeolites, Cladocera, cultivation medium, ammonium, nitrites, nitrates*

1. Introduction

Basaltic tuffs are natural aluminosilicates from zeolite group of minerals. Zeolites possess several unique features, including adsorption, and therefore, they are used in the technological process of fluids purification, including wastewaters [1-3]. This is especially true for systems with closed cycle of water use. In this regard, tuffs are widely used in the recirculation of aquaculture systems as components of water treatment [4, 5].

Live feed is widely used to obtain quality planting material for commercial fish farming and for decorative aquaculture objects [6]. Among all the diversities of forage organisms, an important place is taken by *Cladocera crustaceans*. One of the problems that occur with periodic method of zooplankton cultivation is exhaustion of culture medium caused by the accumulation of metabolic products in it [7, 8]. The use of substances with high adsorption properties, such as zeolites, may have effects on prolonging use of culture media without their update that reduces the costs of live feed. In addition, zeolites possess the ion-exchange properties which can positively affect the availability of micro- and macro-elements for cultivating organisms. Given the above, the purpose of the research was to find the applicability of zeolites from «Polytske-2» basalt deposit during *Cladocera* cultivation.

2. Materials and methods

The mineral samples received from „Polytske-2" basalt deposit, situated in the Rivne Region of Ukraine, were used to study the possibility of basaltic tuffs applied in the

technology of cultivation of live food for fish.

The determination of basaltic tuffs composition was performed using classical methods of chemical analysis [9], the content of Si, Al, Fe, Mg, Ca, P, S – by flame photometry method, Na and K – by atomic absorption spectroscopy.

The studies were conducted on laboratory cultures of *Cladocera crustaceans – Simocephalus vetulus* (Muller) and *Moina macrocop*a (Straus). Cultivation of zooplankton was carried out in 0.5 dm^3 jars using standardized by chemical composition synthetic medium ADaM [10], at a temperature of 21±2 °C, cold light fluorescent glow 2,5–4 klux and 16 hour photoperiod.

To determine the effective amounts of minerals during formation of experimental groups, the tuff was introduced into jars in amounts of 30, 40 and 50 g per 1 liter.

According to the results of previous studies we found that the porosity and specific surface area of basaltic tuff granules depends on the temperature of heat treatment. These parameters reach the maximum values in the temperature range of 150–400 °C. There is a steady trend towards a decrease in the specific surface area and porosity after tuff calcination in the temperature range of 500–1000 °C. It may be caused by the removal of hygroscopic and zeolite water [11]. Taking into account above stated in the present study it was used both natural and thermally activated at temperatures of 150 °C and 1000 °C tuffs, which differ in their sorption properties.

Group of organisms, in cultivation medium in which the tuff has not been introduced, served as a control. The feeding of cultures was performed every 48 hours, yeast *Saccharomyces cerevisiae* at a dose of 0,05 g/l were used as feed. Measurements of pH level were carried out using I-160MI Ion Meter, determination of total mineralization level in culture medium was performed indirectly through conductivity using conductivity meter SX-650 ULab. The content of ammonium, nitrites and nitrates was determined in the culture medium. Measurings the concentration of NH_4^+ and NO_3^- ions were performed by potentiometric method using I-160MI Ion Meter with ion-selective electrodes ELIS-121 NH_4^+ and ELIS-121-121NO_3^-, concentration of NO_2^- was determined by photocolorimetric methods [12].

3. Results and discussion

The mineralogical composition of basaltic tuffs, obtained from „Polytske-2" basalt deposit which was used in the study, includes: zeolites (35–40%), montmorillonites (30–40%), feldspars (10–15%), silicas (4–5%), hematites (3–5%) [13]. The statistically average results of the chemical composition analysis of the tuff are expressed in mass percents of oxides.

The summary of the results shows that the basaltic tuff is an aluminum silicate with a mass ratio Si/Al = 4,7÷5,9, containing Iron in amounts of 68–74 g/kg. Except elements, whose compounds in terms of oxides were presented in table 1, the investigated tuffs also contain trace elements (Mn, Zn, Cu, Co, Ni) in amounts of 0,71–0,08 g/kg. Toxic elements (As, Pb, Hg, Cr) were not found.

Table 1
The chemical composition of basaltic tuff from basalt deposit „Polytske-2" in terms of oxides, the mass fraction expressed in %

Oxides	Mass fraction, %	Oxides	Mass fraction, %
SiO_2	67.44	CaO	0.46
TiO_2	1.75	Na_2O	0.94
Al_2O_3	12.82	K_2O	1.06
Fe_2O_3	10.14	P_2O_5	0.12
MnO	0.09	SO_3	0.11
MgO	5.02		

The results of the studies showed that the use of basaltic tuffs from „Polytske-2" basalt deposit enhances the growth intensity of both zooplankton cultures. A positive effect from tuffs using was manifested at 7–8 days of cultivation in experiment with *M. macrocopa*. The maximal development of Moina culture was achieved both in experimental and control groups on the 14th day, but the density of cultures that were grown using tuffs was 2 times higher (figure 1 a).

The culture of *S. vetulus* is characterized by much lower growth rates with achieving of maximum density on the 4th day, the introduction of natural basaltic tuff in the experimental concentrations (30, 40 and 50 g/l) does not affect the density of *S. vetulus* culture (figure 1 b).

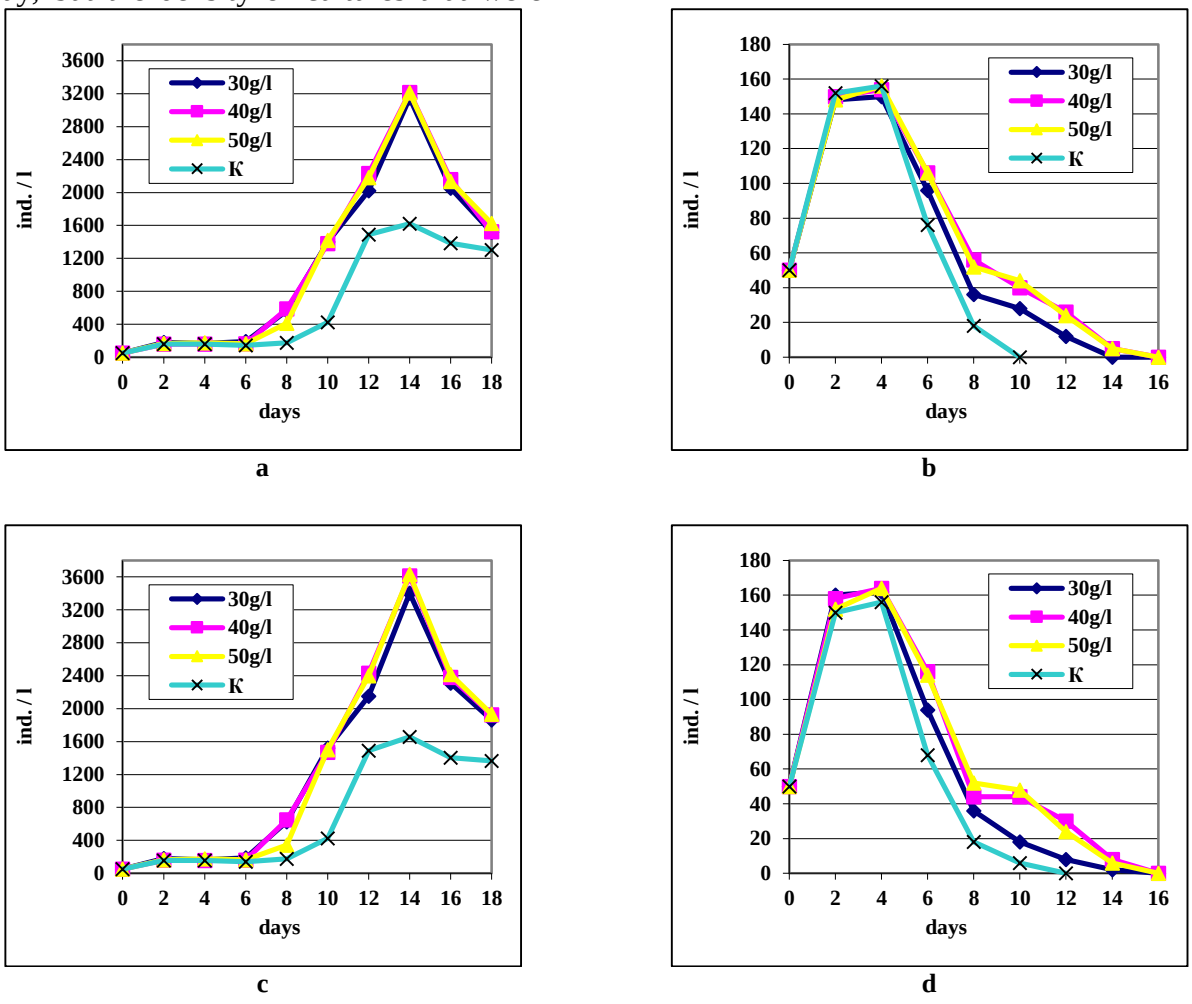


Figure 1. The dynamics of *M. macrocopa* (a, c) and *S. vetulus* (b, d) density using different concentrations of natural unmodified (a, b) and thermally (150 °C) calcined (c, d) basaltic tuffs

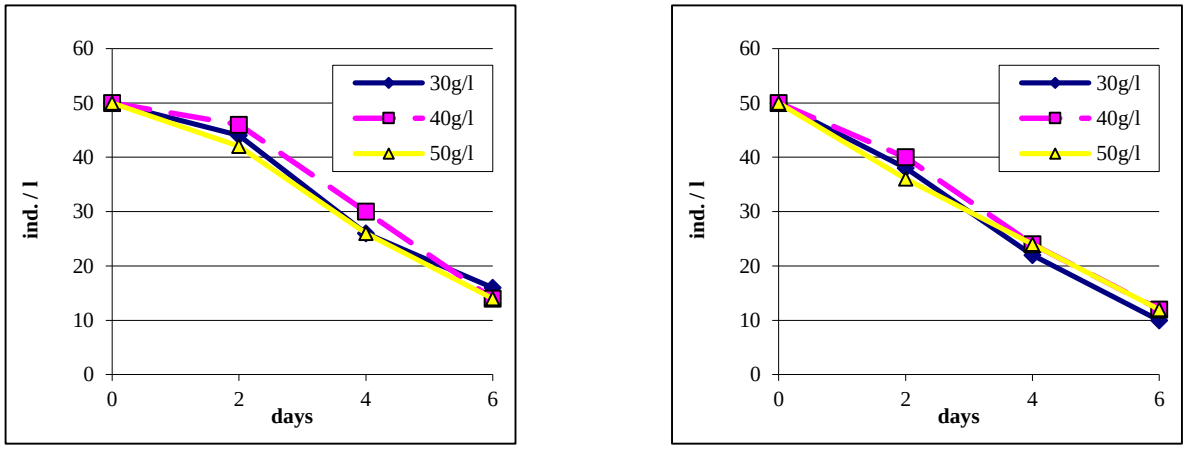
However, it was found that the use of basaltic tuff allows stabilizing the development of culture and slowing its extinction rate.

It is known that the temperature of basaltic tuffs calcination affects their elemental composition and adsorption properties. Respectively, the heat treatment can influence the biological objects that are grown in the presence of basaltic tuffs [14]. In accordance with the research results, it was established that thermally activated tuffs differ-

ently affect density and dynamics of both zooplankton species.

The introduction of tuffs, thermally treated at 150 °C, into jars for *M. macrocopa* cultivation is accompanied by increase of culture density by 2.3 times as compared to the control in contrast to the experiment with natural tuffs, where the difference was 2 times (figure 1 c). The use of tuffs treated at high temperature (150 °C) was accompanied by no changes in *S. vetulus* culture density, while the stabilization of the culture and slowdown of its extinction have been seen like in the case where natural tuffs were used (figure 1d). The negative impact on the culture in both cases was not observed. Due to this fact, the use of zeolite-containing tuffs to increase the mentioned species density is not appropriate.

A negative effect of tuffs, calcined at the temperature of 1000 °C, on the growth of both studied cultures (*M. macrocopa* and *S. vetulus*) was observed in the experiment (figure 2).



a **b**

Figure 2. The density of *M. macrocopa* (a) and *S. vetulus* (b) cultures using thermally calcined (1000 °C) basaltic tuffs

During the first 6 days of the experiment the complete extinction of two zooplankton species has been seen, that is associated with significant changes in the structure and functions of basaltic tuffs.

Changes of pH level during *M. macrocopa* cultivating were observed in the cultivation medium due to the accumulation of metabolic products of living organisms (figure 3).

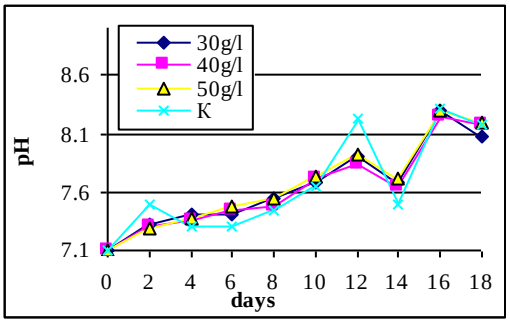


Figure 3. The pH dynamics during *M. macrocopa* cultivation with use of different concentrations of natural unmodified basaltic tuffs

Oleksii KHUDYI, Igor KOBASA, Olga KUSHNIRYK, Lidiia KHUDA, *The application of basaltic tuffs in the technology of cultivation the live feed for fish – preliminary study*, Food and Environment Safety, Volume XIV, Issue 4 – 2015, pag. 368 – 374

Instead, significant increase in pH level in the experiment with *S. vetulus* was not observed, being associated with minor zooplankton density. The influence of changes on pH, using different concentrations of natural form of zeolite-containing tuff, has not been observed, and does not differ greatly from the control experiment.

As mentioned above, tuff calcined at a temperature of 1000 °C inhibited the development of both investigated cultures. However, despite the degradation of culture, the trend of pH level raise is observed, which is obviously associated with the accumulation of food residues, decomposition of dead organisms and ion-exchange processes between solution and tuffs.

The dynamics of total mineralization values during the period of zooplankton cultivation is caused by the accumulation of waste products in the medium, food residues and dead organisms. The marked influence of changing on total mineralization when using thermally activated (150 °C) and natural form of basaltic tuffs at investigated concentrations was not found. Indicators of total mineralization in experimental groups did not differ from the control (figure 4).

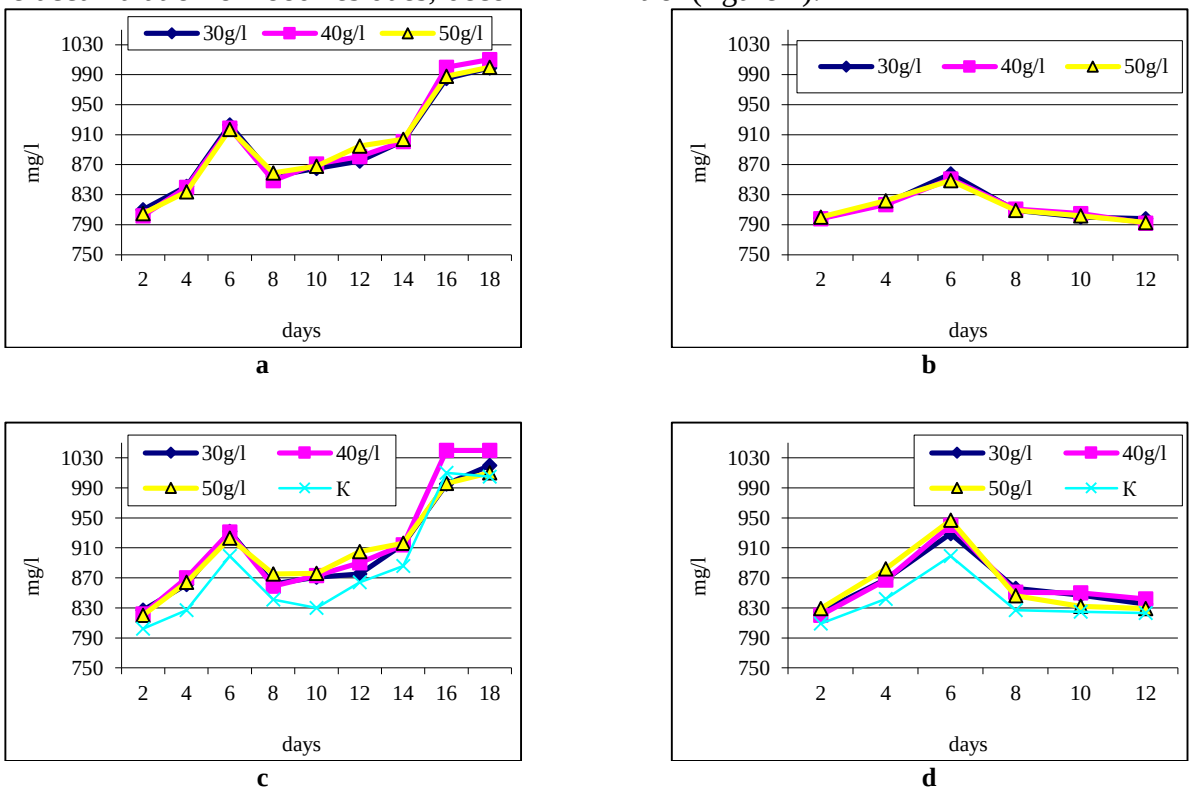


Figure 4. The change of total mineralization values of medium using natural form and thermally calcined tuffs: *M. macrocopa* (a) and *S. vetulus* (b) with natural tuffs; *M. macrocopa* (c) and *S. vetulus* (d) with thermally calcined at 150 °C tuffs

The impact of basaltic tuffs on the dynamics of metabolites accumulation in the cultivation medium, including ammonium ion and the products of its oxidation, nitrates and nitrites, attracts a particular attention. The increased density of the culture is accompanied by increased concentrations of soluble forms of nitrogen.

The research results show that the use of the basaltic tuffs provides the slowdown accumulation of NH_4^+ ions and products of

its oxidation NO_2^- and NO_3^-, apparently due to adsorption processes (figure 5). Accordingly, the increase of concentration of the zeolite-containing tuff from 30 to 50 g/l improves the efficiency of cleaning the liquid phase of cultivation medium due to increasing of adsorption area.

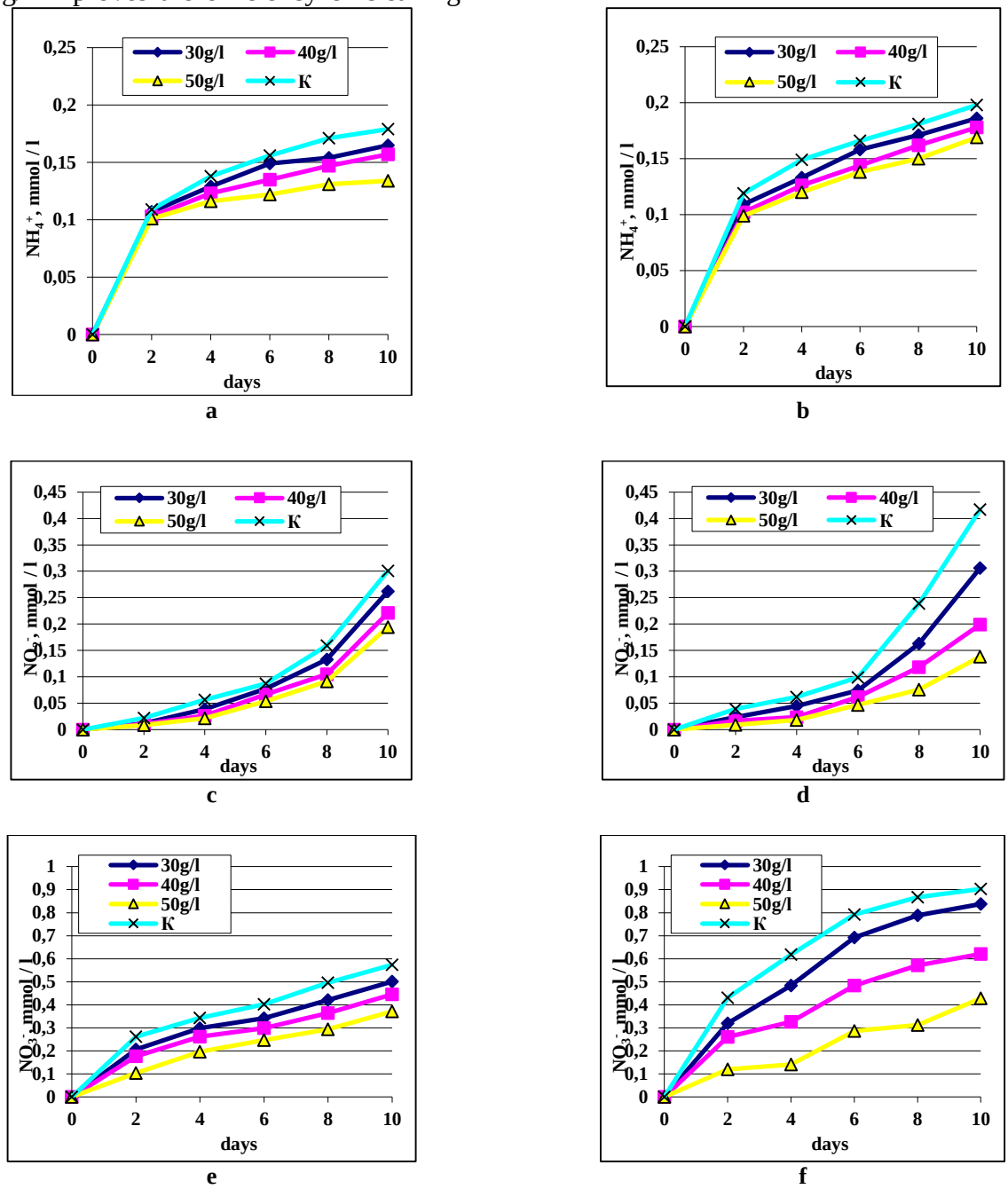


Figure 5. The dynamics in content of nitrogen soluble forms in the medium for *M. macrocopa* (a, c, e) and *S. vetulus* (b, d, f) cultivation using different concentrations of basaltic tuffs

4. Conclusion

Oleksii KHUDYI, Igor KOBASA, Olga KUSHNIRYK, Lidiia KHUDA, *The application of basaltic tuffs in the technology of cultivation the live feed for fish – preliminary study*, Food and Environment Safety, Volume XIV, Issue 4 – 2015, pag. 368 – 374

We can remark that the use of natural and thermally activated at a temperature of 150 °C basaltic tuffs has a positive impact on the development dynamics of zooplankton cultures. Maximal density *of M. macrocopa* cultures in the experiments with natural and activated tuffs was higher than in control group by 2 and 2.3 times respectively. The application of tuffs during *S. vetulus* cultivation did not cause an increase in the density of culture, but slowed the rate of extinction.

The use of basaltic tuffs, calcined at a temperature of 1000 °C, leads to the death of *M. macrocopa* and *S. vetulus* cultures in 6 days. Basalt tuffs provide the effective cleaning of cultivation medium from nitrogen soluble forms. The maximal effect is observed when using 50 g of tuffs for 1 liter of cultivation medium.

5. References

[1]. KALLO D., Applications of natural zeolites in water and wastewater treatment, *Rewiews in Mineralogy and Geochemistry*, 45 (1): 519-550, (2001).

[2]. TARASEVYCH YU.I., KLIMOVA G.M., Obtaining of modified sorbents and their application for water purification from heavy metals, *Journal of Water Chemistry and Technology*, 28 (2): 107-116, (2006). (In Russian).

[3]. PETRUS R., MALYOVANYY M., VARCHOL J., ODNORIG Z., PETRUSHKA I., LESKIV G., Technologies of wastewater treatment using natural dispersed sorbents, *Chemical Industry of Ukraine*, 2: 20-22, (2003). (In Ukrainian).

[4]. VATIN N.I., CHECHEVICHKIN A.V., CHECHEVICHKIN V.N., Sorption treatment of industrial highly concentrated waters from the ammonium ion using natural zeolites. St. Petersburg: 36, (2007) (In Russian).

[5]. SIRAKOV I., VELICHKOVA K., STOYANOVA S., DINEV D., STAYKOV Y., Application of natural zeolites and macrophytes for water treatment in recirculation aquaculture systems, *Bulgarian Journal of Agricultural Science*, 21 (1): 147-153, (2015).

[6]. DAS P., MANDAL S.C., BHAGABATI S.K., AKHTARM.S., SINGHS.K. Important live food organisms and their role in aquaculture. in: *Frontiers in Aquaculture*. (Ed.) M. Sukham, Narendra Publishing House: 69-86, (2012).

[7]. HEDSTROM A., Ion exchange of ammonium in zeolites: a literature review, *J. Environ. Eng.*, 127: 673-681, (2001).

[8]. PABALAN R.T., BERTETTI F.P., Cation-exchange properties of natural zeolites, *Rewiews in Mineralogy and Geochemistry*, 45 (1): 453-518, (2001).

[9]. TSIMBALYUK V.V., VOLOSHCHUK A.G., KOBASA I.M., Effect of heat treatment on sorption properties of basaltic tuff, *Ukrainian Chemistry Journal*, 75 (12): 85-90, (2009) (In Ukrainian).

[10]. KLUTTGEN B., DULMER U., ENGELS M., RATRE H.T., ADaM, an artificial freshwater for the culture of zooplankton, *Water Res.*, 28 (3): 743-746, (1994).

[11]. KOBASA I., MIKULA J., WOLOSCHUK A, TSYMBALIUK W., Influence of thermal treatment on the physical, mechanical and sorption characteritics of the basalt tufa, *Technical Transactions. Mechanics*, 5-M (15): 3-9, (2011).

[12]. LINNIK P. Determination of the nitrite nitrogen concentration in water. in: *Methods of hydroecological researches of surface water*. Logos. Kyiv: 242-244, (2004). (In Ukrainian).

[13]. GOLIAR N., *Tuffs: the use in economic sectors.* Rivne: 30, (In Ukrainian).

[14]. MELNYCHUK V. *Zeolite-smectite tuff of Rivne Region: the biological aspects of application.* Volynski oberegy. Rivne: 184, (2005). (In Ukrainian).