Adsorption properties of zeolite (clinoptilolite) and bentonite applied to pig slurry.

Propriétés d'adsorption de zeolite (clinoptilolite) et bentonite apporté à du lisier de porc.

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Abstract

The influence of two natural absorbents, zeolite (clinoptilolite) and bentonite, applied to pig slurry, were studied with regard to physical-chemical and mikrobiological properties of the mixtures obtained. The investigations were carried out for 14 days and the concentrations of ammonia nitrogen, total nitrogen and phosphorus as well as chemical oxygen demand in the supernatant were determined after 30 min, 2 h, 5 h, 24 h, 7 days of contact. The addition of both natural materials resulted in considerable decrease in the concentration in the supernatant of all chemical parameters studied as early as after 2 hours of contact till the experiment for zeolite (by up to 59% for $N\text{-}NH_4^+$*, 88% for* COD_{Cr}*, 61% for* N_t*, and 93% for* P_t*) and after 24 h up to the end of the experiment for bentonite (by up to 66% for* $N\text{-}NH_4^+$*, 88% for* COD_{Cr}*, 58% for* N_t*, and 95% for* P_t*), in comparison with the control. The plate counts of the observed groups of microorganisms were also decreased.*

Keywords : zeolite, bentonite, pig slurry, solid fraction

Résumé

L'influence de deux adsorbants naturels, la zeolite (clinoptilolite) et la bentonite, apporté à du lisier de porcs a été étudiée du point de vue des propriétés physico-chimiques et microbiologiques du produit. L'essai a été réalisé sur une durée de 14 jours au cours desquels la concentration en azote ammoniacal, en azote total et en phosphore, ainsi que la demande chimique en oxygène dans le surnageant, ont été mesurés après 30 min, 2h, 5h, 24h, 7 jours. L'ajout de ces deux produits naturels diminue très rapidement tous les paramètres mesurés et ce deux heures après l'ajout de zeolite : jusqu'à 59% de l'$N\text{-}NH_4^+$, 88% de réduction de la DCO, 61% de l'azote et 93% du phosphore total ; et 24 h après l'ajout de bentonite (réduction de 66% de la teneur en NH_4^+, 88% de la DCO, 58% de l'azote total et 95% du phosphore total). Les comptages microbiens témoignent également d'une réduction important de tous les groupes de microorganismes.

Mots-clés : zeolite, bentonite, lisier porc, phase solide.

1. Introduction

Agriculture and mainly the animal production belong among important sources of environmental pollution in Slovak Republic. Animal farms operating on a large scale, particularly those concentrating on rearing of pigs, produce large quantities of excrements which pose problems with regard to spreading of pathogens and releasing air contaminants and odours. The problems are frequently intensified by unsuitable storage and handling of slurry (Strauch, 1980, Ondrašoviè et al., 1996).

One of the noxious gases which pollute the environment is ammonia. This gas is produced by bacterial and enzymatic activity in the excrements of animals and is subsequently released into the animal house space and the outer atmosphere. It has toxic effect on housed animals, supports spreading of aerogenic infections and affects directly the immediate surroundings of the farms. In case of its spreading to longer distances it also adds to acidification of soil, eutrophication of water bodies, corrosion of buildings and others. In addition to that its release to the atmosphere means considerable losses of the manuring component of excrements (Amon, 1997).

One of the ways how to decrease the unfavourable effects of excrements on the environment is the construction of water treatment plants on farms with high concentration of animals. This is practised in many European countries in which the quantity of wastes produced by farm animals is higher than the soil purifing capacity can support (Boiran et al., 1996). The wastewater treatment plants which operate on pig farms are based mostly on the aerobical processes of treatment and most frequently comprise mechanical, chemical and aerobic-biological stages.

Problems may also arise in the process of treatment of the solid fraction of pig slurry obtained by separation on vibrating screens. This fraction is important from the epizootiological point of view as it is frequently associated with possible concentration of bacterial and viral pathogens and various stages of endoparasites (Plachý, Juriš, 1994).

Bentonites and zeolites are natural aluminosilicates. The essential component of bentonites is montmorilonite which forms crystals of the smallest size of all clay minerals. Zeolites have three dimensional crystalline structure with channels of molecular dimensions. They exhibit adsorption and ion exchange properties and may find use in the treatment of animal excrements.

The aim of the present study was to investigate the possibilities of utilization of natural zeolite (clinoptilolite) and bentonite from Slovak deposits in the treatment of pig slurry from large-capacity pig farm using literless technology of pig fattening.

2. Materials and methods

Zeolite (from Nizný Hrabovec; powder form) and bentonite (from Jelšový Potok, powder) was added to pig slurry in the amount of 50 g.l^{-1}. The mixture obtained was mixed for 10 min and stored at room temperature (18-19^{o}C). Slurry without any amendment served as a control. Samples for physical-chemical and microbiological examinations were taken from the mixtures in the intervals of 30 min, 2, 5 and 24 h and 7 and 14 days after adding zeolite and bentonite. Samples were observed visually and examined for pH, dry matter, total nitrogen, ammoniacal nitrogen and COD according to Slovak standard STN 83 0540 and Sedláèek et al. (1978), and for total phosphorus according to the standard APHA methods (1985). The methods and results of microbiological examination were published elsewhere.

3. Results and discussion

Efficient management of animal wastes involves maximum recycling of nutrients and avoidance of air, soil and water pollution (Svoboda, 1989). The optimum utilization of pig slurry and evaluation of its quality and manuring value is based on its chemical parameters which are affected by many factors including the time, temperature and way of storage (Ondrašovièová, 1994).

The results of our chemical examinations are presented in Fig. 1 - 5.

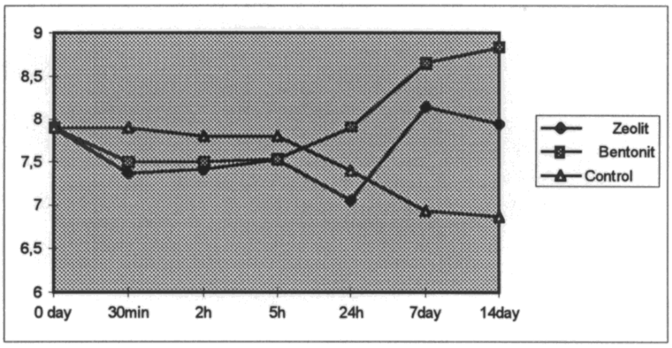

Figure 1
Concentration of hydrogen ions in pig slurry treated with zeolite Z (50 g.l^{-1}) and bentonite B (50 g.l^{-1}) in dependance on the time of contact in comparison with the control (K).

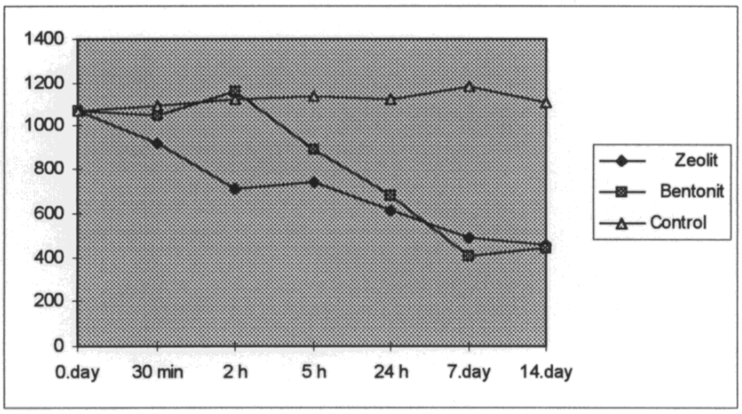

Figure 2
Concentration of ammonia in mg/l in pig slurry treated with zeolite Z (50 $g.l^{-1}$) and bentonite B (50 $g.l^{-1}$) in dependance on the time of contact in comparison with the control (K).

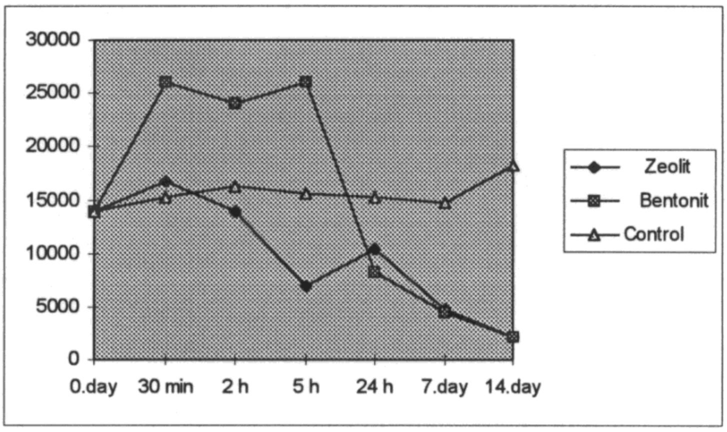

Figure 3
Concentration of chemical oxygen demand in mg/l in pig slurry treated with zeolite Z (50 $g.l^{-1}$) and bentonite B (50 $g.l^{-1}$) in dependance on the time of contact in comparison with the control (K).

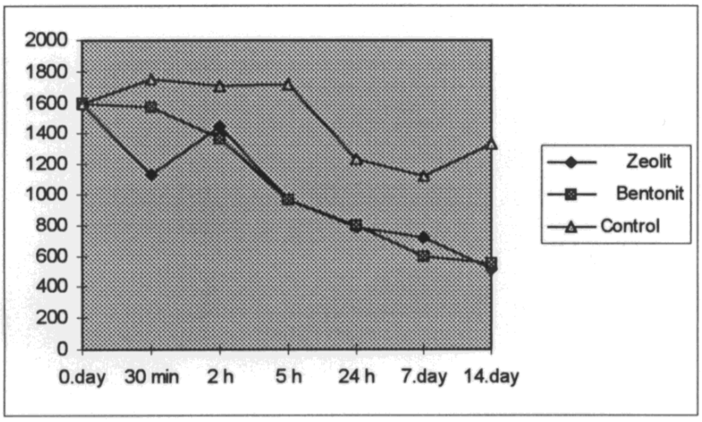

Figure 4
Concentration of total nitrogen in mg/l in pig slurry treated with zeolite Z (50 $g.l^{-1}$) and bentonite B (50 $g.l^{-1}$) in dependance on the time of contact in comparison with the control (K).

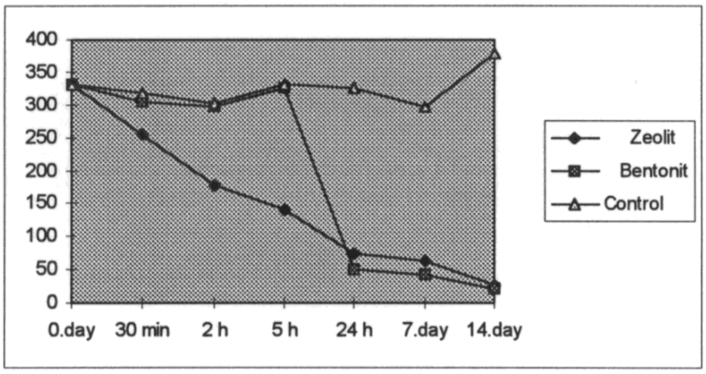

Figure 5
Concentration of total phosphorus in mg/l in pig slurry treated with zeolite Z (50 $g.l^{-1}$) and bentonite B (50 $g.l^{-1}$) in dependance on the time of contact in comparison with the control (K).

Visual observations showed that the mixture of zeolite and slurry sedimented in a similar way as was described by Vargová et al. (1995) while the mixture containing bentonite formed almost homogeneous gelatinous mass without any supernatant. Separation of this mixture to solid and liquid fractions occured in the course of 24 h.

Figure 1 shows the changes in pH after the addition of zeolite and bentonite in comparison with the control. The differences between the values of pH for the zeolite and bentonite mixtures and the control increased gradually and were the highest at the end of the period of observation.
Significant differences between experimental mixtures and the control slurry were

observed in the concentration of ammoniacal nitrogen (Fig. 2). The mixture of slurry and zeolite exhibited significant decrease in the concentration of $N\text{-}NH_4$ in the supernatant in comparison with the control as early as after 30 min of contact and the effect of this adsorbent was observed till the end of the period of observation. The effect of bentonite on this parameter became evident after 5 h of contact reaching maximum effectiveness (66%) after 7 days.The addition of either zeolite or bentonite resulted in almost 50 % decrease in $N\text{-}NH_4$ concentration as early as after 24 h of contact with the slurry.

The values of COD in the supernatant also showed significant differences in comparison with the control (Fig.3). The efficiency of removal of COD by zeolite and bentonite reached 67 and 69 % resp. after 7 days of contact and 88 % for both adsorbents after 14 days of contact. The effect of bentonite was delayed due to poor separation of phases in the first hours of observation.

The effect of bentonite and zeolite on the decrease in total N in the supernatant appeared almost immediately after adding these materials to the slurry and persisted throughout the experiment copying more or less the behaviour of concentrations of ammonia (Fig.4).

Very interesting were the results obtained for the concentration of total P in the supernatant (Fig. 5). We may speculate that the decrease in this parameter was related to better sedimentation of the solid portion of slurry after the addition of sorbents, particularly zeolite.

Our results support the findings of V a r g o v á (1994) about the prospective use of zeolite in the treatment of excrements of farm animals already in the initial stages of the treatment process when this material can contribute to better sedimentation of suspended particles and decrease in ammonia nitrogen, COD, N_t and P_t in the supernatant. The sediment can be combined with the solid fraction obtained in the first mechanical stage of treatment and used in plant production. Similar considerations apply to bentonite. Zeolite and bentonite amendment of soil can have favourable effect on structural properties of soil, retaining of moisture and balance of nutrients. Simultaneous use of very small quantities of both materials appears promising, especially in countries which have deposits of these sorbents, and deserves further testing.

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