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CHEMICAL ASPECTS OF STABILIZATION OF THE SOLID FRACTION OF PIG SLURRY AMENDED WITH NATURAL ZEOLITE

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ABSTRACT

The solid fraction of pig slurry obtained by mechanical separation is frequently applied to agricultural land without proper treatment and in such cases it presents a hygienic and ecological risk. The addition of zeolite to this fraction can contribute to better utilization of nutrients and to decreased load on the environment.

This study focused on the effects of the addition of 1% and 2% natural zeolite (clinoptilolite) to the solid fraction of pig slurry upon the decomposition processes during

3-month outdoor storage at temperatures ranging from 10 to 30°C (April-June). The presence of zeolite affected the temperature in the core of the substrates and the investigated chemical parameters (pH in water extract, dry matter at 105°C, residue after combustion at 550oC/4 h, ammonia nitrogen $N\text{-}NH_4$).

The temperature in the core of the substrates 1-3 (S1-control, S2-1% zeolite, S3-2% zeolite) differed throughout the period of investigation. The highest temperatures were measured in the substrates with zeolite (62.5°C) during the first two weeks of storage while only 27.6°C were recorded in the control.

pH values point at differences in the stabilization process of the examined substrates. A lower pH was found in zeolite-amended substrates after 3 weeks of storage. This is ascribed to the more intensive decomposition processes and increased production of acids in the zeolite.containing substrates in the first half of the experiment. After 7 weeks of storage we may assume an effect of zeolite on the mineralization of N-substances, particularly adsorption of $N\text{-}NH_4$ in the substrate containing 2% zeolite. The amount of zeolite added significantly influenced the levels of DM and residues determined after combustion.

Key words: zeolite (clinoptilolite), solid fraction, pig slurry

INTRODUCTION

One of the problems of animal breeding is the production of excreta which pollute the housing and living environment with conditionally pathogenic and pathogenic microorganisms (Ondrašovičová, 1998; Vasiľ, 2000, 2001). Large scale piggeries produce great amounts of slurry which with view to the restricted area of agricultural soil can not be used solely for dunging. When improperly handled, pig slurry presents a great danger by its chemical and microbiological composition as well as its emissions. On the other hand, if treated properly, it is a rich source of nutrients which should be returned into soil (Ondrašovič et al., 1996).

Most of the slurry produced in piggeries throughout Slovakia is treated by aerobic processes in biological wastewater-treatment plants. In the first stage of treatment the solid fraction of slurry (SF) containing a large proportion of poorly decomposable organic substances unaccessible to plants as well as high numbers of microorganisms and parasite eggs is separated and should be further processed by composting (Juriš et al., 1991). In practice the SF is usually stored in dungyards where it matures under anaerobic conditions.

In order to decrease the load on the environment and improve the utilization of nutrients the effects of zeolite in the process of treatment were investigated . The high affinity of zeolites to NH_4^+ and the possibility of the release of NH_4^+ throughout a longer period of time are extremely interesting from the viewpoint of environmental protection when handling excreta (Kithome et al., 1998)).

The present study was concerned with the effects of the addition of two different amounts of natural zeolites upon the stabilization processes in the substrates, the course of temperature in their core as well as upon changes of selected chemical indices.

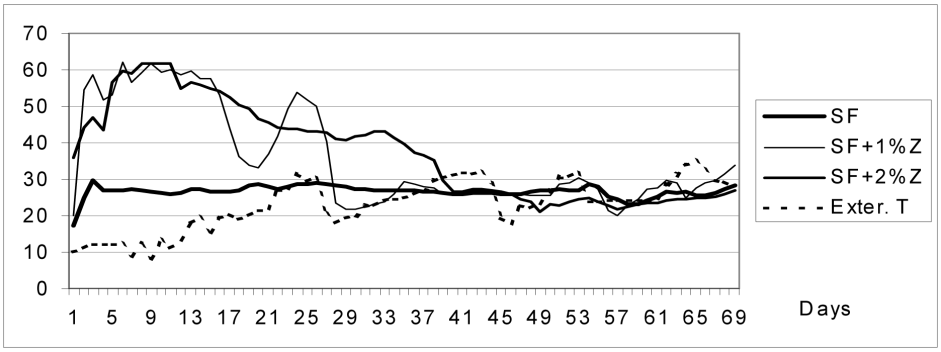
MATERIALS AND METHODS

In the first stage of treatment (separation on vibration sieves) 300 kg of SF of pig slurry (22.9 % dry matter) were obtained to which natural zeolite (40 - 56% clinoptilolite) mined at Nižný Hrabovec, Slovakia (main fracions: 76.9 % - 0.125-0.250 mm, 10.8 % - 0.25-0.5 mm, cation exchange capacity 0.77 mol/L, predried at 105 °C) was added at 1 and 2 vol% (substrates 2 and 3, respectively). The mixtures were stored in a closed concrete dungyard for 3 months during which the temperature of the environment fluctuated between 10 and 30 °C. Temperature in the core of the substrates was recorded and chemical examinations were carried out in order to determine the pH values in the aquaeous extract of the SF (5g + 45ml, dilution 1:2 for pH), dry matter contents of the substrate at 105 °C and the residue after combustion at 550 °C /4h as well as titration levels of ammonia nitrogen. The zeolite-free solid fraction was used as a control (substrate 1).

RESULTS AND DISCUSSION

During storage of dung and the SF of pig slurry decomposition of organic matter occurs which is accompanied by a weight decrease; a product is obtained which is less odorous and more safe from the hygienic point of view (Killham, 1994).

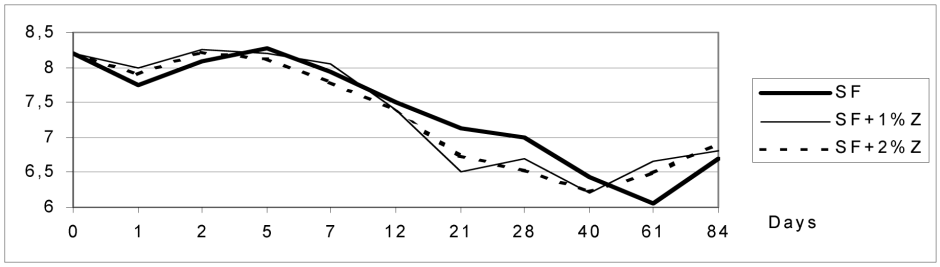
Fig. 1. Temperature (°C) in the core of substrates 1-3 and of the environment



The temperature in the core of substrates 1-3 (S1 - SF, S2 - SF+1% zeolite, S3 -SF+2% zeolite) differed throughout the period of investigation. The highest temperatures (62.5°C) were measured during the first two weeks of storage in the substrates with 1% and 2%

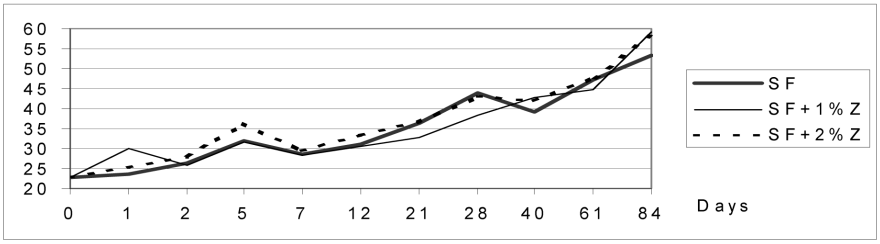
zeolite while only 27.6°C were recorded in the control substrate. According to Strauch and Ballarini (1994) temperatures that develop during composting generally reach a 50-70°C temperature range which suffices to devitalize vegetative bacteria (e.g. Salmonellae); this had been proved by microbiological investigations (Vargová, 1996). Our results showed that the presence of zeolite allowed to reach 62.5°C in the amended substrate which ensured sanitation of the substrate intended for application to agricultural soil.

Fig. 2. pH values



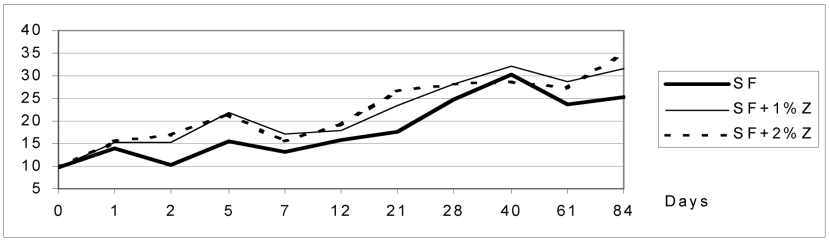
PH values are an important characteristic of the composting process. During storage mineralization of organic nitrogen to ammonia nitrogen takes place and pH values increase. After 3 weeks of storage the pH values in the zeolite-amended substrates were decreased which was related to the more intensive nitrification and the production of acids. After 7 weeks, however, pH values in the zeolite-amended substrates were higher than in the controls. This can be ascribed to the adsorption of ammonia nitrogen by zeolite and its gradual release.

Fig. 3. Dry matter content (%)



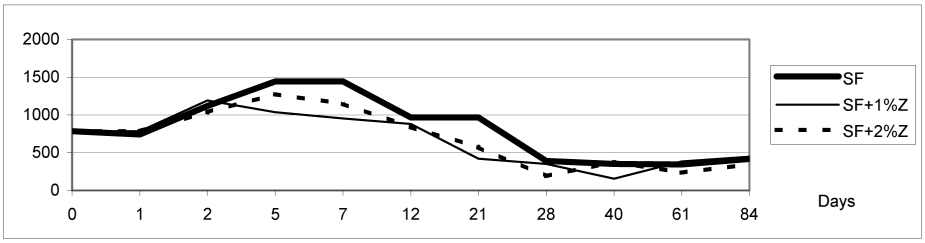
The dry matter content is an indice influenced by the decomposition processes. The initial increase of this indice in the amended substrates during the first week was also related to water retention in the structure of zeolites. After 4 weeks of storage the DM contents increased which coincided with the release of retained fluid and its evaporation in consequence of the high temperature of the environment (average 30°C).

Fig. 4. Ash content (%)



Losses stated by combustion are considered to be one of the most exact methods of determining the organic carbon contents (Navarro et al., 1993). The latter presented 45.14% and 32.49 - 37.37% at the start and at the end of the experiment, respectively. The C:N ratio was 19:1 at the start of the experiment. During storage of the excreta nitrogen and carbon mineralization as well as release of their volatile compounds occur. Throughout the experiment the values of the residue after combustion were increased in substrates 2 and 3 when compared with the controls and correlated with the DM level which also reached its maximum in substrate 3.

Fig. 5 Ammonia content (mg.kg^{-1})



During the storage of dung and farm animal slurry continuous decomposition of the organic N-fraction occurs and the share of inorganic NH_4- N fraction increases (Vargová, 2000). The greatest differences between the values of ammonia nitrogen in the substrates 1-3 were observed in the first week of storage when the maximum value of this parameter was stated in the control substrate. After three weeks of storage a gradual decrease of the N-NH_4 levels occurred. This fact can be explained by the more intensive mineralization of the suspended organic N-fraction in the zeolite-amended substrates as well as by certain losses of ammonia which coincides with the pH values observed (Vargová, 2000). By adsorption of ammonia ions zeolite improves the nitrogen intake of plants by preventing excessive nitrification and release of nitrates and decreases the risk of NH_4^+ toxicity.

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