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Conference paper

TRANSFORMATION OF NITROGEN FORMS AND THEIR RELEASE DURING STORAGE OF PIG SLURRY SOLIDS AMENDED WITH NATURAL ZEOLITE

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Summary

Pig slurry solids, as one of the products of pig slurry treatment, present a risk to the environment due to their chemical composition and potential presence of pathogens and parasitic forms. Investigations were carried out to observe the effect of amending pig slurry solids with 1 and 2% natural zeolite (clinoptilolite) and storing the obtained substrates under anaerobic conditions or with turning during 12 weeks. We determined changes in water extractable forms of nitrogen as indicators of decomposition processes. Both doses of zeolite tested affected the release of ammonia nitrogen into the extract and 1% addition created more favourable conditions for nitrification between weeks 3 and 6 of storage.

Key words: pig slurry, zeolite (clinoptilolite), nitrogen, decomposition

Introduction

Due to limited capacity of agricultural land, the slurry produced by intensive pig-fattening farms is frequently treated by activated sludge. Besides nutrients, considerable portion of bacteria, viruses, protozoa and parasitic stages, that are present in the slurry, may pass to the solid fraction (SF) obtained by mechanical separation in the first stage of the treatment. Because of that this fraction should be processed, preferably by composting, before its application to cropland.

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However, all the basic conditions for aerobic biothermical processing of this substrate are not always met in practice and simple storage for different period of time is used instead. Under such conditions, the temperature in the substrate does not always reach sufficiently high level and the resulting substrate may not undergo complete decomposition. This may result in hygiene and ecological risk after application of such substrate to agricultural land. Some natural materials, such as zeolites, exhibit unique adsorption and ion-exchange properties and may affect the processes of decomposition by binding and gradual release of nutrients and water and producing better conditions for microorganisms that play key role in decomposition of organic matter (4, 8).

The aim of our study was to investigate the effect of natural zeolite (clinoptilolite) in the process of transformation of nutrients and their release during storage of pig slurry solids.

Material and methods

Small-scale experiment (50-55 kg of SF) was conducted with the solid fraction (SF) of pig slurry, produced by intensive pig-fattening farm, amended with 1 or 2% by weight of natural zeolite and stored at a room temperature (18-23 °C) for 12 weeks in plastic bags under anaerobic conditions (S1-S3), or with turning after 3 and 6 weeks of storage (S4-S6). Unamended SF was used as a control.

The zeolite (40-56% clinoptilolite) that was used throughout the experiment was obtained from deposits in Nižný Hrabovec, Slovakia (main fractions: 76.9% - 0.125-0.250 mm, 10.8% - 0.25-0.5 mm; CEC 0.77 $mol.l^{-1}$; pre-dried at 105 °C).

The examination included recording of temperature in the core of substrates in 1 h intervals and determination of chemical parameters in the substrates that were published elsewhere (8). In addition to that, water extracts of the substrates were analysed for pH, (5g + 45 ml H_2O, filtrate diluted 1:2), electric conductivity (EC), and extractable forms of nitrogen (ammonia N, nitrate N, org. N - by subtracting the sum of ammonia and nitrate N from total N; 100g + 500 ml H_2O, 5 min. shaking, dilution).

Samples for determination of total nitrogen were digested using a HACH-Digesdahl apparatus. N_t was distilled with 40% NaOH, concentration $N\text{-}NH_3$ in water extract was determined by titration or photometrically after steam distillation and $N\text{-}NO_3$ by ion selective electrode and ORION Research analyser. All experiments were performed at least in duplicate and the results presented are means of the measurements.

Results

Temperature measurements in the core of substrates showed that the highest values were found in the controls (S1 - 31.5 °C; S4 - 36.9 °C), while those in the substrates amended with zeolite reached only 29.8-30.0 °C.

The values of pH and electric conductivity (EC) in water extracts are summarised in Table 1.

Table 1. - VALUES OF pH AND EC OF WATER EXTRACTS OF SUBSTRATES S1 -S6

Weeks	Anaerobic conditions			Turning		
	S1	S2	S3	S4	S5	S6
			pH			
0	8.43	8.43	8.43	8.43	8.43	8.43
3	7.20	7.65	7.48	7.00	7.86	7.26
6	6.71	6.30	6.17	7.35	6.41	6.51
12	6.78	6.35	7.52	7.16	7.05	7.15
			EC			
0	1.25	1.25	1.25	1.25	1.25	1.25
3	2.48	2.23	2.12	0.74	1.93	2.35
6	0.61	0.64	1.08	0.57	1.01	1.25
12	0.53	0.45	1.08	0.60	0.51	0.60

Results of determination of extractable forms of nitrogen (ammonia nitrogen $N\text{-}NH_3$; nitrate nitrogen $N\text{-}NO_3$; organic nitrogen Norg : N_{total} - [$N\text{-}NH_3$ + N - NO_3]) in water extracts are presented in Fig. 1 a,b - 3 a,b.

Discussion

Matured organic material or compost can be defined as stabilized and sanitized product of composting, which has undergone decomposition and is in the process of humification. Maturation of stored animal wastes is accompanied by changes in chemical properties and availability of nutrients to plants. The use of immature compost can cause phytotoxic effects as well as N deficiency to plants, which reduces plant yield (1).

Temperature in the substrates is one of the most important indicators of decomposition processes and hygiene safety of the resulting material. Our results showed that zeolite had no positive effect on temperature in the core of substrates. The temperatures reached in our study were not sufficient to ensure sanitation of any of the investigated substrates. One of the reasons might be the high initial moisture content (76.5-78.5%).

Fig. 1 a: Substrate1: Aanaerobic control

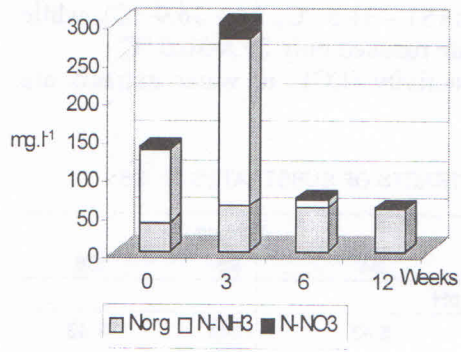


Fig.1b: Substrate 4: Turning - control

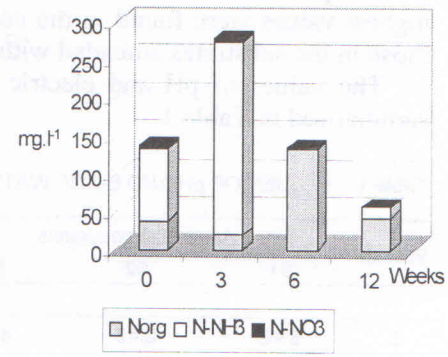


Fig.2a: Substrate 2: Anaerobic - 1% zeolite

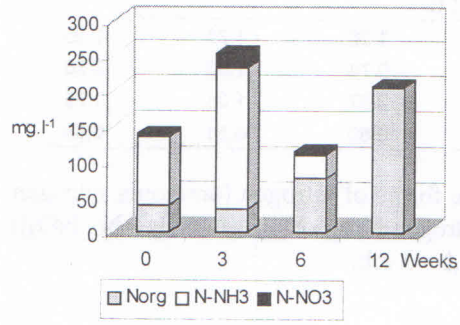


Fig. 2b: Substrate 5 - 1% zeolite

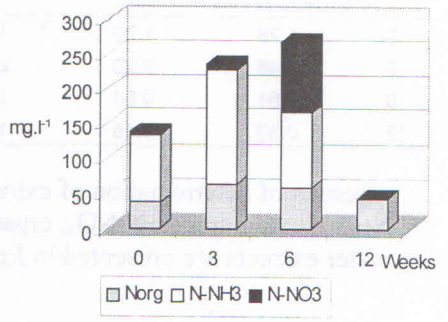


Fig. 3a: Substrate 3: Anaerobic - 2% zeolite

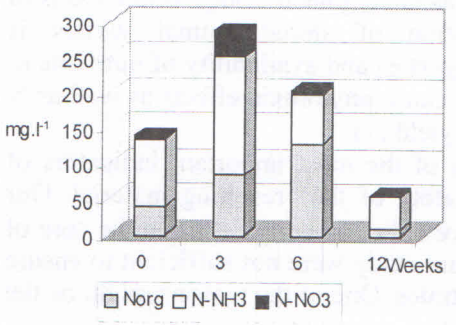
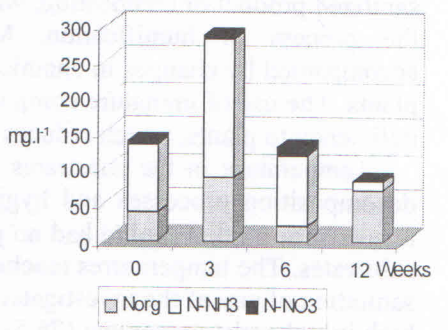


Fig. 3b: Substrate 6 - Turning - 2% zeolite



Except for the initial value, pH was in the range considered optimal for composting (5.5-8.0) (2). The lower pH in the substrates with zeolite (S2, S3, S5, S6) after 6 weeks of storage may be ascribed to increased production of organic acids and increased nitrification in the turned substrates. The latter is supported by increased concentration of $N\text{-}NO_3$ in the water extract of S5. The high pH in S3 after 12 weeks of storage may result from adsorption and subsequent release of $N\text{-}NH_3$.

The sum of soluble ions in water extracts is indicated by EC measurements. There were significant differences between the controls and the substrates amended with zeolite. Under anaerobic conditions of storage, EC values corresponded to the temperatures in the core of substrates. It was evident that the release of ions from S3 was more gradual as relatively high EC was recorded throughout the experiment. In the substrates with turning, considerable decrease in EC was observed already after 3 weeks of storage, particularly in S4 that showed low values up to the end. An effect of zeolite on this parameter was evident in S5 and S6 up to the 6^{th} week of storage. It was more pronounced in the substrate amended with 2% zeolite (S6).

Compost maturity is difficult to define. It cannot be assessed by a single chemical, physical or biological parameter but a combination of parameters should be used instead. Saviozzi (6) hypothesized that changes in water-soluble compost components may provide indicators of the advancement of the composting process. There was a change in water extractable forms of nitrogen investigated in our study. The differences in concentration of ammonia, nitrate and organic nitrogen suggest more gradual release of ammonia nitrogen over the experimental period and more favourable conditions for nitrification in the S5 substrate amended with 1% zeolite.

In conclusion it should be mentioned that the system investigated was extremely complex and there were many factors that could affect the decomposition processes. However, the results obtained in this study and in some previous ones (5, 9) show that the effect of zeolite depends also on the dose used. At very low doses of zeolite (1-2% by weight) and certain conditions (C:N ratio, access of air) this material supported decomposition processes and activity of ammonification and nitrification bacteria while adsorption of ammonia prevailed at higher concentrations. This is in agreement with the statement of Jorgensen et al. (3). Although laboratory experiments are conducted under conditions that differ from those in practice, they may provide some information towards increased utilization of nutrients, contained in similar substrates, and decreased environmental pollution resulting from agricultural production.

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TRANSFORMACIJA DUŠIKOVIH OBLIKA I NJIHOVO OSLOBAĐANJE ZA VRIJEME POHRANE KRUTOG DIJELA SVINJSKOG GNOJA OBOGAĆENOG ZEOLITOM

Sažetak

Kruti dio svinjskog gnoja, kao jedan od produkata obrade svinjskog gnoja, predstavlja rizik za okoliš zbog svog kemijskog sastava i potencijalnog prisustva patogenih I parazitskoh oblika. Istraživanja koja smo proveli promatrajući efekt " popravljanja" krutog dijela svinjskog gnoja dodatkom 1 i 2 % zeolita (clinoptilolita) i pohranjujući dobiveni substrat pod anaerobnim uvjetima ili okrečući ga kroz 12 tjedana. Utvrdili smo promjene u vodi izlučivim oblicima dušika, kao indikatore procesa razlaganja. Obje testirane doze zeolita utjecale su na oslobađanje amonijevog dušika u ekstrakt, 1 % dodatak stvorio je povoljnije uvjete nitrifikacije između 3 i 6 tjedna pohrane.

Ključne riječi: svinjski gnoj, zeolit (clinoptilolit), dušik, razlaganje

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