Treatment of sewage sludge with lime and zeolite in relation to its application to agricultural soil

Venglovský, J., Sasáková, N., [1]Papajová, I., [2]Tofant, A., Ondrašovičová, O., Ondrašovič, M., Vargová, M., Hromada, R., Gregová, G., Poljak, V.
University of Veterinary Medicine, Komenského 73, 041 81 Košice, Slovak Republic
[1]Parasitological Institute of the Slovak Academy of Sciences, Hlinkova 3, 040 01 Košice, Slovak Republic
E-mail: jan@venglovsky.com

Abstract

The progressive implementation of Urban Waste Water Treatment Directive 91/271/EEC results in increasing quantities of sewage sludge requiring safe disposal. Due to high content of nutrients, the use of sewage sludge in agriculture is encouraged, but only in a way which prevents its harmful effects on soil, vegetation, animals and man. The risks associated with agricultural use of sewage sludge arise mostly from bacterial and viral pathogens, eggs of parasites and some metals which concentrate in the sludge during wastewater treatment. To eliminate this risk, the raw sludge must be subjected to proper treatment.

The aim of the present study was to investigate the treatment of sewage sludge produced by municipal wastewater treatment plant treating municipal wastewaters from a source of approximately 250 000 inhabitants. The sludge (S) was amended with quick lime and/or zeolite, using 3 % by weight of either lime (S+L), zeolite (S+Z), or combination of both (S +LZ). During 6-week stabilisation of experimental (S+L, S+Z, S+LZ) and control (S) substrates we determined changes in pH and ammonium nitrogen in water extracts as chemical factors that can affect survival of pathogenic micro-organisms. Our microbiological examination focused on plate counts of faecal coliforms and faecal streptococci for which the limit values are determined by the Act No. 188/2003 on application of sewage sludge and sediments, effective in SR.

The results obtained showed that lime and lime with zeolite affected significantly the pH level throughout the experimental period while the content of ammonia differed significantly in the substrate amended with zeolite.

Microbiological examination revealed that counts of faecal coliforms were affected by addition of lime and lime and zeolite, but only up to week 3-4 of stabilisation, probably in relation to increased pH. Faecal streptococci were decreased significantly in the substrate amended with zeolite and lime. At the end of the 6-weeks stabilisation period both faecal coliforms and faecal streptococci were below the limit set by the Act No. 188/2003.

Introduction

Treatment of municipal wastewaters is associated with production of considerable quantities of sewage sludge which poses hygienic and environmental problems. Sewage sludge may contain a large variety of bacterial and viral pathogens including *Salmonella* spp., *Shigella* spp., *Yersinia* spp., and enteroviruses as well as eggs of parasites such as *Ascaris lumbricoides* and oocysts *Cryptosporidium* spp. and *Giardia* spp. (Reddy *et al*., 1981; Straub *et al*., 1993, 1994). Because of that, before its recycling, the sludge is subjected to additional treatment that uses a range of processes, such as anaerobic digestion, dewatering or addition of some chemicals. Because most of the processes are not associated with higher temperatures, the application of this material to soil or other ways of its disposal have some limitations related to potential survival of pathogens, various stages of endoparasites and heavy metals.

The aim of our study was to investigate the changes in sewage sludge resulting from its treatment with quick lime and/or zeolite, adding 3 % by weight of either lime (S+L), zeolite (S+Z), or combination of both (S +LZ), focusing on some chemical parameters and bacteriological plate counts over a 6-week stabilisation period.

Material and Methods

The study was carried out on sludge produced by a two-stage aerobic waste-water treatment plant (WWTP) treating wastewater from a town agglomeration of approx 100 000 people. The produced sewage sludge was dewatered and its stabilisation was examined under laboratory conditions after adding quick lime, powdered zeolite and zeolite with lime (3% by weight each) during 42 days of storage. The results were compared with unamended sludge stored under identical conditions. The following materials were used: commercially available lime (CaO, Carmeuse, Slovakia), powdered zeolite (main fraction 0.125-0.250 mm) from the Slovak deposit in Nižný Hrabovec (42 - 56 %) clinoptilolite.

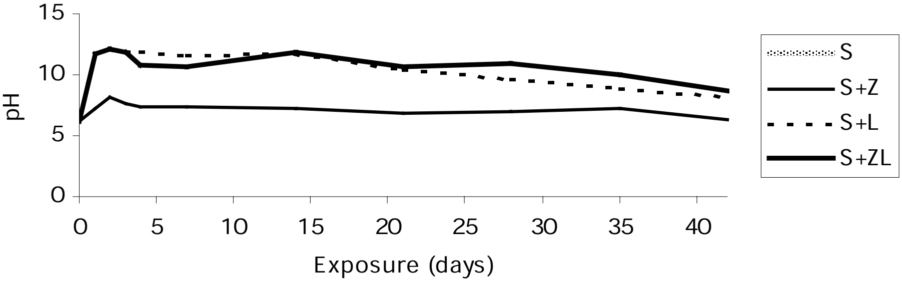
The chemical examination of individual substrates included determination of pH with pH electrode and ammonium nitrogen in water extract titrimetrically after steam distillation.

Bacteriological examination consisted of determination of plate counts of faecal coliform bacteria on Endo agar (Imuna, Slovakia) at 43^{o}C and faecal streptococci on Slanetz-Bartley agar (Biomark, India) at 37^{o}C.

Results and Discussion

Pathogens may survive for a remarkable period of time in excrements, sludges and the environment. This raises some risk particularly in relation to agricultural utilization of untreated or insufficiently treated sludge or wastes of animal origin (Papajová et al., 2002; Juriš *et al*., 2000). Multiresistant bacteria are becoming increasingly important since their transmission via the environment as well as the introduction of resistance genes into other bacteria may cause tremendous problems in human and veterinary medicine (Tschäpe, 1996). The organisms used to monitor the effectiveness of sanitation of organic wastes and municipal sludges include faecal coliforms and faecal streptococci.

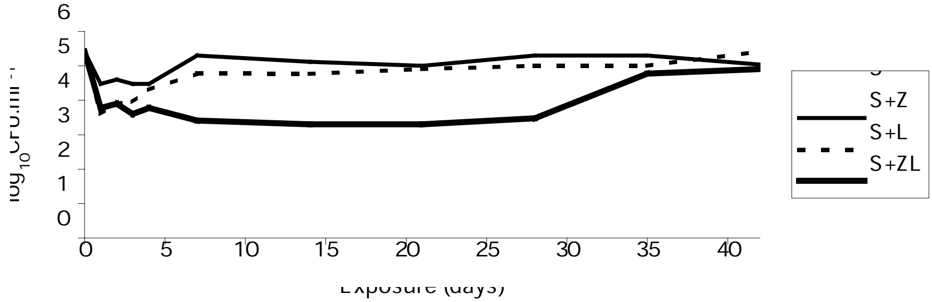
Fig 1. pH levels during 42-day storage of treated sludge (S – sludge; S+Z – sludge amended with zeolite; S+L – sludge amended with quick lime; S+ZL - sludge amended with zeolite and quick lime)



From the chemical parameters, pH level is one of the most important factors affecting survival of micro-organism. Fig. 1 shows changes in pH during 42-day stabilisation in individual substrates obtained by addition of lime, powdered zeolite and lime and zeolite to sewage sludge. The pH values in substrates amended with lime and lime with zeolite increased to 11.8 - 11.9 but only for up to about 12 days when they began to decrease as the storage processed. The final values ranged between 8.1 and 8.8 compared to the control (6.8) and substrate amended with zeolite (6.4).

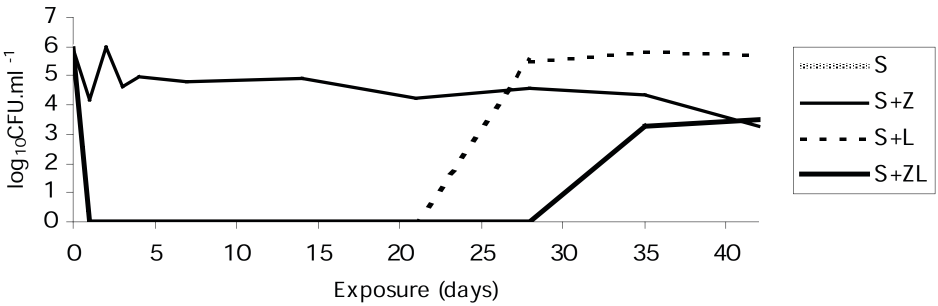
Determination of ammonia nitrogen in water extracts of individual substrates showed little effect of zeolite on this parameter when compared with the control. On the other hand, according to expectations and in relation to pH levels, ammonia was released rapidly from the substrates amended with lime and lime and zeolite and remained higher throughout the experiment. The results imply that amendment with lime results in loss of nitrogen and the addition of zeolite cannot compensate for this despite its high affinity to ammonia ions.

Fig 2. Plate counts of faecal coliform bacteria during 42-day storage of treated sludge (S – sludge; S+Z – sludge amended with zeolite; S+L – sludge amended with quick lime; S+ZL - sludge amended with zeolite and quick lime)



During the period of low pH, no faecal coliform bacteria were recovered from the respective substrates up to days 21-27 of the storage (Fig. 2) . After this period we detected them again and their plate counts gradually increased, in the substrate S+V even above the initial level. Plate counts of faecal streptococci showed a decrease by about two orders for up to 27 days of storage only in the substrate amended with lime and zeolite (Fig. 3). In the remaining substrates and the control sludge the differences were minimal throughout the storage time.

Fig 3. Plate counts of faecal streptococci during 42-day storage of treated sludge (S – sludge; S+Z – sludge amended with zeolite; S+L – sludge amended with quick lime; S+ZL - sludge amended with zeolite and quick lime)



Treatment of sewage sludge by lime was investigated by a number of authors, some of them concentrating also on parasite eggs ((Novák et al., 1998; Juriš et al., 1992, Papajová et al., 2002), but the effect of liming was usually observed only immediately after addition of lime. High devitalisation effect of lime was observed by Jepsen et al., (1997), who recorded pH as high as 12.3 and reduction in faecal streptococci by 3 orders after 24-hour action. Bujoczek et al. (2002) observed elimination of *Salmonella* spp within 24 hour after liming of sludge at pH 10.

Our results showed that quick lime and lime with zeolite devitalised faecal coliforms and to some degree also faecal streptococci, but the effect was pronounced only for 21-26 with faecal coliforms and after that the plate counts started to increase gradually back to the initial or even higher level. The decrease (by about two orders) in faecal streptococci was observed only after addition of lime and zeolite and persisted up to day 27 of storage. We can assume that this decrease was closely related to pH so it is desirable to test it more in the future, for example by adding lime in several time-spaced doses.

Acknowledgement
The study was supported financially by the grants VEGA No. 1/0620/03 and 2/4178/04.

Literature references

Bujoczek, G., Oleszkiewicz, J. A., Danesh, S., Sparling, R. R. (2002): Co-processing of organic fraction of municipal solid waste and primary sludge - stabilization and disinfection. Envir. Techn., 23: 227 - 241 Juriš, P., Plachý, P., Tóth, F., Venglovský, J. (1992): Effect of biofermentation on Ascaris suum eggs. Helminthologia, 29: 155 – 159

JEPSEN, S.E.; KRAUSE, M.; GRUTTNER, H.: Reductional of fecal streptococcus and salmonella by selected treatment methods for sludge and organic waste. Wat. Sci. Tech., 11, 1997, 512-523.

Juriš, P., Plachý, P., Tóth, F., Venglovský, J. (1992): Effect of biofermentation on Ascaris suum eggs. Helminthologia, 29: 155 - 159

Novák, P., Lukešová, D., Čížek, A., Zabloudil, F. (1998): Hygienic-ecological aspects of treatment of farm animal excrements. In Venglovský, J., Ondrašovič, m., Sokol, J., Juriš, P., Krajňák, M. (Eds.): Hygienic and ecological problems in relation to veterinary medicine. Copycenter, Košice: 73 - 80

Papajová, I., Juriš, P., Lauková, A., Rataj, D., Vasilková, Z., Ilavská, I. (2002): Transport of Ascaris suum eggs, bacteria and chemical pollutants from livestock slurry through the soil horizon. Helminthologia, 39: 77 - 85