Effect of quick lime, lime dust from separators and phosphoric acid on stabilisation of sewage sludge

*Sasáková, N., Venglovský, J., Ondrašovičová, O., Ondrašovič, M., *Papajová, I., Vargová, M., Hromada, R., Halán, M., Laktičová, K., Kudriková, D.*
University of Veterinary Medicine, Komenského 73, 041 81 Košice, Slovak Republic
**Parasitological Institute of the Slovak Academy of Sciences, Hlinkova 3, 040 01 Košice, Slovak Republic*
E-mail: jan@venglovsky.com

Abstract

Wastewater treatment plants intended for treatment of municipal wastewaters produce considerable quantities of raw sewage sludge which requires additional treatment to eliminate hygienic and environmental risks related to its disposal. Treated sludge is defined as having undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazard resulting from its use.

In the present study we investigated stabilisation of sewage sludge originating from a wastewater treatment plant treating municipal wastewaters produced by source of about 100 000 inhabitants. The sludge (S) was treated with quick lime (S+LK), lime dust from separators (S+L) and phosphoric acid (S+P), using 3% addition by weight. We decided to test phosphoric acid because it is recommended as a suitable disinfectant for manure and soil.

The investigations were carried out for 20 days. Of the chemical parameters determined we present changes in pH and ammonium nitrogen. The pH level was affected initially by all substances added until about day 13 after which the differences in individual substrates were minimal. The level of ammonium nitrogen in water extracts was affected the most by addition of phosphoric acid and also by lime dust.

From the bacteriological point of view, faecal coliforms and faecal streptococci are the most important parameters reflecting hygiene quality of the sludge and potential risk related to its disposal. Faecal coliforms were decreased significantly only for one day by addition of lime dust and for about 10 days by addition of quick lime. Regarding the plate counts of faecal streptococci, quick lime and lime dust resulted in a pronounced decrease which, however, persisted only for up to 13 days of storage. Phosphoric acid had practically no effect on fecal coliforms and faecal streptococci.

Introduction

Treatment and disposal of excess sludge produced by biological aerobic wastewater treatment plants increases considerably the costs of wastewater treatment. The treatment focuses on decrease in total volume of sludge, improvement of its handleability and on stabilization of sludge which ensures decomposition of organic substances and devitalisation of potential pathogenic micro-organisms and parasite eggs. The various ways of treatment include physical processes (heating, thickening, dewatering), chemical processes (addition of various chemicals) and biological processes (anaerobic and aerobic stabilisation, composting).
The aim of our study was to examine the effect of quick lime KOVAP (S+LK), lime dust from separators (S+L) and phosphoric acid (S+P) on stabilisation of sewage sludge with regard to some chemical parameters and bacterial plate counts.

Material and methods

The investigations were carried out with lime powder - commercial name KOVAP (S+LK), lime dust from electrostatic separators KOVAS J (S+L) and H_3PO_4 (S+P). The mentioned

chemicals were added to sewage sludge using 3% addition by weight and unamended sludge served as a control (S). The obtained substrates were stored at 16.6 – 19.3 °C for 20 days. The pre-treated (dewatered) sewage sludge used in our experiment was produced by a wastewater treatment plant treating municipal wastewaters from a source of about 100 000 inhabitants.

During storage we recorded temperatures in the centre if individual substrates using programmable Commeter System thermometers (Rožnov pod Radhoštěm, CR).

Of the chemical parameters determined we focused on pH and ammonium nitrogen in water extracts (1:10) of respective substrates. The pH level was measured with pH electrode (HACH) and ammonium nitrogen was determined titrimetrically after steam distillation.

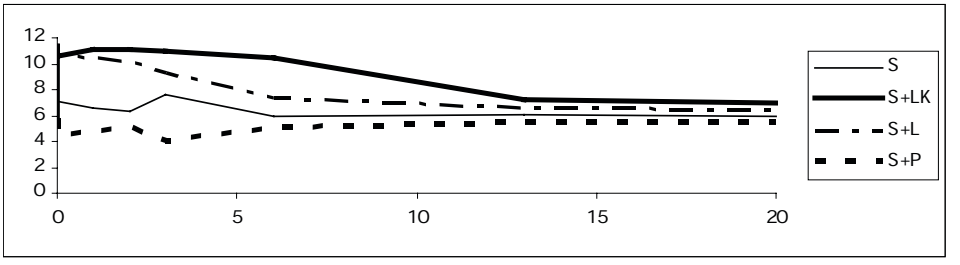
Bacteriological examination included determination of plate counts of faecal coliforms on Endo agar (43°C) and Slanetz-Bartley agar (37°C), resp.

Results and discussion

Chemical stabilisation of sewage sludge, particularly with lime, has been tested in an effort to decrease epidemiological risk associated with its disposal and application. ALLIEVI et. al., (1994) investigated the effect of H_3PO_4 and $Ca(OH)_2$ as acidic and alkaline substances that could be used to disinfect sludges.

We focused on some materials that are produced as waste (lime dust from electrostatic separators) and on phosphoric acid as a chemical recommended for disinfection of manure and soil.

Fig. 1 pH level during 20-day storage of treated sludge



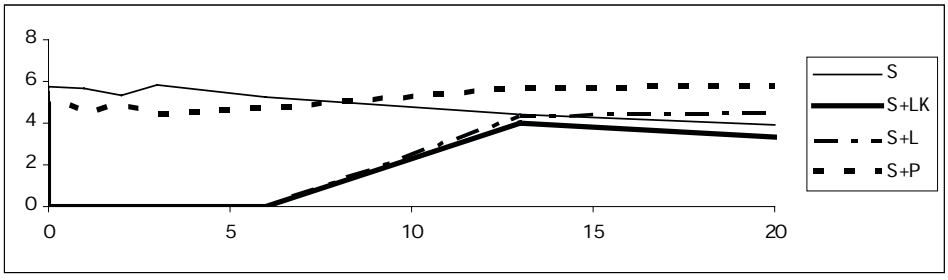
Two hours after addition of lime, an increase in pH (Fig. 1) was observed to the levels of 11.3 (S+LK) and 11.1 (S+L) contrary to the control and the H_3PO_4-amended substrates (5.9 and 4.6, resp.). Differences were observed throughout the experiment but were less pronounced after day 13 of stabilization and on day 20 reached 7.0 and 6.5 in the substrates with lime and lime dust, resp., 5.4 in H_3PO_4-amended substrate and 6.1 in the control sludge. pH above 10 was observed in S+LK up to day 6 and in S+L up to day 2. The course of pH affected also other chemical and microbiological parameters. The differences between S and S+P, S+LK and between S+L and S+P were significant ($P<0.05$).

Ammonia nitrogen in water extract of the substrate S+P increased on day 2 to 476 $mg.l^{-1}$ while in substrates S+LK and S+V varied between 140 and 160 $mg.l^{-1}$ and in control, sludge reached 266 $mg.l^{-1}$. After that, until the end of the experiment, ammonia values were the highest in the substrate S+P, followed by S+V and the lowest level was observed in the control. The differences in ammonia release most likely contributed to differences in survival of micro-organisms.

The addition of lime and phosphoric acid to sludge affected plate counts of both faecal coliforms and faecal streptococci. Both these groups of bacteria are considered important indicators of hygiene quality of sewage sludge and are included among parameters deciding about potential handling and disposal of the sludge.

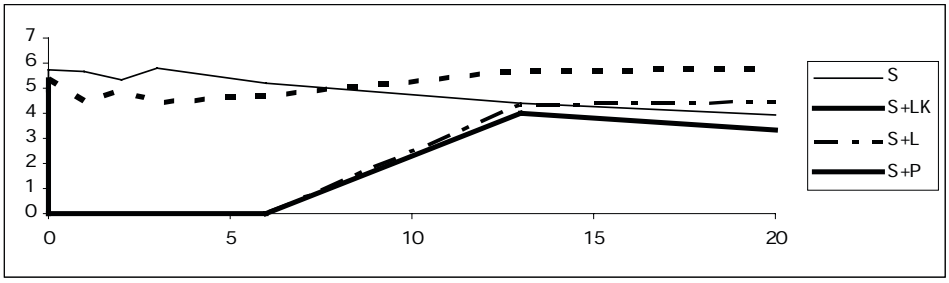
After addition of quick lime and lime dust the plate counts of faecal coliforms showed a rapid decrease almost to zero by 2 hours after addition but we were able to recover them again after two days in the S+L substrate and after 6 days in the S+LK substrate (Fig. 2). Then their numbers increased rapidly and exceeded even those in the control. The results correlated with the decrease in pH in the respective substrates. In the remaining substrates (S+P and S) the plate counts varied less. On day 20, at the end of the experiment, the lowest plate counts of faecal coliforms were detected in the control sludge ($6.6.10^5$ CFU.ml^{-1}). In the remaining substrates the plate counts of faecal coliforms were by two orders higher and exceeded even the initial level. Statistically significant differences were observed between S+LK and S+P, between S+L and S+P ($P<0.05$).

Fig. 2 Plate counts of fecal coliform bacteria during 20-day storage of treated sludge



The most pronounced effect of both types of lime was observed in plate counts of faecal streptococci (Fig. 3). Two hours after addition of lime we were not able to recover the faecal streptococci neither from S+LK nor from S+L substrates while the plate counts in S+P and the control substrate changed only little. However the pronounced effect of lime lasted again up to about 10 days after which we could again recover these bacteria in higher numbers, although the increase was not as high as that observed with faecal coliforms. On day 20, at the end of the experiment, the plate counts of faecal streptococci in S+L reached $2.9.10^4$ CFU.ml^{-1} and in S+LK they were the lowest and reached only 2.10^3CFU.ml^{-1}. The plate counts on day 20 reached $5.2.10^5$CFU.ml^{-1} in S+P and 8.10^3CFU.ml^{-1} in the control sludge. The difference between S+LK and S+L were significant ($P<0.01$).

Fig.3 Plate counts of fecal streptococci during 20-day storage of treated sludge



The results show that the addition of powdered quick lime and lime dust from separators to the investigated sewage sludge showed only temporal effect on the investigated bacteria which was related particularly to change in pH and, to some degree, to different release of ammonia from the substrates. Phosphoric acid had practically no effect on faecal coliforms and faecal streptococci. Our results agree with those obtained by ONDRAŠOVIČOVÁ et al., (1994) who observed changes in chemical and microbiological properties in animal slurry during storage after disinfection with 3% CaO and 1.5% phosphoric acid.

In the agreement with MIGNOTTE et al. (2001), our experiments confirmed that devitalisation effects of liming depend particularly on pH and the time of persistence of the respective ph and less on the percentage of lime in the substrate. This aspect may be important when using less valuable materials that will require higher concentrations. The chemicals tested which showed some bactericidal effects are suitable also from the environmental point of view as no harmful substances are introduced into the soil (GANTZER et al., 2001)

Acknowledgement

The study was supported by the Projects VEGA No. 1/3485/06 and 1/2397/05.

References

GANTZER, C.; GASPARD, P.; GALVEZ, L.; HUYARD, A.; DUMOUTHIER, N.; SCHWARTZBROD, J.: Monitoring of bacterial and parasitological contamination during various treatment og sludge. Water- Research-Oxford, 35, 16, 2001, 3763-3770.

MIGNOTTE-CADIERGUES, B.; MAUL, A.; HUYARD, A,; CAPIZZI, S.; SCHWARTZBROD, L.; MORRIS, R.; JOFRE, J.: The effect of liming on the microbiological quality of urban sludge. Water-Science-and-Technology, 43, 12, 2001, 195-200.

ONDRAŠOVIČOVÁ, O.; ONDRAŠOVIČ, M.; PARA, Ľ.; VARGOVÁ, M.: Changes in some chemical and microbiological parameters in slurry during storage and after addition of chemical disinfectants. (in Slovak), Živočíšna výroba 39, 1994, 365-374.