FAO European Cooperative
Research Network

RAMIRAN

Recycling of Agricultural, Municipal and Industrial Residues in Agriculture

Network Coordinator: José Martinez, Cemagref, Rennes (France)

RAMIRAN 2002

Proceedings of the 10th International Conference of the RAMIRAN Network

General Theme: Hygiene Safety

Štrbské Pleso, High Tatras, Slovak Republic
May 14 - 18, 2002

Edited by Ján Venglovský and Gertruda Gréserová

ISBN 80-88985-68-4

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AEROBIC AND HYDRATE LIME STABILIZATION OF SEWAGE SLUDGE - COMPARISON

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ABSTRACT

Aerobic mesophilic stabilization of primary sludge (max. 25°C) devitalized the tested *Salmonella typhimurium* strain within 48 hours. The dependance of the time of survival of mesophilic microorganisms on temperature and that of coliform microorganisms on the time of sludge stabilization was statistically proved.
Lime hydrate revealed a higher disinfecting effect devitalizing the strain *S. typhimurium* after 60 min. exposition. Sludge pH increased after the addition of $Ca(OH_2)$ to values from 12.3 to 12.6. Dependance of the survival time of indicator microorganisms (mesophilic microorganisms) on pH has been statistically proved.

Key words: aerobic mesophilic stabilization, lime hydrate stabilization , municipal sludges, wastewater treatment plant, *Salmonella typhimurium*, survival

INTRODUCTION

Sludge arising during treatment of municipal wastewaters presents a valuable source of organic matter, nitrogen, phosphorus, potassium and some trace elements.The fact that wastewater treatment plants (WTP) are localized in the suburbs of towns and villages in close vicinity of intensively used soil offers the possibility of an optimum solution for utilizing surplus sludge in agriculture. However, besides positive aspects there are also certain risk factors. One of the most significant risk aspects is the presence of viruses, bacteria and parasites which are of importance from the viewpoint of hygiene, epidemiology and epizootiology. To eliminate these risk factors different technologies are used (aerobic thermophilic stabilization, aerobic thermophilic sludge stabilization with a subsequent anaerobic process, lime disinfection of sludge by $Ca(OH_2)$ or CaO, composting of sludge etc.). For these reasons examination was aimed at the comparison of two treatment technologies: the influence of aerobic stabilization and lime hydrate stabilization. Since under our conditions Proteus, Salmonella,Citrobacter and Escherichia coli are the most frequently occurring pathogens isolated from sludge, this study was mainly concerned with the observation of the effect of the abovementioned technologies upon survival of *Salmonella typhimurium* and upon the dynamics of indicator microorganisms in the sludge.

MATERIAL AND METHODS

In the experiments raw primary sludge from sedimentation containers of the municipal WTP in Poprad were used.

Aerobic exothermic stabilization of raw (primary) sludge took place in the laboratory fermentor. The equipment was prepared at the Parasitological Institute of the Slovak

Academy of Sciences (SAV) in Košice according to the scheme of Hotař (1974). Air was introduced into the fermentors from a pressure vessel in which increased pressure at a range of 0.20 - 0.35 Mpa was maintained by means of a compressor. Perfect dispersion of the air pressed into the fermentor was achieved by leading the pipe near the stirring device. The fermentor worked at a discontinuous single filling regime and was placed in the laboratory at a temperature of 17-25°C. The active stabilization volume of the aerobic fermentor was 5,000 ml. The sludge was continuously stirred with a two-branch stirring device at 2770 r per min. Throughout stabilization pH and temperature values were recorded by the Bioblock Scientific 93317 registration device (Bioblock).

To observe the effect of liming a modified equipment was used. The modification was based upon closing the openings of the pipes for in- and outlet of air. To stabilize sludge commercially produced lime hydrate (light, airy, white, Kalcit s.r.o., Gombasek, Slovak Republic) was used at an amount of $10 g.l^{-1}$ ($100 mg.g^{-1}$ dry matter in the sludge). One liter of sludge with no lime hydrate added and kept at 4°C served as a control.

Inoculation and isolation of Salmonella typhimurium

The freeze-dried strain *Salmonella typhimurium* SK 14/39 (ŠZÚ, Prague, Czech Republic) was used as the test strain. Prior to stabilization sludge was inoculated with a broth culture of *S. typhimurium* at a dose of 250 ml per 5 l of sludge; the control sludge was inoculated with 50 ml of the broth culture. The starting concentrations are given in Tables 1 and 2. In the course of the experiment quantitative and qualitative examinations have been carried out. For non-selective culturing buffered pepton water (BBL, Becton Dickinson) incubated for 24 hours at 37°C was used, whereas for selective culturing selenite culturing medium (Imuna) with a 48-hour incubation at 37°C, and a selective culturing medium according to Rappaport-Vassiliadis (Merck, Darmstadt) incubated for 48 hours at 43oC, were used. After incubation each culturing medium was spread on XLD agar (Imuna) and incubated for 24 and 48 hours at 37°C. Suspective colonies were subjected to biochemical examinatiaon by means of the identification system for bacteria of the family Enterobacteriaceae (BBL Enterotube II, Becton Dickinson). Serological examination was carried out at the Department of Microbiology of the State Veterinary Institute in Košice.

Determination of the dynamics of indicator microorganisms.

Sludge samples were processsed by the method of Philipp et al. (1990). The counts of indicator microorganisms were determined according to STN standard 830531. For examination of coliform and faecal coliform bacteria Endo agar (Imuna) was used, examination for psychrophilic and mesophilic bacteria was made on agar No. 2 (Imuna) and faecal streptococci were determined on selective agar (Imuna).

Determination of physical-chemical indices of stabilization

Of the physical-chemical parameters pH, total N and chemical oxygen demand (COD) were stated by methods according to STN standard 83 0550.

Statistical evaluation of the experiments

Regression analysis of logarithmically transformed data was used to express the effect of physical-chemical parameters upon the survival of the tested *S. typhimurium* strain as well as of the dynamics of indicator microorganisms. Testing the slope of the straight line from the X axis the level of dependance between the observed parameters and the survival of the individual microorganisms was determined.

RESULTS

Aerobic stabilization of sludges

Aerobic stabilizationtook place in the mesophilic temperature range. The maximu temperatures achieved in the individual experiments amounted to 33.3, 38.8 and 45°C, respectivelz. Aerobic mesophilic fermentation caused devitalization of the tested S. typhimurium strain in experiment 1 and 2 within 48 hours. At the same time, quantitative detection of the tested strain was only possible until 24 h after start of the experiment. Survival of mesophilic and coliform microorganisms has been proved to significantly depend on temperature ($P<0.05$) and stabilization time of the solid fraction ($P<0.01$), respectively.

Sludge stabilization by lime hydrate

In the course of the experiment the temperature of the stabilized sludge did not change markedly and ranged from 21 to 25°C. After the application of $Ca(0H)_2$ sludge pH increased to 9.81 - 12.14. Under the given conditions the tested *S. typhimurium* strain survived as few as 60 minutes. The strong disinfecting effect of lime hydrate was also stated by findings of the reduction of indicator microorganisms with the exception of psychrophilic ones. The latter survived 24 hours. All other microorganisms under investigation (mesophilic, coliform, faecal coliform, faecal streptococci) were devotaliozed within 60 min. after the addition of lime hydrate.

The time of indicator microorganism survival was statistically proved to depend upon pH (level of significance $P<0.01$); this did not apply to the psychrophilic microorganisms where the level of sigsnificance was stated to be $P<0.05$.

DISCUSSION

From the results of this study it is obvious that aerobic fermentation in the mesophilic temperature range (maximum stabilization temperature 45°C) did not have a sufficient devitalizing effect upon S. typhimurium; the effect upon indicator microorganisms proved to be similar. Aerobic stabilization devitalized the tested *S. typhimurium* strain after 48 hrs whereas quantitative proof of that strain was only possible until h 24 of the experiment. In comparison to aerobic stabilization lime hydrate stabilization had an increased disinfecting effect. After the addition of lime hydrate both the tested strain and the indicator microorganisms were devitalized within 60 minutes. With regard to the vegetative forms of microorganisms the sludge became sterile; this in fact decreased the risk of pathogen transmission to farm animals and subsequently to the food chain (Cabadaj et al., 1995; Pavlová et al., 1992; Vasiľ, 1993). Our results confirmed the findings of Strauch (1988) and others since a dose of lime hydrate was used which is considered to be sufficient for microbial pathogen, mainly Salmonella spp. disinfection by those authors as well.

We stated temperature to be the main devitalizing agent and changes of pH to be important factors affecting the survival of Salmonellae in sludges. The importance of temperature as the main devitalizing factor during aerobic stabilization was also confirmed by Strauch et al. (1970) who reported that inactivation of Salmonella spp. in sludges required aerobic stabilization at 40°C with pH and the species of Salmonellae being important factors affecting the success of aerobic stabilization. According to Drnevich and Smith (1975) effective reduction of Salmonella spp. occurred after 24 h

exposition of municipal sludge to a temperature of 45°C in the aerobic fermentor; this is not in full accordance with our findings since both in the 1st and in the 2nd experiment *S. typhimurium* was confirmed qualitatively. Based on this finding as well as on the fact that Salmonellae are thermolabile microorganisms requiring an optimum growth temperature between 35°C and 42°C, we tend to support the conclusions of Wellings et al. (1976) and Smith et al. (1975) according to whom aerobic thermophilic stabilization (45-70°C) has an increased devitalization effect. A critical view was presented by Bitton et al. (1984) and Plachá and Venglovský (1999) who reported aerobic mesophilic stabilization taking place usually at 37°C to have a low disinfecting effect.

Since in addition to temperature pH changes are the main devitalizing factor, we tried to confirm this fact during lime hydrate stabilization. Similarly to Jepsen et al. (1997) we succeeded to confirm the high devitalizing effect of lime hydrate. During the process of stabilization the above authors observed pH values that were identical with those seen in our experiments (12.3) and at the same time they recorded a reduction of faecal streptococci by 3 orders after 24 h stabilization, with salmonellae being undetectable. However, in our experiments reduction of faecal streptococci counts had a different course since total inactivation of indicator microorganisms (except of psychrophilic ones) was achieved already after 60 min. stabilization.

The effects of pH upon the reduction of indicator microorganisms were statistically proved; thus the findings of the above authors were confirmed according to whom high pH levels cause devitalization of microorganisms. Similarly the effects of total nitrogen were confirmed the levels of which decreased during liming. This was caused by ammonia release which according to Bitton (1994) and Venglovský et al. (1997) is abruptly released from sludges after pH has increased to more than 9.

From our results as well as from the present state of knowledge it is obvious that aerobic mesophilic stabilization does not have a sufficient disinfecting effect, therefore further methods of sludge processing are suggested (pasteurization, chemical disinfection, composting). On the basis of our results we recommend liming at doses suggested by agronomists for the effective stabilization of sludges. In this way the dunging value of sludges can be increased and periodical liming of agricultural land can be substituted for. Application of sludges with an alkaline pH causes a pronounced decrease in the uptake of heavy metals by plants which is an effective measure of preventing heavy metals from entering the food chain.

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