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HYGIENIZATION OF SEWAGE SLUDGES BY LIMING

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ABSTRACT

The direct application of sewage sludges in agriculture is hazardous due to pathogens, heavy metals in unstable compounds and synthetic organic compounds. The new Directive No. 382/2001 issued by Ministry of Environment of the Czech Republic determines conditions for the use of treated sewage sludges in agriculture. For their hygienization the lime treatment using both quick lime and milk of lime can be utilized.
Laboratory and operational tests with dewatered sludge from a waste water treatment plant (average capacity of 4800 m^3/day) were carried out. The former were focused on the lime dosage optimization from the view of a pH development in time, concentration of ammonia, nitrate and total nitrogen, dry matter, structure of the final product and content of pathogens. Operational tests in the water treatment plant were realized with a mixing machine STABI-MATIC and the same type of lime and sludge as in the laboratory. Mixtures were prepared with 2 and 15 wt. % of quick lime. The pH development in time were observed within 1 - 60 days and pH values were always found higher than 12. Contents of pathogens in raw and limed sludges were compared. Already the CaO dosage of 2 wt. % was able to reduce pathogens under detection limits of methods used. By this efficient way e. g. *Salmonella spp*., coliforms and enterococci were disposed.

INTRODUCTION

Sludges produced by sewage disposal plants are suitable materials for fertilizing and reclamation of soils, because they are the valuable source of nutrients and trace elements. Furthermore, they contain a high portion of organic matter (30-50% of dry matter depending on treatment technologies) and improve physical properties of soil (bulk density, porosity, water capacity, soil aggregates structure, etc.) as well as microbial activity. Therefore they can alternate organic or organic-mineral fertilizers. On the other hand, their direct application on land is hazardous due to pathogens, heavy metals in unstable compounds and synthetic organic compounds. In accordance with the European legislation the new Directive No. 382/2001 on the use of treated sludges on land was issued by Ministry of Environment of the Czech Republic. It deals with technical conditions, limits of main hazardous substances in land and sludges and last but not least with their monitoring. The best way, from the view of hygienization, is to treat sludges by any efficient process decreasing mentioned risks such as thermal treatments, thermophilic and mesophilic stabilization and conditioning with lime. Efficient factors of liming sludges by CaO are as follows: the extensive heat development within the reaction of CaO with water in sludges, high pH values (> 12) and the gaseous ammonia effect. In addition, limed sludges can improve the present bad situation in the Czech Republic from the view of the decreased lime fertilizers applications.

MATERIAL AND METHODS

Laboratory experiments. Dewatered sludge from a waste water treatment plant was mixed with 2, 3, 5, 7, 9 and 11 wt. % of lime. After 12 hours under ambient temperature following analyses of original sludge and limed mixtures were carried out:

- dry matter at 105 °C (constant weight)
- NH4-N and NO_3-N by the Bremner distillation
- N_{total} by the Kjeldahl method
- pH values of water suspensions (1:1, 1:10)
- consistency - visual check
- microbiological tests of original sludge and the mixture with 2 wt. % of lime

Ordinary quicklime ground under 200 μm was used for sludge liming. The same material was used for the operational trial.

Operational experiments. In a waste water treatment plant, with the average water capacity of 4800 m^3/day, sludge from sedimentation tanks (around 4 wt. % of dry matter) was dewatered in a centrifuge with the help of organic polymer. The average concentration of dry matter during the trial was approximately 21 wt. %. Dewatered sludge was dosed (450 kg/h) into the mixing machine STABI-MATIC 2 developed by the Lhoist Engineering Department. The maximum capacity of this mixer is 6 m^3/h. Due to the insufficient amount of produced sludge, only two lime doses (2 and 15 wt. %) were tested. Within the trial samples of mixtures were taken and analyzed as follows:

- consistency - visual check
- microbiological tests - thermoresistant coliform bacteria - standard CSN ISO 7899-2
  - enterococci - standard CSN ISO 7899-2
  - Salmonella spp. - standard CSN ISO 6579
- pH values of water suspensions (1:1)

RESULTS AND DISCUSSION

Laboratory experiments. Table 1 presents concentrations of different nitrogen forms in original and limed sludges. The decrease of N_{total} with the increase of lime concentrations is in Fig. 1. This influence can be expressed well by the parabolic dependence.

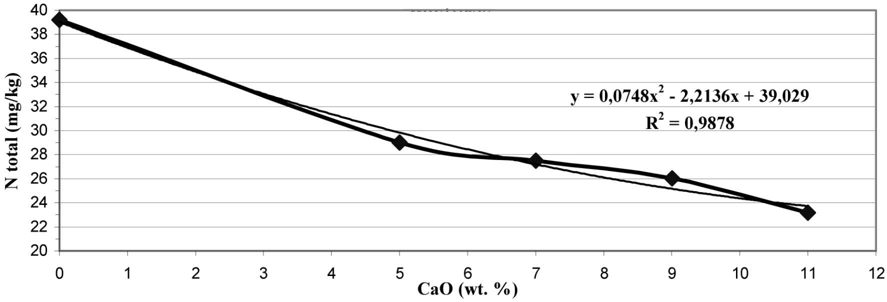
Table 1 Concentrations of different nitrogen forms in original and limed sludges.

material	dry matter	NH_4-N	NO_3-N	N_{total}
	(wt.%)	(g/kg of dry matter)		
dewatered sludge	24.36	5.38	2.13	39.20
+ 5 wt. % CaO	-	-	-	29.02
+ 7 wt. % CaO	30.79	1.07	0.32	27.51
+ 9 wt. % CaO	32.62	1.32	0.40	26.03
+ 11 wt. % CaO	34.45	1.28	0.52	23.19

From results obtained it is clear, the higher lime content in the mixture, the higher dry matter and lower N_{total} due to the ammonia escape.

Except of original sludge all limed sludge water suspensions reached pH > 12. From the view of real applications, consistency of mixtures with 3, 5 and 7 wt. % of lime was quite improper (pastes). Only mixtures with 9 and 11 wt. % of lime showed the right consistency (friable aggregates).

Fig. 1 Influence of lime admixture on total nitrogen concentration in mixtures



Operational experiments. Biological analyses of original sludge and limed mixtures are presented in Table 2. Pathogens limits according to the Directive 382/2001 are in Table 3.

Table 2 Contents of pathogens in original and limed sludge

parameter	unit	CaO (wt. %)			
		0	15 (op.)	2 (op.)	2 (lab.)
sludge age	day	1	14	14	30
dry matter	wt. %	21.8	38.9	31.5	-
mesophilic bacteria	cfu/g	$3.8 \, . \, 10^8$	-	-	-
coliform bacteria	cfu/g	$3.5 \, . \, 10^6$	-	-	-
thermoresistant col. bact.	cfu/g	$1.7 \, . \, 10^6$	< 50	< 50	< 50
fungi	cfu/g	$4.0 \, . \, 10^5$	-	-	-
enterococci	cfu/g	$3.9 \, . \, 10^4$	< 50	< 50	< 50
Salmonella spp.	-	positive	negative	negative	negative

Table 3 Microbiological limits for applications of sludges on land

sludge category	thermoresistant coliform bact. (cfu/g)	enterococci (cfu/g)	Salmonella spp.
I	$< 10^3$	$< 10^3$	negative
II	10^3 - 10^6	10^3 - 10^6	-

I - sludges generally used in agriculture
II - sludges for technical crops growing

It is obvious original untreated sludge is dangerous for the direct application on land. Both laboratory and operational tests proved the good hygienization of this sludge by quicklime. Even the addition of 2 wt. % of lime is sufficient to meet limits for pathogens.

Both limed sludge water suspensions reached pH > 12 within the followed period (1 - 60 days). Regarding real applications only the mixture with 15 wt. % of lime possessed the appropriate consistency of friable aggregates.