

The Effect of Lime Stabilization on the Microbiological Quality of Sewage Sludge

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ABSTRACT

Agricultural utilization of wastewater sludge is practiced in many parts of the world. Sludge may contain a variety of pathogenic microorganisms, which can spread diseases if there is human exposure to the sludge. Therefore, sludge must be treated before disposal and reuse. In this study the effect of liming on the microbiological quality of urban liquid raw sludge in Isfahan Wastewater Treatment Plant (IWTP) was investigated. Sludge samples were taken from IWTP, and the initial concentrations of total solids, volatile solids, total coliform, fecal coliform, *Salmonella* and ova of parasites were determined. Then adding lime to increase the pH of sludge to 11 and 12 and the effect of liming on the parameters was carried out after 2, 24, 72 and 120 hours. *Salmonella* was inactivated completely in treated sludge after two hours. The removal of up to 99% of fecal coliform was obtained for two ranges of pH. However, reduction of ova of parasites at pH 11 and 12 after five days were found only 56% and 83.8% respectively. Sludge treated with lime meets USA Environmental Protection Agency (EPA) standards regarding Class B and Class A after 2 and 24 hours respectively. At pH higher than 11 and 12 treated sludge with lime meets vector attraction reduction requirements after two hours. However, at a pH higher than 11 and 12 treated sludge with lime does not meet the guideline for pathogen reduction of class a regarding eggs of parasites.

Keywords: *Sludge, Liming, Salmonella, Coliform*

INTRODUCTION

Sludge treated with alkali can be used in agriculture, gardening and mining. The increase in biosolids resulting from stabilization with alkali materials causes favorable conditions for growth of vegetables as a result of improvement in soil characteristics (U.S.EPA, 1984; Ahmad and Sorensen, 1999; U.S.EPA, 2000).

However, sludge may contain constituents who are potentially harmful to animals and humans who consume the crops. Pathogenic microorganisms such as bacteria, viruses, protozoa and eggs of

parasitic worms can be spread by sludge (Metcalf & Eddy, 1991; Vesilind, et al, 1997; Straub, et al. 1998 ;). There are a lot of processes for treatment and stabilization of sludge, but liming is one of the processes that can reduce pathogenic organisms significantly (Pescod, 1992; Amer, 1997; Jepsen et al., 1997).

The effect of liming on the microbiological quality is reported to be related to the pH and not to the percentage of added lime. It has also been shown that *Salmonella* are eliminated from solid sludge in 24 hours at pH 10. It was concluded that the removal of pathogenic microorganisms depended on the pH reached by the sludge, the period of liming activity and the dryness of the sludge (Strauch, 1999).

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Although helminth eggs in sludge are more resistant to liming as compared to other microorganisms, sludge treatment with lime reduces their concentration considerably (Gerksen, et al.1995; Amer, 1997).

According to the literature, sludge treatment with lime may meet Class A and B requirements in EPA guidelines for control and reduction of pathogens in sewage sludge (USEPA, 1992).

The Class A requirement is to reduce the pathogens in sewage sludge to below detectable levels. The Class B requirement is to ensure that pathogens have been reduced to levels that are unlikely to pose a threat to public health and the environment under the specific use conditions(USEPA, 1992). Lime is a cheap and easily accessible chemical and therefore it was decided to investigate the effect of liming on the microbiological quality of sludge in Isfahan South Wastewater Treatment Plant (ISWTP).

MATERIALS AND METHODS

Seven samples of raw sludge were taken from IWTP and transferred to the Environmental Health Laboratory, Isfahan School of Public Health. The sludge was poured into two separate one-liter beakers and 9.8 and 21.3 grams of lime were added in order to increase the pH to 11 and 12 respectively.

Then the samples were mixed for two hours and stored for five days. Analysis was carried out after 0, 2, 24, 72 and 120 hours. Total and volatile solids were measured according to APHA, 1992 section G. (APHA, 1992).

Total coliform, fecal coliform, *Salmonella* and helminth eggs were detected according to EPA,

1992 guidelines (U.S.EPA, 1992). Enumeration of total coliform and fecal coliform were carried out using multi-tubes methods and the results expressed as MPN per 100 ml. *Salmonella* was enumerated by the pour plate method using Xylose Lysine Decarboxylase Agar (XLD) (CM 469, Oxoid). The plates were incubated inverted at 37 ± 0.5 °C for 24 hours then all red colonies with black centers were counted per 4 g. dried mass (DM). In order to count the viable eggs, the sample was filtered through a sieve with 315 µm pores and subjected to flotation in a ZnSO₄ solution. A two-phase extraction was then carried out with 0.1 N H₂SO₄ and eggs incubated for 3 weeks at 26 °C in 0.1 N H₂SO₄ for viability testing. Viable eggs were counted in a Sedwick-Rafter cell.

RESULTS

The results obtained from this study are summarized in Tables 1 and 2. The average pH was 6.6 in the raw sludge of ISWTP. Average total and volatile solids were found 2.5% and 67.4% respectively. The average initial microbial concentration in the raw sludge for total and fecal coliform was 48×10^8 and 1.6×10^7 per gram of dried sludge respectively. *Salmonella* enumeration was recorded 55 per 4 grams and the number of viable helminth eggs was 180 per gram of dried sludge solids. The variation of these parameters in different times of treatment with lime is shown in Table 1 and 2. The amount of lime measured to increase the pH to more than 11 and 12 was 9.8 and 21.3 g. per liter, respectively.

Table 1: The results obtained with sludge liming at different pH

Parameters	No. of samples	pH	Raw sludge	After 2 hours	After 24 hours	After 72 hours	After 120 hours
Total coliform (MPN/g)	7	12	1.3x10 ⁸	4.2x10 ⁵	4.4x10 ³	1.5x10 ³	6.3x10 ¹
Fecal Coliform (MPN/g)	7	12	1.3x10 ⁷	1.1x10 ⁵	3.0x10 ²	3.5x10 ¹	3.1x10 ¹
Total Coliform (MPN/g)	7	11	1.7x10 ⁸	8.2x10 ⁵	1.3x10 ⁵	1.6x10 ⁵	2.0x10 ⁵
Fecal Coliform (MPN/g)	7	11	1.8x10 ⁷	1.3x10 ⁵	9.5x10 ²	1.8x10 ³	3.6x10 ³
Salmonella (MPN/4g)	7	12	54	<2	0	0	0
Salmonella (MPN/4g)	7	11	54	<2	0	0	0
Total Solids (%)	7	12	2.5	4.2	5.0	5.8	6.5
Total solids (%)	7	11	2.4	4.2	4.8	5.5	6.3
Volatile solids (%)	7	12	67.6	22.9	21.1	20.4	19.2
Volatile solids Reduction (%)	7	12	-----	66.1	68.8	69.8	71.6
Volatile solids (%)	7	11	67.3	41.3	40.4	40.0	42.0
Volatile solids Reduction (%)	7	11	-----	38.6	39.9	40.6	37.6
Viable helminth eggs (No./g)	7	12	135	65	53	32	22
Viable helminth eggs (No./g)	7	11	225	135	112	55	98

Table 2: Lime dosage and variation of pH in different times of storage

Parameters	Raw - sludge pH	Average Lime dosage	pH after 2 hours	pH after 24 hours	pH after 72 hours	pH after 120 hours
pH	6.6	21.3 g/l	12.5	12.5	12.5	12.5
pH	6.6	9.8 g/l	11.4	10.7	10.2	9.3

DISCUSSION

The results obtained from this study were analyzed with regard to EPA regulations for control of pathogens and vector attraction in sewage sludge. The U.S. Environmental Protection Agency (EPA) has established a regulation for the use and disposal of sewage sludge (U.S.EPA, 1992). This regulation protects public health and the environment through requirements designed to reduce the potential for contact with the diseases-bearing microorganisms in sewage sludge applied to the land or placed on a surface disposal site. These requirements are divided into two categories: The requirements designed to control and reduced pathogens in sewage sludge and those to reduce the ability of the sludge to attract vectors.

A. The effect of lime on pathogen reduction

The pathogen reduction requirements for sewage sludge are divided into two categories: Class A and Class B. (U.S.EPA, 1992). In Class A the density of fecal coliform in the sewage sludge must be less than 1000 MPN per gram total solids (dry weight basis) or the density of *Salmonella* sp. bacteria must be less than 3 MPN per 4 grams of total solids. Class B requirements can be met only by fecal coliform density in the treated sludge of 2 million MPN or CFU per gram total solids sewage (dry weight basis) (U.S.EPA, 1992, Jimenez, 2000)). As can be seen from Table 1 at pH 12 after two hours the sludge met the requirements for Class B. At this pH Class A requirements met for *Salmonella* and fecal coliform after 2 and 24 hours respectively. At pH 11 requirements for Class B met after two hours. Again requirements for Class A were met for *Salmonella* and fecal coliform after 2 and 24 respectively. However, at pH higher than 11 regrowth of bacteria was observed after 72 hours and the sludge no longer conformed to Class A requirements. The results also showed

that lime treatment did not increase the efficacy of helminth eggs inactivation at pH 11 and 12 and during observation period of this study.

B. The effect of lime on reduction the ability of the sludge to attract vectors

Requirements for reducing vector attraction can be achieved if the mass of volatile solids in the sludge reduced by at least 38% or raise the pH to at least 12 and maintain it for two hours or maintain a pH of at least 11 for 22 hours (Mignotte, 2001). Table 2 showed lime treatment lead to an increase the pH of sludge to values over 11 and 12 and storage for two hours can be met requirements for reducing vector attraction. At pH 12 this status was maintained throughout the period of this study (five days). However, at pH 11 due to reduction in pH the requirements could not be met.

This study showed that liming improved the microbiological quality of sludge. The efficiency of sludge liming in terms of the elimination of pathogenic microorganisms depends on the pH achieved in the sludge and duration of liming activity. *Salmonella* were eliminated from sludge at pH 11 and 12 in the first two hours. The results demonstrated the very strong inactivation of *salmonella* during liming. Liming improved the microbiological quality of sludge provided that the pH was maintained at higher than 11 for two hours (met Class B) or for 24 hours (met Class A). Inactivation of helmet eggs required increase the pH to higher than 12 for more than 24 hours.

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