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Comparison of Extended Aeration Activated Sludge Process and Activated Sludge with Lime Addition Method for Biosolids Stabilization

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Abstract: This study was conducted to disposal biosolids from Serkan sewage treatment plant and lime stabilized biosolids, from April 2002 to March 2003. Lime stabilization of biosolids was performed in the reactor with 30-liter capacity at Hamadan medical sciences university. Average amounts of VS/TS ratio, SOUR, fecal coliform and viable helminth ova density in disposal biosolids from Serkan treatment plant were 0.754, 3.395 mg.0_2/g.vs.h, 1.93×10^8 MPN/g of dry solids and 1100 ova/4 g of dry solids, respectively. By lime addition ratio about 0.4 g $Ca(OH)_2$ /g of dry solids of biosolids, pH was not dropped under 12 and fecal coliform was not growth after 30 days. Disposal biosolids from Serkan treatment plant was raw. Lime addition could be stabilized this biosolid and the products could be well used as a landfill cover, or a soil conditioner. Capital and annual cost of activated sludge with lime stabilization biosolids was cheaper than extended aeration activated sludge about 45 and 55%, respectively.

Key words: Extended aeration activated sludge, lime stabilization, biosolids reuse

INTRODUCTION

Extended aeration activated sludge process is a most common for wastewater treatment in small communities[1]. This method was choosing for many of municipal and industrial Waste Water Treatment Plants (WWTP) in Iran[2].

The extended aeration process is similar to the conventional plug-flow activated sludge process except that it operates in the endogenous respiration phase of the growth curve, which requires a low organic loading and long aeration time. Operation is based usually on long solid retention time (SRT= 20 to 30 days) and long hydraulic retention time (HRT= 24 h) values. In the past, the extended aeration process was thought to need long SRT_S to provide well-stabilized biosolids for reuse. However, with stricter regulations governing biosolids stabilization, separate aerobic digestion facilities are used to meet the requirements for reuse. High capital and annual cost and the lack of well-stabilized biosolids in many cases of exiting plants are two basic problems for this method[1]. Therefore, using of the cost-effective and efficient methods such as activated sludge process combined with lime biosolids stabilization should be noted.

Lime stabilization is generally more cost-effective and simpler than alternative biosolids options and quality of the resultant biosolids is often superior. While the addition of lime results in a modest increase in sludge volume, this method generally requires less space than alternatives[3]. These plants may be easily added to processes that have inadequate capacity to meet regulatory requirements. Therefore, these facilities can be used to supplement existing solids treatment capacity. Also, lime stabilization is particularly applicable in small plants or when the plant will be loaded only seasonally[4].

In this process, lime is added to untreated sludge in sufficient quantity to raise the pH[5]. The lime dosage required varies with the type of sludge and solids concentration. Typical dosages are reported in Table 1[1]. The high pH creates an environment that halts or substantially retards the microbial reactions that can otherwise lead to odor production and vector attraction. The biosolids will not putrefy, create odors, or pose a health hazard so long as the pH is maintained at this level. The process can also inactivated virus, bacteria and other microorganisms present[5,6].

Most lime treatment facilities have the flexibility to produce either class A or class B regulations

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Table 1: Typical lime dosages for pretreatment sludge stabilization

	Solids concentration (%)		Lime dosage g $Ca(OH)_2$/g dry solids	
Type of sludge	Range	Average	Range	Average
Primary	3-6	4.3	0.06-0.17	0.12
Waste activated	1-1.5	1.3	0.21-0.43	0.30
Anaerobically digested mixed	6-7	5.5	0.14-0.25	0.19
Septage	1-4.5	2.7	0.09-0.51	0.20

recommended by United State Environmental Protection Agency (USEPA)[7].

To meet Class B requirements using lime stabilization, the pH of the biosolids must be elevated to more than 12 for 2 h and subsequently maintained at more than 11.5 for 22 h. To meet Class A, the Class B elevated pH requirements are combined with elevated temperatures (70°C for 30 min)[3].

Based on the classes of lime-stabilized biosolid achievement, which could be reused as a landfill cover, commercial fertilizer or soil conditioner[8].

According to the Water Environment Federation (WEF), as of 1997, almost 20% of all biosolids were processed with lime stabilization[3]. But at this time this method was not used in any WWTP in Iran.

The main objective of this study was to compare the efficiency of extended aeration activated sludge and activated sludge with lime addition process for biosolids stabilization. Due to this objective, Serkan WWTP in Hamadan province of Iran was choose and investigated. This plant worked based on the extended aeration activated sludge process for wastewater treating of 5000 persons.

MATERIALS AND METHODS

This study was accomplished on the disposal biosolids of Serkan WWTP from April 2002 to March 2003 in two separate sections.

Investigation of stability and reuse potential of disposal biosolids: Due to this regard, samples were taken at the sludge outlet from WWTP in four times. Sludge samples were tested for stability and reuse potential indexes such as: the ratio of Volatile Solids to Total Solids (VS/TS), Specific Oxygen Uptake Ratio (SOUR), pH, Fecal Coliform (FC) and viable helminth ova densities. Finally, the characteristics of disposal biosolids were compared to biosolids stabilization and reuse criteria's[9-11].

Efficiency study of lime addition for biosolid stabilization: In this section, a glass reactor with 30 L capacity and an electrical mixer with variable round per minute were used. The reactor was loaded by untreated biosolids of Sarkan WWTP and then sufficient amount of hydrate lime (due to the concentration of dry solids of biosolids) was mixed to it. Stability and reuse potential indexes of lime added biosolids were checked along 4 weeks in this reactor. During this period, pH, FC and viable helminth ova densities were tested and compared to biosolids stabilized criteria's[9,10].

For finding the optimum ratio of lime addition to dry solids of biosolids, this action was done in four times. Finally, the optimum ratio was choose the amount, which could be, raised the pH of mixture over 12 for 2 h and held it over 11 for 4 weeks.

Analyses were done according to the methods outlined in APHA[12] except for viable helminth ova density, which was done by the methods outlined in USEPA[10]. All of analyses were performed at the environmental health laboratory of Hamadan medical sciences university. The SPSS software was used to perform statistical analysis of the collected data.

For choosing the cost-effective method, cost analyzes of activated sludge with lime stabilization biosolids method and extended aeration activated sludge process was compared.

RESULTS

The characteristics of disposal biosolids from Serkan WWTP were presented in Table 2. The results showed that, the minimum amounts of VS/TS ratio, SOUR, FC and viable helminth ova densities in biosolids were 0.73, 3.12 mg.0_2/g.vs.h, 1.17×10^7 MPN/g of dry solids and 203 ova/4 g of dry solids. The maximum amounts of these criteria's for stabilized biosolids are: VS/TS ratio=0.6, SOUR=2 mg.0_2/g.vs.h[11], FC density = 1000 (class A) and or 2×10^6 (class B) MPN/g of dry solids and helminth ova density = 1 ova/4 g of dry solids (class A)[9,10]. Based on the statistical tests, there are significant differences between the amounts of these parameters in Serkan WWTP disposal biosolids with stabilized biosolids criteria's (at least $p<0.01$).

As indicated in Table 3, the amounts of lime dosage in 4 times of reactor loading with Serkan WWTP disposal biosolids were; 0.75, 0.6, 0.21 and 0.4 g Ca $(OH)_2$/g of dry solids, respectively.

Figure 1 shows the pH variation in lime-stabilized biosolids during 4 times of reactor loading. The results showed that the pH remained over 12 in 4 times of reactor loading at least for 18, 30, 15 and 30 days, respectively (Fig. 1).

The variation of FC density in lime-stabilized biosolids during 4 times of reactor loading and the

Table 2: Characteristics of disposal biosolids from Serkan WWTP

	Steps			
Parameters	1	2	3	4
pH	7.43	7.88	7.8	7.15
VS/ TS ratio	0.76	0.78	0.75	0.73
SOUR ($mg.0_2/g.vs.h$)	3.12	3.85	3.40	3.22
FC (MPN/g dry solids of biosolids)	8.2×10^7	1.27×10^8	1.17×10^7	5.5×10^8
Viable helminth ova (ova/4 g dry solids of biosolids)	2333	992	873	203

Table 3: Results of lime-stabilized biosolids of Serkan WWTP

	Steps			
Parameters	1	2	3	4
Activated degree of $Ca(OH)_2$, %	46.2	77	77	77
Ratio of g $Ca(OH)_2$ to g dry solids of biosolids	0.75	0.60	0.21	0.40
Viable helminth ova (ova /4 g dry solids of biosolids)	295	314	443	122

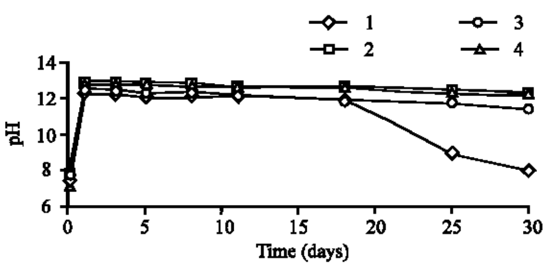

Fig. 1: Variation of pH in lime-stabilized biosolids of Serkan WWTP

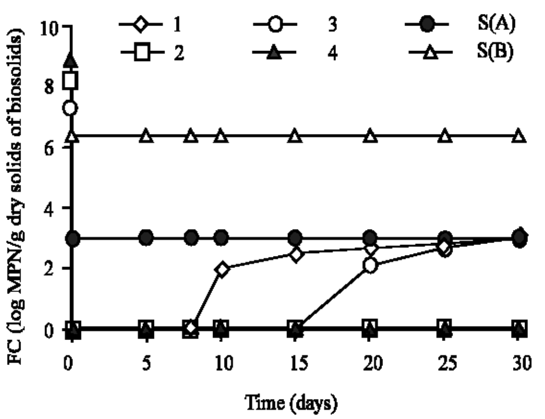

Fig. 2: Variation of FC in lime-stabilized biosolids of Serkan WWTP, S(A): Standard class A, USEPA, S(B): Standard class B, USEPA

amounts of FC in A and B classes of USEPA criteria[9,10] were shown in Fig. 2. It is observed (Fig. 2) immediately after the lime addition to biosolids, FC density was decreased to 0 for all of times. After 30 days past, FC densities in lime-stabilized biosolids for 1st to 4th times of reactor loading were 980, 0, 900 and 0, MPN/g of dry solids, respectively (Fig. 2).

The results of the four times viable helminth ova analyze in lime-stabilized biosolids showed that the minimum density of this parameter was 122 ova per 4 gram dry solids (Table 3) after 30 days past. This amount was related to 4th time of reactor loading. There is a significant difference between this amount and the amount of class A of USEPA criteria ($p<0.01$)[9,10].

The capital and annual cost of activated sludge with lime stabilization biosolids method are very cheaper than extended aeration activated sludge process about 45 and 55%, respectively.

DISCUSSION

Stability and reuse potential of disposal biosolids form Serkan WWTP: The amounts of VS/TS ratio and SOUR in disposal biosolids from Serkan WWTP are very higher than the criteria's for stabilized biosolids[11]. Therefore, these biosolids are raw and destabilized. Comparison of the microbial quality of disposal biosolids and USEPA criteria showed that the biosolid was not in class A or B, because of, it should not be disposed to environment or reused for any purposes[13,14]. This result is in agreement with the earlier work of Farzadkia[2] on some extended aeration activated sludge WWTP in Tehran, Iran.

At the time of this study, Serkan WWTP biosolids were reused as a fertilizer in farmland, this action cased to environmental pollution and dangerous for public health in this area. For this reason, stabilization of these biosolids before reusing or disposal should be noted intensively.

Efficiency of lime addition for Serkan WWTP disposal biosolids stabilization: For lime stabilization of biosolids, 0.4 g of hydrate lime was added per gram of dry solids, in the first time. Due to the low activated degree of hydrate lime (46.2%) for keeping the pH over than 12, this ratio was added to 0.75 during the time of rector loading. In this step, pH dropped under 12 after 15 day and under 11 after 21 days past and FC was growing from 8th day and increased to 980/g of dry solids of biosoilds after 30 days past.

For removing this problem in the second time, hydrate lime with high-activated degree (77%) was chose and added to biosolids with 0.6 increasing ratio. In this step, pH did not drop under 12 and FC wasn't growing after 30 days past.

For minimization of lime dosage in the third step, 0.21 g of hydrate lime (77%) was added per gram of dry solids of biosolids. In this time, pH dropped under 12 after 15 day and under 11.5 after 30 days past, also FC was growing from 11th day and increased to 900 per gram of dry solids of biosoilds after 30 days past.

In the fourth step, for optimization the lime ratio and improvement the last results, 0.4 g of hydrate lime (77%) was added per gram of dry solids of biosolids. In this step, pH did not drop under 12.5 after 22 days and under 12 after 30 days past, also FC was not growing after 30 days past.

As indicated in Fig. 1 and 2, in the lime addition reactor, pH amounts and FC removal efficiency increases with increasing the lime dosage from 0.2 to 0.6 g $Ca(OH)_2$/g of dry solids of biosolids. However, Fig. 1 and 2 indicate that there is a little benefit in operating the reactor at a lime dosage exceeding 0.4 g Ca $(OH)_2$/g of dry solids of biosolids. Therefore, this amount can be considered as an optimum ratio of lime addition for Serkan WWTP biosolids stabilization.

The results of microbial analyzes showed that lime stabilized biosolids were classified on class B of USEPA category in all of 4 times of reactor operation. Based on the studies conducted by White[15], Collins and Retal [16] Leffler and Drill[17] these stabilized biosolids could be beneficially reused as landfill cover material, poor soil reconditioner and co-composting material. If fertilizer using of disposal biosolids would be noted the microbial quality of biosolids must be improved up to class A of USEPA category[18]. For finding the class A condition in lime-stabilized biosolids, National Lime Association recommends to use of quicklime with exothermic reaction could be noted[3].

The cost analyzes indicated that activated sludge with lime stabilization biosolids method is more cost-effective than extended aeration activated sludge process. A series of studies conducted by National Lime Association, comparing lime stabilization to composting, thermal drying and digestion technologies found that this method has unit costs as mush as 60% lower than alternatives. Reduced capital cost requirements of lime addition are even more dramatic-particularly important for municipalities with limited capital budgets[3,19].

On the basis of the obtained results, activated sludge with lime stabilization biosolids is an efficient and cost-effective method. This method could be well used in municipal and industrial WWTP. Also it is a suitable and cheap substitute for extended aeration activated sludge process. Due to this regard, we intensively recommend to use of this method in WWTP in Iran.

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