USE OF TREATMENT PLANT SLUDGES AS BIOSOLID

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ABSTRACT

This study was conducted to demonstrate the effectiveness of post-lime stabilization process on disinfection of sludge and producing Class B biosolid. Belt filtered sludge samples were obtained from Izmir Çiğli Wastewater Treatment Plant. Samples were stabilized using quicklime in doses ranging from 1 to 25% (w/w). Raw sludge pH values were between 6,48-6,90 with an average 6,69. Lime addition increased the pH to 11,25-12,55. Fecal coliform densities of raw sludge were between $5.72*10^7$-$3.8*10^8$ number/g DM with an average $21.86*10^7$ number/g DM. Metal concentrations were below the allowable limits established for land application of biosolids. The recommended quick lime dose was determined for biosolids in order to achieve the pH-time criteria and the levels of microorganisms required by the US EPA.

ÖZET

Bu çalışma, kireç ile son arıtım prosesinin çamur dezenfeksiyonu ve B sınıfı Biyokatı eldesi üzerine etkisini göstermek amacıyla yürütülmüştür. Belt filtre ile susuzlaştırılmış çamur örnekleri İzmir Çiğli Atıksu Arıtma Tesisi'nden alınmıştır. Örnekler, ağırlıkça %1-25 sönmemiş kireç ilave ile stabilize edilmiştir. Ham çamur pH değeri 6,48-6,90 arasında değişirken, ortalama değer 6,69 olarak belirlenmiştir. Kireç ilavesi çamur pH deeğrini 11,25-12,55 seviyelerine kadar yükseltmiştir. Ham çamurdaki fekal koliform miktarı $5.72*10^7$-$3.8*10^8$ adet/gr kuru madde olarak belirlenmiş ve ortalama $21.86*10^7$ number/gr kuru madde olarak hesaplanmıştır. Örneklerin ağır metal içerikleri, biyokatıların arazide kullanımları için izin verilen sınır değerlerin altında ölçülmüştür. Biyokatılar için önerilen sönmemiş kireç dozu A.B.D Çevre Koruma Ajansı tarafından istenen pH-zaman kriterini ve mikroorganizma seviyesini sağlayacak şekilde belirlenmiştir.

1. Introduction

Utilization of sewage sludge in agriculture is a form of beneficial material recycling which results in the reduced use of commercial chemical fertilizers and recycling of valuable resources. In European Countries more than one third of the total sludge produced is recycled in agriculture (WEB_1, 2005). However, the potential risks associated with the presence of pathogens, heavy metals and organic pollutants are well known, as well as the short and long term effects that these contaminants have on soil, from a microbial and agronomic point of view (Sanchez-Monedero et al., 2003; Capizzi-Banas et al., 2004). Whereas the risk associated with the presence of heavy metals and persistent organic pollutants can only be controlled by limiting the amounts of sludge applied to the soil, the amount of pathogens can be reduced by the sludge stabilization treatment prior to addition to the soil.

Lime stabilization of sludge is an alternative to biological processing because of its low capital and operational costs when compared with the other systems such as digestion or incineration. The process of lime stabilization has been shown to reduce pathogens in sludge, enabling lime-treated sludge to be safely disposed of in landfills or applied to land (Boost, 1998).

In order to protect public health the EEC issued the 86/278/EEC Council Directive and US EPA issued *"40 CFR Part 503 Standards for the use or disposal of sewage sludge"* and this rule became effective on the 22nd of March, 1993. In Turkey, the land application, fairly agricultural utilization, of municipal sludge and treated industrial sludge has been regulated by Regulation of Soil Pollution Control was published in the official gazette of Turkey numbered as 24609 on December 10th of 2001 and issued by the Ministry of Environment and Forestry.

Within the context of this study, it is aimed to investigate the characteristics of both raw sludge and lime-treated biosolids as well as to determine the quicklime doses required to meet the regulations for Class B biosolids.

2. Materials and Methods

The sludge used in the tests was sampled from Izmir Cigli Municipal Wastewater Treatment Plant (ICWWTP). Raw dewatered sludge samples were taken from the outlet of belt press unit of the plant. Sludge samples were collected in plastic containers fitted with a tight lid and stored at 4°C.

Before lime addition, characteristics of raw sludge were examined. Table 1, represents the characteristic of raw sludge. Then, raw sludge samples were mixed with quick lime (CaO) in order to obtain stabilized sludge or biosolids. The dosages range between 1 g -25 g of CaO to 100 g dewatered sludge (1-25% weight/weight). Sludge and lime were mixed manually with a plastic spoon in the plastic bowls.

Table 1. Characterization of raw sludge used in experimental studies

Parameters	Sample 1	Sample 2	Sample 3	Average
pH	6.48	6.90	6.81	6.69
D.M. (%)	16.25	16.77	19.56	17.905
O.M. (%)	71.28	62.13	65.73	66.705
F.C. (number/g DM)	$3.8*10^{8}$	$5.72*10^{7}$	$1.53*10^{8}$	$21.86*10^{7}$
Total P(mg/kg DM)	980	1030	975.5	1002.75
Zn (mg/kg DM)	1510	433.9	456.1	971.95
Cu (mg/kg DM)	174	145.6	125.8	149.9
Cr (mg/kg DM)	114.7	193.2	214.8	164.75
Pb (mg/kg DM)	55	81.1	66.8	68.05

Each sample was analyzed for dry matter (D.M.), organic matter (O.M.), and fecal coliforms according to Standard Methods (APHA, AWWA, WPCF, 1995). Sludge and biosolids pH values were measured in deionized water using 1:2 (w/v) sludge/water ratio according to EPA Method 9045C. Heavy metal analyses were performed using acid extraction procedure EPA Method 3050B. After applying procedure to sludge samples; zinc (Zi), chromium (Cr), lead (Pb), cupper (Cu) concentrations were measured using Ati Unicam 929/1011 AA Spectrometer. Total phosphorus content was measured according to Standard Method 4500-P D. First step was acid extraction of samples. Then, phosphorus contents of standard and sample solutions were determined by using Nova 60 Spectrophotometer.

3. Results and Discussions

3.1 Characteristics of Biosolids

As the raw sludge samples, also lime stabilized sludge characterizations were evaluated. Table 2, Table 3, and Table 4 summarize the biosolids characterization according to the sample number. The pH values represented in tables are measured just after liming.

Table 2. Biosolid characteristics of Sample 1 with respect to various lime doses

Parameters	Raw sludge+%5 CaO (w/w)	Raw sludge+%15 CaO (w/w)	Raw sludge+%25 CaO (w/w)
PH at time=0	12,53	12,55	12,55
D.M. %	22,15	31,53	39,04
O.M.%	44,68	40,28	13,33
F.C. (number/g DM)	993	<159	<128
Total P (mg/kg DM)	720	638	620
Zn (mg/kg DM)	650	768	305,4
Cu (mg/kg DM)	146,6	109,1	70,1
Cr (mg/kg DM)	19,98	16,2	7,8
Pb (mg/kg DM)	11,9	-	-

Table 3. Biosolid characteristics of Sample 2 with respect to various lime doses

Parameters	Raw sludge+ %1 CaO (w/w)	Raw sludge+ %2 CaO (w/w)	Raw sludge+ %3 CaO (w/w)	Raw sludge+ %5 CaO (w/w)	Raw sludge+ %15 CaO (w/w)	Raw sludge+ %25 CaO (w/w)
pH at time=0	11,25	12,34	12,42	12,42	12,45	12,51
DM %	18,04	19,09	19,79	21,99	29,32	38,44
O.M.%	59,96	56,09	54,45	41,86	36,13	16,62
F.C. (number/g DM)	$3,32*10^7$	$2,5*10^6$	44467	2544	1773	208
Total P(mg/kg DM)	880	820	800	795	780	640
Zn(mg/kg DM)	423,4	398,6	377,8	361,4	241,6	249,6
Cu(mg/kg DM)	144,1	140,9	107,32	99,3	72,42	59,1
Cr(mg/kg DM)	173,6	-	-	67,6	37	20,6
Pb(mg/kg DM)	76,8	67,8	50,9	58,6	53,7	48,8

Table 4. Biosolid characteristics of Sample 3 with respect to various lime doses

Parameters	Raw sludge+ %1 CaO (w/w)	Raw sludge+ %2 CaO (w/w)	Raw sludge+ %3 CaO (w/w)	Raw sludge+ %5 CaO (w/w)	Raw sludge+ %15 CaO (w/w)	Raw sludge+ %25 CaO (w/w)
pH at time=0	11,61	12,23	12,53	12,56	12,58	12,62
DM %	20, 825	22,06	22,97	25,11	35,46	42,63
OM%	62,58	58,99	56,18	44, 85	38,56	19,65
F.C. (number/g DM)	$2,3*10^7$	$1,3*10^6$	31345	11150	1128	<938
Total P(mg/kg DM)	824,23	782,96	756,25	737,56	720,31	681,26
Zn(mg/kg DM)	438,8	395,2	379,7	261,4	218,6	199,57
Cu(mg/kg DM)	111,1	108,9	101,53	91,82	79,2	64,23
Cr(mg/kg DM)	198,43	179,22	165,26	142,53	98,51	76,28
Pb(mg/kg DM)	56,23	45,96	38,49	23,25	28,56	12,32

3.2 Changes in pH

The importance of measuring the pH during lime stabilization is based on the relationship of this parameter to pathogen destruction. To produce Class B biosolids, the US EPA requires that the pH must be kept above 12 units for a 2- hour contact time. According to E.U. Working Document, for conventional treatment of biosolids the pH should reach 12 directly after liming and keep it at least 12 for 24 hours. Thus variation of pH was observed:

- just after liming, pH at time 0
- 2 hours later, pH at 2 hrs
- 24 hours later, pH at 24 hrs

Based on the pH value of average of raw sludge and biosolid samples during 24 hours after treatment with different lime dosages, seven series of curves were constructed as shown following in Figure 1.

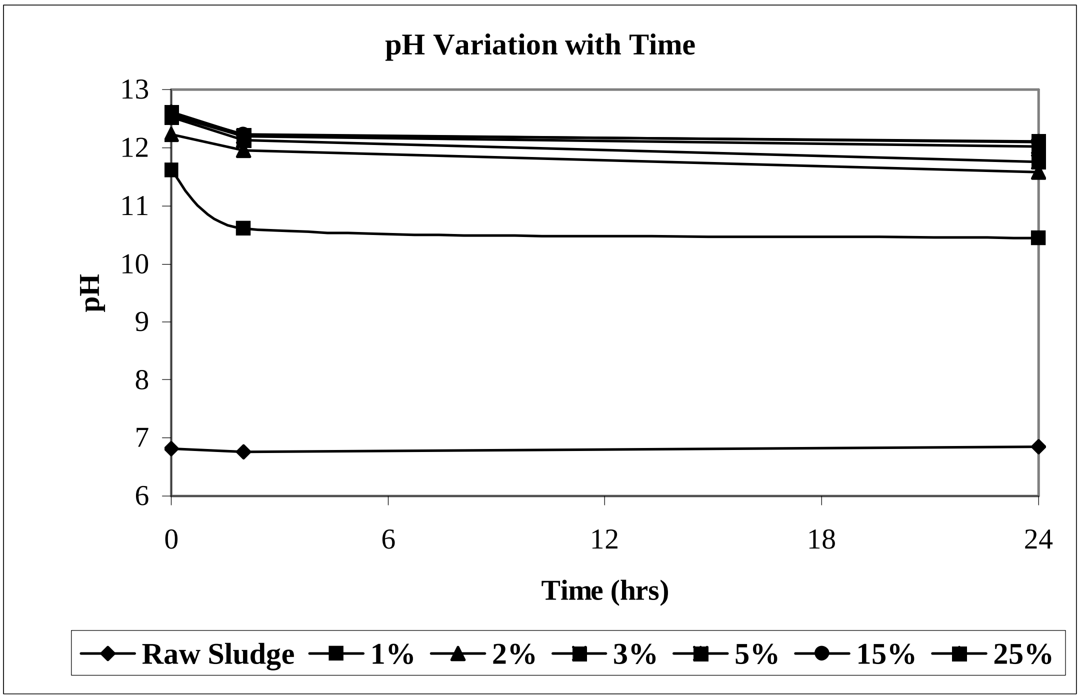

Figure 1. pH variations for biosolids through 24 hours

The average pH of raw sludge is around 6,7. The results show that 1% and 2% (w/w) lime dosages are not sufficient for keeping pH over 12 during 24 hours. Thus, optimum dosage for pH variation was determined as 3% (w/w) lime addition. This value will be compared with the dosage required to reduce density of fecal coliforms below 2×10^6 MPN/g DM.

3.3 Changes in Fecal Coliform Densities

Because the US EPA requires that Class B biosolids have a fecal coliforms density of less than 2×10^{6} MPN per gram of dry matter, this limit was compared with the experimental data to determine the quick lime dose needed to meet this criterion. The average fecal coliform concentrations in samples of dewatered and stabilized sludge are presented in Figure 2. A dose of 2% quicklime was enough to meet the U.S. EPA criterion. However, although this is satisfied, a higher dose was recommended in the previous section because of pH-time requirement.

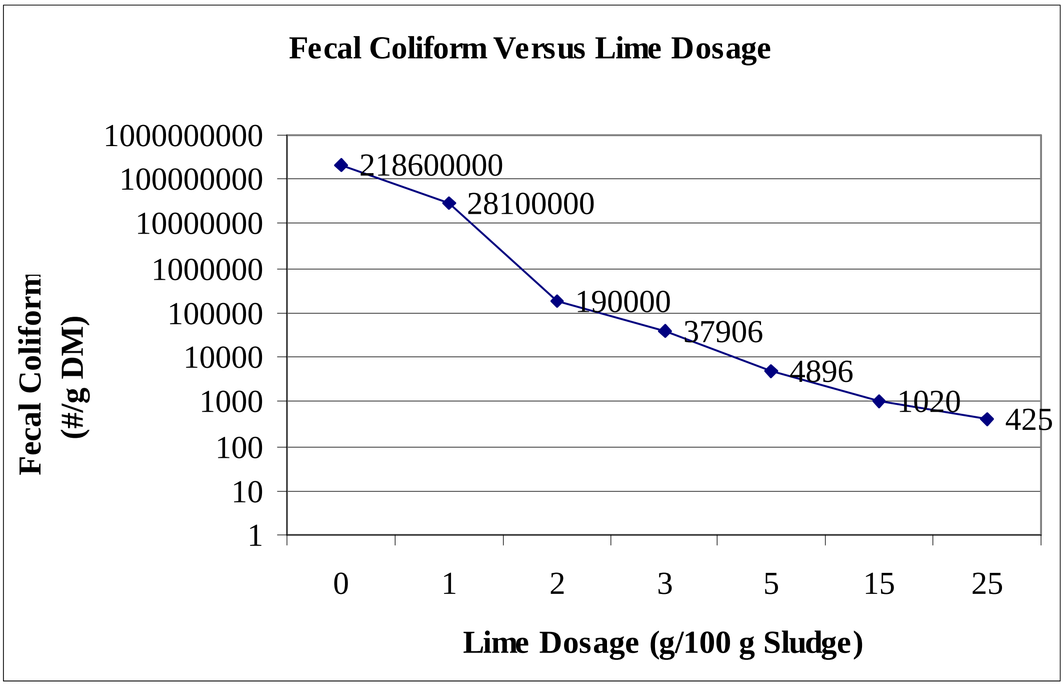

Figure 2. Fecal coliform variations for samples prior and after liming

3.4 Heavy Metals

Metal concentrations in biosolids must meet the limits established by the governments. The importance of limiting their concentration is based on the possibility of their accumulation in soils and thus presenting toxicity and bioaccumulation in some crops (Dinel et al., 2000).

Figure 3, Figure 4, Figure 5 and Figure6 show the average data for Zinc, Chromium, Cupper and Lead. In figures, also maximum allowable limits of US EPA, EU and Turkey regulations for heavy metals are represented.

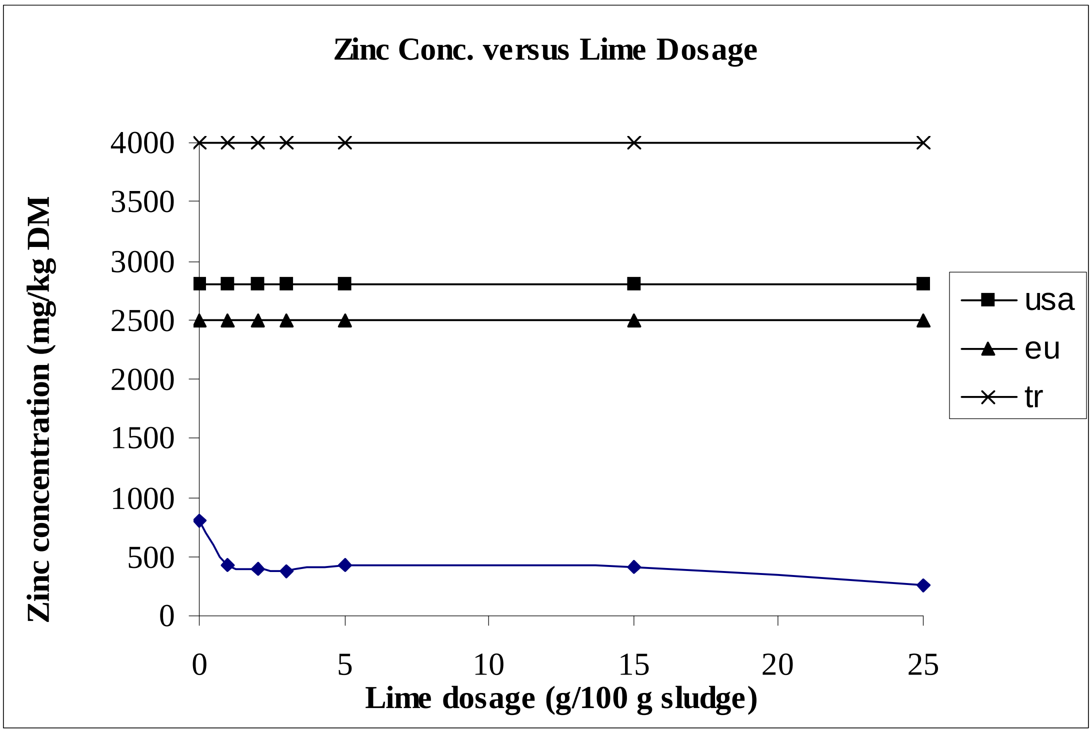

Figure 3. Zinc concentration variation in samples

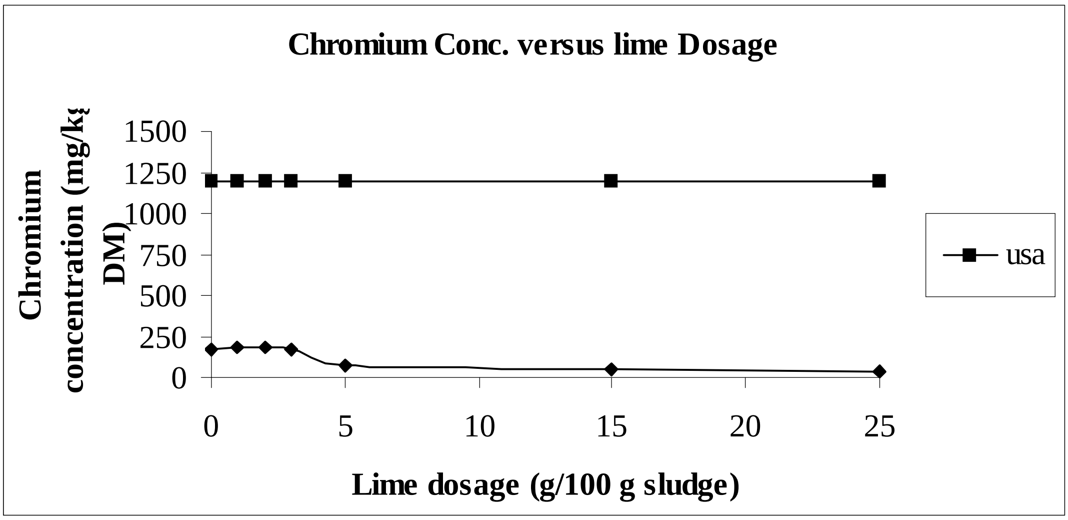

Figure 4. Chromium concentration variation in samples

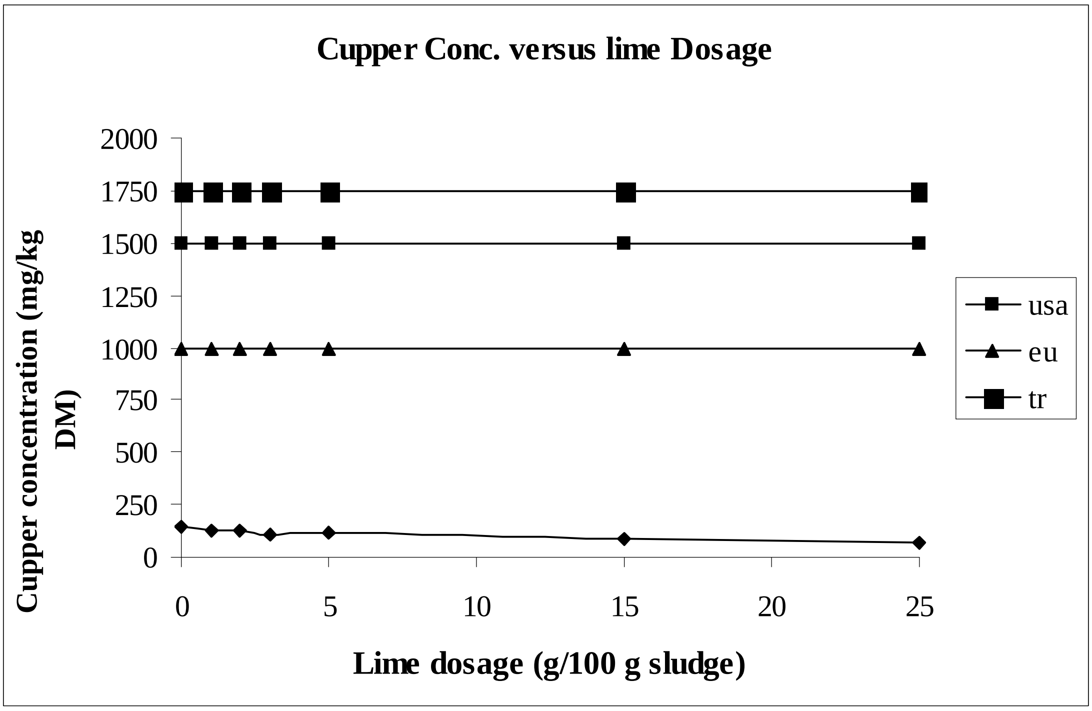

Figure 5. Cupper concentration variation in samples

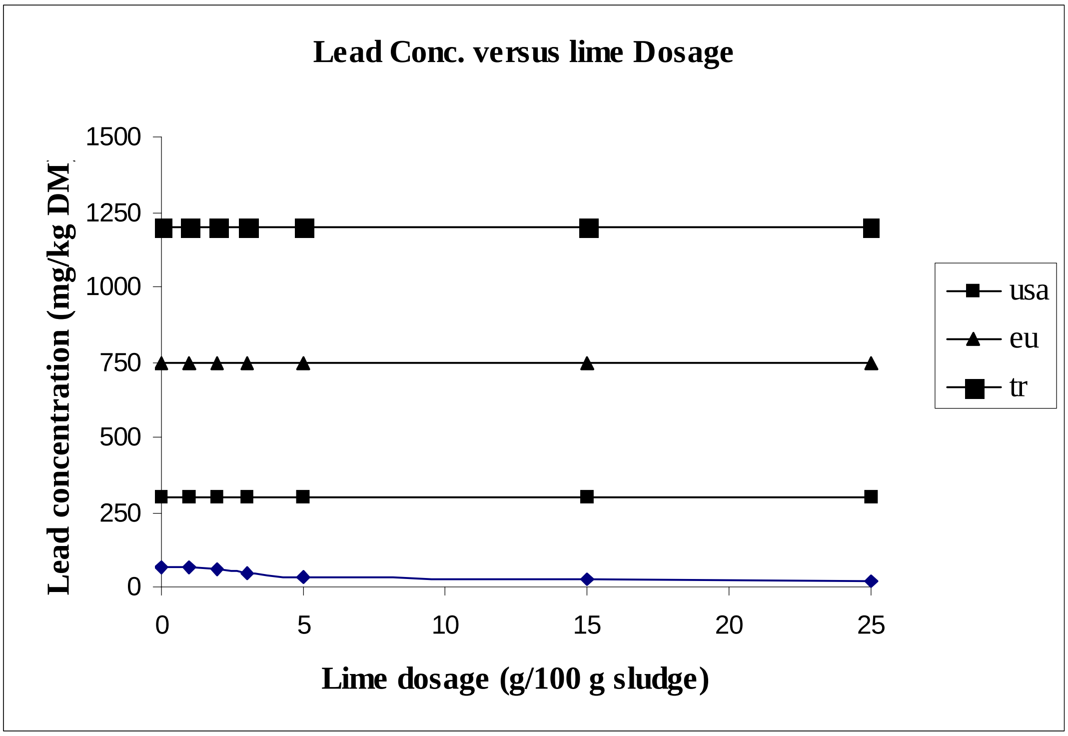

Figure 6. Lead concentration variation in samples

The average values for all metals analyzed were quite below the allowable concentrations for biosolids. The lime addition decreased the metal content. This doesn't imply that that total heavy metals applied to the soil through lime-stabilized sludge would be less than that applied through raw sludge. However, existing rules regulate the heavy metals based on a dry-weight basis, disregarding the fact that sludge treatment influences its dry matter content.

4. Conlusions

This report outlines a sustainable, financially feasible, and effective sludge management strategy. The goal of the proposed sludge treatment system is to convert the waste products produced by the biological treatment plant into a valuable resource for the local community, in a financially and ecologically sustainable manner. By utilizing inexpensive and locally available technologies the sludge can be treated to compliance with U.S. EPA, EU, and Turkey standards for land applied sludge, ensuring the health of the community and environment. The recommended treatment system includes lime addition for disinfection called 'post lime treatment'.

The dose needed to meet the pH criteria higher than 12 units for two hours is higher than the dose needed to reduce the density of fecal coliforms below 2×10^6 MPN per gram of dry matter, which guarantees that the pH-time criteria set by the US EPA are adequate to meet the fecal coliforms requirement.

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