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# Stabilization of Al-Rustamiya Waste Water Treatment Plant Sludge Using Lime

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**Abstract—** Sewage sludge treatment and discarding is a costly and environmentally sensitive problem. Sludge production will continue to increase as new sewage treatment plants are built and environmental quality standards are becoming stricter. The processes of stabilization using alkaline chemicals operating on a simple principle of raising pH to 12 or higher, with efficient mixing time and a suitable contact time ensured that microorganisms are either inactivated or destroyed. A 0.157 $m^3$ rotating tank was designed to treat Al-Rustemeyia wastewater treatment plant's sludge. Characteristics of raw sludge were examined through two parameters: pH, and fecal coliform analysis. Different lime doses of (0- 25) g CaO/100 g sludge were introduced to raw sludge. Samples were mixed manually in a rotating tank. Samples were analyzed 2 hours and 24 hours after mixing by rotation. pH and fecal coliform results were compared with EPA and national Iraqi guidelines. Results showed that 120 g of quicklime per 3 kg of sludge is acceptable to meet Class B criteria and 450 g per 3 kg sludge to meet Class A criteria according to EPA's 40 CFR Part 503.The results indicated that lime treatment to stabilize sludge could be an appropriate solution provided that soil conditions do not deteriorate.

**Keywords—** Wastewater Treatment Plants, Sludge, Biosolids, Fecal Coliforms, Lime.

## 1. Introduction

Sludge disposal is a popular problem to all wastewater treatment plants (WWTPs), as many of non-degradable substances in the influent stream will be transmitted to the sludge phase. Yet part of the sludge may be considered as a resource of nutrients [4]. Nutrients contents and organic matters can be used as soil conditioner or can produce biogas while other part may harm the environment such as heavy metals, organic micro-pollutants and pathogens. The main problem is that the valuable part of matter in the sludge is mixed with other substances; those that may damage the environment [6]. Lime addition for the treatment of sewage sludge is commonly more cost-effective and simpler than other biosolids treatments options and the bacteriological quality of the resultant biosolids is often superior [12]. Sludge treatment plants have high annual cost and intensively need a professional operatory [8]. Thus, cost-effectiveness and simpler methods for sludge stabilization are mostly needed. Lime is added to untreated biosolids in sufficient quantity to raise the pH [14]. The required lime quantity varies with biosolids type and concentration [10]. High pH creates an environment that halts or basically retards the microbial reactions that can else lead to odor production and vector attraction [12]. The process can also inactivate virus, bacteria, and other microorganisms [9]. Most lime treatment facilities have the flexibility to produce either Class A or Class B regulations, where Class A is fecal coliforms density less than 1000 Most Probable Number per gram of sludge (1000 MPN/g Sludge) ,While Class B is less than 2000000 Most Probable Number per gram of sludge (2000000 MPN/g Sludge) thes regulation were recommended by United State Environmental Protection Agency (USEPA) [5]. Lime plays an important role in reducing the microbial content of sludge's pathogens, reducing availability of heavy metals, enhancing the agricultural benefits and lowering the respective environmental threats [11]. Although there is a National Iraqi Standard [7] concerning sludge, sludge disposal, and sludge management, still there are no actual major activities for controlling pollution of WWTPs sludge in

Iraq. Consequently, sludge is generally raw, untreated and is mostly being applied in lands.

To meet Class B criteria, the pH of the sludge must be increased to more than 12 for 2 hours and retained at more than 11.5 for 22 hours. To meet Class A, Class B raised up pH requirements are combined with higher temperatures (70°C for 30 minutes) [2]. On the basis of the classes, the lime-stabilized sludge possibly reused as a cover for solid waste in landfill, marketable manure or soil conditioner [3]. This survey was carried out to study lime addition to Al-Rustemiya WWTP sludge on a pilot scale system, and to evaluate the microbial and soil conditioning quality of the treated sludge.

## 2. *Materils and Methods*

### 2.1 *Tank Design*

A cylindrical tank was designed as a horizontal rotating drum (125 cm long and 40 cm in diameter) containing four adjacent rooms. Each room contains an opening of 13 cm diameter, as shown in Fig (1.a, b). The tank was made of carbon steel. Inside walls were painted with epoxy to avoid corrosion. pH meters (Electronic pH Meter) were fixed on the outside surface with their probes inserted inside the rotating tank. Different mass ratios of sludge and lime were introduced to the rotating tank to ensure complete mixing in a closed chamber.

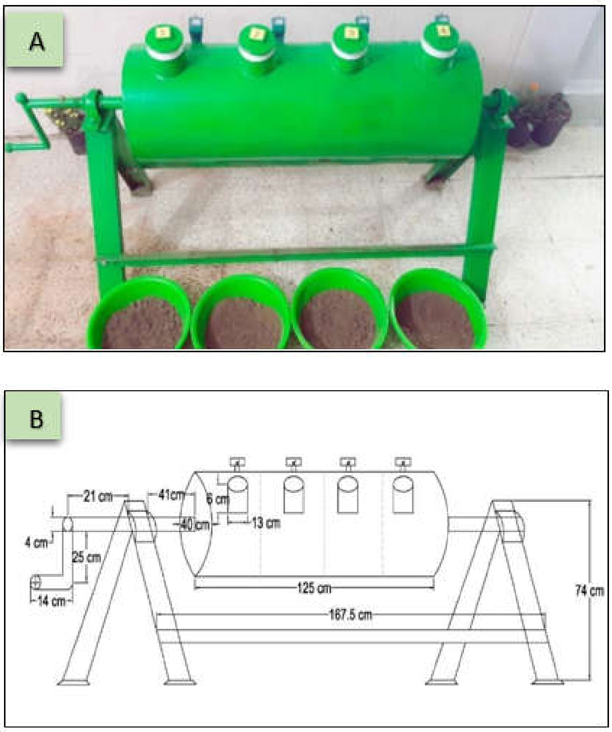


**Figure 1**: (A) Rotating Mixing Tank
(B) A Schematic Diagram of the Rotating Mixing Tank

### 2.2 *Raw Materials*

Raw dewatered sludge samples were collected from the drying bed units of Al-Rustemiyah Wastewater Treatment Plant using plastic containers fitted with a tight lid and stored in isolated cool area. Characteristics of raw sludge were examined through pH, and fecal coliform analysis. Results were reviewed and compared with National Iraqi Standard [7] and EPA's 40 CFR Part 503 regulations for land application [5]. Sample containing (0, 1, 2, 3, 4, 5, 15, 25) g lime for each 100 g sludge were prepared and introduced into the four chambers of the rotating tank consequently as listed in table 1.

**Table 1**: Mass of Sludge to 3kg Lime wt./wt.

| Lime/sludge | Lime (kg) |
|---|---|
| 0g of lime /100g sludge | 0 |
| 1g of lime/100g sludge | 0.03 |
| 2g of lime/100g sludge | 0.06 |
| 3g of lime/100g sludge | 0.09 |
| 4g of lime/100g sludge | 0.12 |
| 5g of lime/100g sludge | 0.15 |
| 15g of lime/100g sludge | 0.45 |
| 25g of lime/100g sludge | 0.75 |

### 2.3 *Analytical Procedure (Characterization of the biosolids)*

#### *2.3.1 pH*

pH analysis becomes a necessitate parameter, since the addition of lime is for the purpose of sterilization, pH should be raised to reach 12 and more if sludge is to be utilized as compost on agricultural lands [13].

#### *2.3.2 Pathogenic Microorganism*

Fecal coliform bacterium densities were measured by method of Total Plate Count [1]. All tests and experiments were held in the Environmental Central Laboratory in Baghdad Environmental Directorate / Ministry of Health and Environment.

## 3. *Results and Discussion*

### *3.1 pH*

pH was recorded through the following frequencies:

- just before liming
- 2 hours later
- 24 hours later

pH of raw sludge was 6.8 on the average. Results showed that (30, 60 and 90) g lime/3 kg sludge dosages were not sufficient for keeping pH over 12 for 24 hours. While, the minimum and best lime dosage was found to be 120 g lime /3 kg sludge that kept pH more than 12 as shown in table 2. This value will be compared with the dosage required to decrease fecal coliform numbers below $2 \times 10^6$ MPN/g sludge.

**Table 2**: pH Variations According to Lime Dosage.

| Dosage lime / 3 Kg of sludge (g) | pH 2hr later | pH 24hr later |
|---|---|---|
| 0 | 6.8 | 7 |
| 30 | 10 | 11.2 |
| 60 | 10.7 | 11.5 |
| 90 | 10.8 | 11.5 |
| 120 | 12.4 | 12.4 |
| 150 | 12.7 | 12.8 |
| 450 | 12.8 | 12.8 |
| 750 | 12.9 | 12.9 |

### *3.2 Pathogenic Microorganism*

Fecal coliform density for raw sludge was ($3 \times 10^8$) MPN/g sludge. Sludge samples were mixed with lime according to the doseges listed in table 3. Samples were analyzed for fecal coliform 2hr and 24hr later to evaluate the destruction or inactivation of pathogenic microorganism. Fecal coliform and pH. Experiment results were compared with USEPA requirements to determine lime best dosage needed. A dose of 120g lime /3 kg sludge was enough to meet the USEPA criterion Class B, while 450g was enough to meet U.S. EPA criterion Class A as shown in Fig.2 and Fig.3 respectively.

**Table 3:** Fecal coliform and pH. data after 2hr and 24hr mixing

| Dosage Lime (g)/ 3 kg sludge | Fecal Coliform (Number/g sludge) 2hr later | pH 2hr later | Fecal Coliform (Number/g sludge) 24hr later | pH After 24hr later |
|---|---|---|---|---|
| **0** | 300000000 | 6.8 | 700000000 | 7 |
| **30** | 56000000 | 10 | 52000000 | 11.2 |
| **60** | 30000000 | 10.7 | 10000000 | 11.5 |
| **90** | 8000000 | 10.8 | 6000000 | 11.5 |
| **120** | 62000 | 12.4 | 50000 | 12.4 |
| **150** | 4300 | 12.7 | 3400 | 12.8 |
| **450** | 1800 | 12.8 | 998 | 12.8 |
| **750** | 325 | 12.9 | 228 | 12.9 |

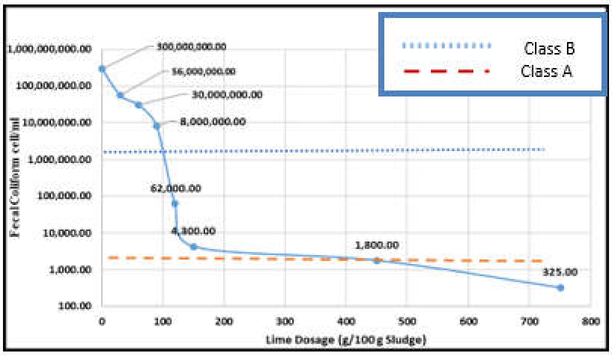


**Figure 2**: Fecal Coliform Count vs. Lime Dosage after 2-hrs of Mixing

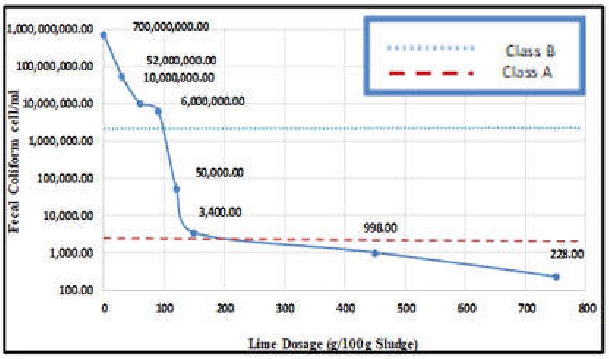


**Figure 3:** Fecal Coliform Variations vs. Lime Dosage after 24-hrs of Mixing.

### *4. Conclusions*

Reliable criteria of USEPA indices and National Iraqi Standard have been relied upon to compare microbial quality of biosolids in Al-Rustemiyah WWTP. Fecal coliform was reduced to 1800 MPN/g sludge after 2hr of mixing, and 998 MPN/g sludge after 24 hr meeting Class A of EPA using 450g lime/3 Kg sludge, at pH 12.8 with 99.99% fecal coliform reduction for both contact times. While for meeting Class B fecal coliform were reduced to 62000 MPN/g sludge after 2hr of mixing achieved a 99.97% fecal coliform reduction and 50000 MPN/g sludge after 24 hr of mixing achieved 99.99% fecal coliform reduction, using 120g lime /3 kg sludge at pH was 12.4.

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# تثبيت حمأة محطة الرستمية لمعالجة مياه الصرف الصحي باستخدام ماء الجير

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**الخلاصة** – تعد معالجة حمأة مياه الصرف الصحي والتخلص منها مشكلة مكلفة وحساسة للبيئة ، وان إنتاج الحمأة مستمر في الزيادة طالما ان هناك محطات جديدة مع ملاحظة تزايد صرامة معايير الجودة البيئية. ان عملية التثبيت باستخدام المواد الكيميائية القلوية التي تعمل على مبدأ بسيط الا وهو رفع الرقم الهيدروجيني إلى 12 أو أعلى ، مع خلط كفوء ووقت اتصال مناسب لضمان تدمير او تعطيل الكائنات الحية الدقيقة. تم تصميم خزان دوار بحجم 0.157 متر مكعب لمعالجة عينات من حمأة الصرف الصحي من محطة معالجة مياه الصرف الصحي في الرستمية. تم فحص خصائص الحمأة الخام من خلال اثنين من المتغيرات: الرقم الهيدروجيني ، وتحليل القولونيات البرازية. باضافة جرعات مختلفة من ماء الجير CaO (0-25) غم لكل 100غم من الحمأة الخام و خلط العينات يدويًا في الأسطوانة الدوارة ثم تحليل العينات بعد 2 و 24 ساعة بعد الخلط وبالتناوب. تمت مقارنة نتائج الأس الهيدروجيني والقولونية البرازية مع محددات وكالة حماية البيئة الامريكية ومسودة التعليمات الوطنية العراقية. أظهرت النتائج أن 120 غم من الجير لكل 3 كغم من الحمأة مقبول لتحقيق معايير الفئة B و 450 غم لكل 3 كغم من الحمأة لتحقيق معايير الفئة A وفقًا لـ EPA’s 40 CFR Part 503 . اثبتت النتائج ان استخدام الجير لتثبيت الحماة هو حل مناسب ولاسيما في الزراعة شرط أن لا تتدهور ظروف التربة.

**الكلمات الرئيسية** –محطات معالجة المياه العادمة ، الحمأة ، المواد الصلبة الحيوية، القولونيات البرازية ، ماء الجير.