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Low Cost Treatments of Sewage Sludge

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المُلخص العربى

كانت أساليب وتقنيات معالجة الحمأة التي يتم تنفيذها في مصر محدودة جدا لسنوات عديدة. وكان الاهتمام الرئيسي لعملية تجفيف الحمأة من خلال أحواض التجفيف الطبيعيه دون أي اهتمام بخصائص أو نوعية الحمأة المنتجة .و في الآونة الأخيرة، كان هناك اهتمام في توسيع استخدام تقنيات وأساليب جديدة لمعالجة الحمأة. وتعتبر طرق التخلص الحالية من حمأة الصرف الصحي قضية بيئية حاسمة في مصر. فاصبح هناك اهتمام متزايد بشأن إدارة الحمأة الناتجه من معالجه مياه الصرف الصحي بسبب المخاطر البيئية، والتي نتجت عن التوسع السريع لمحطات معالجة مياه الصرف الصحى والذى ينعكس في التشريعات المحلية و التي غالبا ما تعتمد ببساطة على لوائح البلدان دون أي محاولة للتكيف مع الأوضاع المحلية.وقد أجريت هذه الدراسة على الفحص الميكروبيولوجي والكيميائي لعدد 8 عينات من حمأة مياه الصرف الصحي مع وبدون إضافات ذات نسب مختلفة effective Microorganisms (EM1) - قش الأرز – خبث افران الحديد - تراب الاسمنت). وقد اسفرت الدراسه عن نتائج : pH (6.55 - 7.98). وكانت أعلى قيمة للمواد العالقة الكليه عند نقطه بدايه التجربه بقيمة (21800 مل جم / لتر)، في حين كانت أقل قيمة (2360 مل جم / لتر) للعينة رقم 6. و كانت أدنى قيمة للاكسجين الكميائى المطلوب والاكسجين البيولوجي المطلوب تم الحصول عليها في العينة رقم 6 بقيمة (2891 مل جم / لتر) و (1321 مل جم / لتر) على التوالي، أما التحاليل البكتيريولوجية فكانت أفضل عملية إزاله لبكتيريا القولون الكليه وبكتيريا القولون البرازيه من خلال إضافة قش الأرز بنسبة 20٪ + 1: EM250 (العينة رقم 6) كانت 96٪ و 76٪ على التوالي .اسفرت النتايج ان المواد المضافة ادت الى تحسين الخواص الكيميائية والميكروبيولوجية لحمأة مياه الصرف الصحى ويمكن استخدامها في المناطق الحضرية حيث تظهر عجزا في مرافق الصرف الصحي الملائمة.

Abstract:

For many years, the methods and technologies for sewage sludge treatment, which are implemented in Egypt, were very limited. The main attention was devoted to the process of sludge drying, mainly through natural drying beds without any interest of the characteristics or quality of the produced sludge. Recently, there is an interest in expanding the use of new techniques and methods for sewage sludge treatment. The present disposal routes of sewage sludge represent a critical environmental issue in Egypt. Recently, there has been an increasing concern about sewage sludge management due to the environmental risks, which resulted from the fast expansion of wastewater treatment plants without equal attention in dealing with the produced sludge Currently, a quite small attention is given to sludge management, which is reflected in the local legislations that often simply depend on regulations of industrialized or more advanced countries without any attempt to adapt it to local situations. This study was conducted on microbiological and chemical examination of 8 samples of sewage sludge with and without additives with different ratios (Effective Microorganisms (EM) - Rice Straw- Slag- Cement dust).From our results the pH ranges (6.55 -7.98).The highest TSS was at (0) time with value (21800 mg/l.), whereas the lowest value was (2360 mg/l) for sample 6. The lowest COD and BOD value obtained at sample 6 with value (2891 mg/l) and (1321mg/l respectively. For bacteriological analyses the best removal for total coliform and fecal coliform count was achieved by addition of 20% rice straw+1:250EM (sample 6) was 96% and 76% respectively. From all results the additives have improved the chemical and microbiological characters of sewage sludge and can be used in the urban areas where they are showing deficits in adequate sanitation facilities.

Keywords: Chemical and Microbiological Characters of Sludge-cementdust-Effective Microorganisms-slag-Rice Straw-Sewage Sludge

Introduction

Municipal wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. It is estimated that under acceptable quantity of water supply each individual contributes approximately 100 liters of wastewater per day to a city's sewerage flow. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum and contaminants resulting from the mixing of wastewaters from different sources [1]

Wastewater needs to be adequately treated prior to disposal or reuse in order to: (a) Protect receiving waters from gross fecal contamination as they are often used as a source of untreated drinking water by downstream communities; (b) Protect receiving waters from deleterious oxygen depletion and ecological damage; and (c) Produce microbiologically safe effluents for agricultural and aqua cultural reuse [2]

Since a long period, Egypt has been concentrating its efforts on sanitation services mainly on wastewater treatment, while little priority has been given to sludge management in practice.

The primary focus of investment has been addressed to water supply, sewerage networks and wastewater treatment. Until 2004, the percentage of population served by wastewater facilities was very low. More than 80 % of the rural areas and about 40 % of the urban areas are showing deficits in adequate sanitation facilities [3].

The sludge disposed during the various wastewater treatment processes can be a major concern for wastewater treatment plants. Most of the water treatment plants in Egypt discharges the sludge into the River Nile with no treatment. The discharging of sludge into water body leads to accumulative rise of aluminum concentrations in water, aquatic organisms, and human bodies. Some researchers have linked aluminum's contributory influence to occurrence of Alzheimer's, children mental retardation, and the common effects of heavy metals accumulation. Consequently stringent standards of effluent discharge are coming into effect, and thus proper management of the sludge becomes inevitable [4].

It is expected that sewage sludge disposal will be one of the most complex environmental problems facing the engineering field in Egypt. In general, sludge that is discharged from treatment plants in the form of dehydrated cakes has a high water content of 75-85 % and one sludge stabilization option is to dry it, which yield a solid that is low in humidity. This solid can be easily stored recycled, or transported to other facilities. Dried sewage sludge can be dumped in landfills, incinerated, or gasificated. Thermal drying is an efficient method that produces a biologically stable material with improved characteristics [5].

Due to the physical-chemical processes involved in the treatment, the sludge tends to concentrate heavy metals and poorly biodegradable trace organic compounds as well as potentially pathogenic organisms (viruses, bacteria etc) present in waste waters. Sludge is, however, rich in nutrients such as nitrogen and phosphorous and contains valuable organic matter that is useful when soils are depleted or subject to erosion. The organic matter and nutrients are the two main elements that make the spreading of this kind of waste on land as a fertilizer or an organic soil improver suitable [6].

Objectives:
This research deals with some points of treating wastewater sludge to investigate the following objectives:

1- Decrease the volume of treated sludge.

2- Increase the performance of the treated sludge

3- The suitable operational doses of EM1, cement dust, slag and rice straw which achieve suitable removal ratios of COD and other parameters complying with Egyptian Environmental laws.

4- Make technical and economical comparison between this developed system and the common conventional treatment system used in Egypt.

5- To reduce the pathogenic organism content and thus to improve the hygienic state of the sludge and to reduce microbiological risks to health and environment.

6- To reduce the fermentation capacity the fresh sludge order to make the treated sludge less odorous.

Materials and Methods
Study Area and Location

Our Sample of sludge was collected after the secondary treatment at south of wastewater treatment plant of 6^{th} of October.

Materials

Our materials are (3-L) glass bottles with closed stoppers, rice straw (RS), effective microorganisms (EM1), cement dust and Slag. Different ratio was added to each glass as follow.

Figure (1) A bench scale reactors were operated at El south waste water treatment plant 6^{th} of October. Batch studies were performed on (3-L) glass bottles with closed stoppers, 2-L working volume

Beaker 1: thickened sludge+1:250 EM1 + 20% R.S

Beaker 2: thickened sludge+1:250 EM1 + 20% R.S + 5% slag (7.5gm)

Beaker 3: thickened sludge+1:250 EM1 + 20% R.S + 4.5 gm cement dust

Beaker 4: thickened sludge+1:250 EM1 + 20% R.S + 3 gm cement dust

Beaker 5: thickened sludge+1:250 EM1 + 20% R.S + 20% slag (30 gm)

Beaker 6: thickened sludge+1:250 EM1 + 20% R.S + 10 % slag (15 gm)

Beaker 7: thickened sludge

Figure (1) Bench Scale

To achieve the study requirements, the following chemical and bacteriological characteristics are investigated according to the American Standards Methods for examination of water and wastewater[7]for zero time at the begging of the study and after 3weeks (pH-TSS-COD-BOD-*Total coliform- Fecal coliform*)

A. Chemical analyses

A.1.pH

The pH of the water samples were measured and recorded by using pH digital meter at the point of sample collection. This was done by deepened the electrodes point of the pH meter in to the water sample for thirty seconds; it was then rinsed with distilled water and deionised water finally. (Orion model 210 A USA).

A.2.Total Suspended Solids (TSS)

TSS was determined according to method 2540, of the American Standard Methods using an accurate sensitive electric balance (Denver instrument model M 220 USA). Electric drying furnace (Merose Park ILI, USA), muffle furnace and filtration equipment include standard glass fiber filter paper of 0.15 μm (Whatman).

A.3.Chemical oxygen demand (COD)

COD was measured according to method 5220, of the American Standard Methods using (LAB-LINE Multi unit Extraction Heater 1090-0866, USA)

A.4.The biochemical oxygen demand (BOD)

BOD was performed according to method 5210 of the American Standard Methods using the standard airtight bottles and dissolved oxygen (DO) meter (YSI Model 51 B SIMPSON Electric Company, ILL 60120, USA).

B.Bacteriological analyses:

Presumption Coliform Count (Multiple Tubes Technique):

Serial dilutions were done for each of our samples then. Fifteen (15) sterile tubes containing inverted Durham tubes examine the tubes to make sure that the inner vial is full of liquid with no air bubbles. Sterilize by autoclaving at 15 lbs pressure (121C°) for 15 minutes., then were arranged and divided into 3 set of five. 10 ml of single strength lauryl tryptose broth (Lab M) medium was dispensed into each of the tube. The first five set were inoculated with 1 ml of the first dilution, then the second five set of the tubes were inoculated with 1 ml of the second dilution, while the third five set of the tubes were inoculated with 1 ml of the third dilution. The tubes were mixed thoroughly and incubated at 37C° for 24 hrs and up to 48 hrs respectively. It were then observed for any formation of gas production or color change of the broth from violet to yellow in the inverted Durham tubes which indicate a positive presumption test.

Confirmatory Total Coliform Test Techniques:

A loooful was taken from the positive culture tubes from the presumption test and inoculated in to Brilliant green broth medium which contains Durham tubes. It was incubated at 37 C^{o} for 24 hrs. It was then observed for the presence of gas production which confirms the presence of total coliform bacteria. Media Sterilized by autoclaving at 15 lbs pressure (121C°) for 15 minutes**.**

Fecal Coliform Test Techniques:

A loooful was taken from the positive culture tubes from the presumption test and inoculated in to EC broth medium and incubated at 44.5 C^{o} for 24 hrs. It was then observed for the presence of growth which confirms the presence of fecal coliform bacteria [8].Sterilize by autoclaving at 15 lbs pressure (121C°) for 15 minutes.

Results and Discussion

A. Chemical analyses

A.1.pH

Figure (2) which represent the pH of selected samples with different concentrations of additives.

pH ranges from 6.55 -7.98 in selected samples. The lowest pH achieved in sample (1: thickened sludge+1:250 EM1 + 20% R.S) which indicate that mixture act to decrease pH during our research. This results agreed with [9].while the highest pH obtained at sample (7: thickened sludge) with pH 7.98. The pH measured values obtained falls within the pH measured values obtained falls within the W.H.O recommended Standard values.

A.2.Total Suspended Solids (TSS)

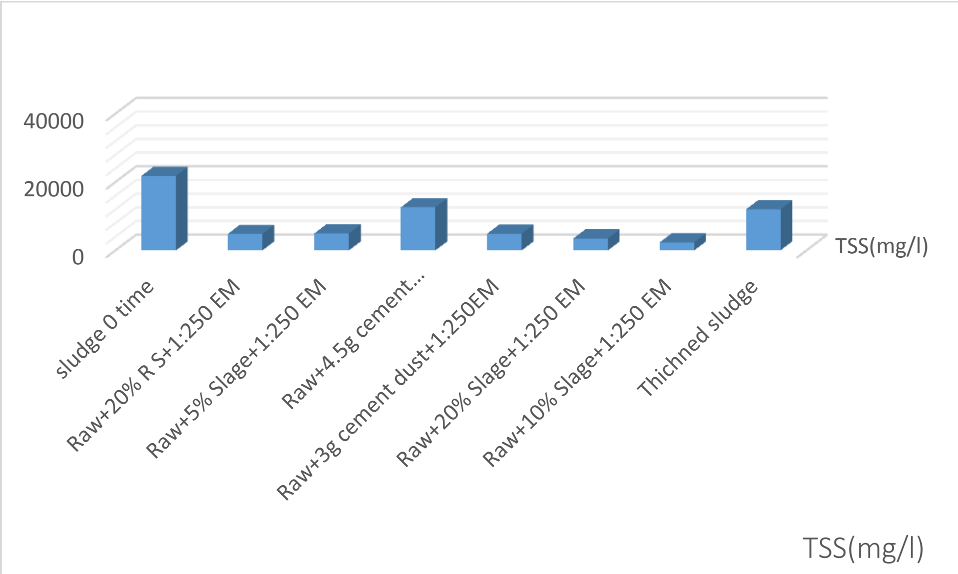

Figure (3) which represent the TSS of selected samples with different concentrations of additives.

From fig (3) TSS has noticed decrease with different additives concentrations. The high removal of TSS obtained at sample (6: thickened sludge+1:250 EM1 + 20% R.S + 10 % slag (15 gm)) with 2360 mg/l while the lowest removal was obtained at sample (0 time) with 21800 mg/l. it is clear that cement addition reduce the sludge volume and as addition increase the reduction increase in sample 4&5 respectively However, it can be inferred that Portland cement is much more viable for inorganic wastes, but not suitable for the organic-high wastes such as sewage sludge This is because organic matters has detrimental effects on the hydration reactions of cement and accordingly lowers the solidification/ stabilization performance. Therefore, recently additives have been used during the cement based solidification/stabilization process in order to improve the influences from the organic matters in sewage sludge Our results agreed with [10].it was clear that the mixed addition of EM1, R.S and slag was very good for TSS reduction The primary and the secondary effects of EM application and reduction of sludge were remarkable [11].

A.3.Chemical oxygen demand (COD)

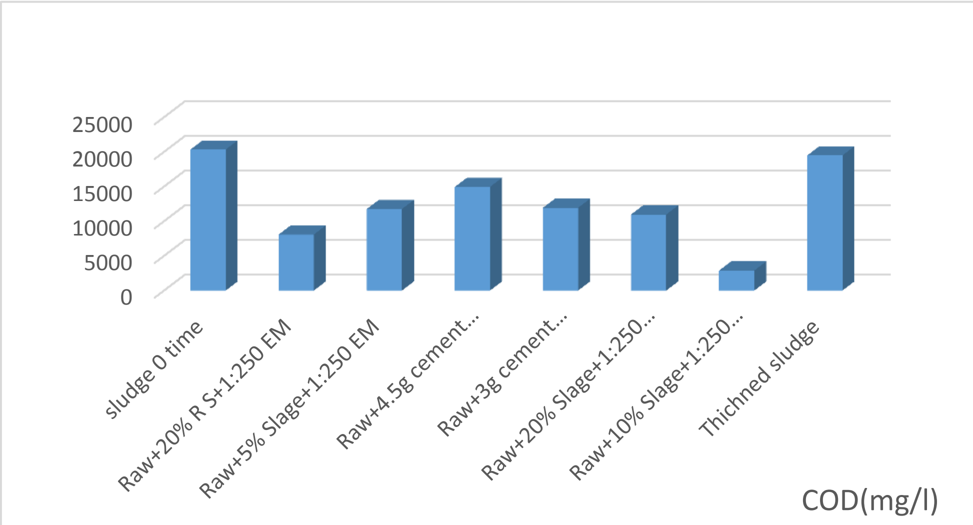

Figure (4) which represent the COD of selected samples with different concentrations of additives.

The high values for COD were observed for samples 0, 7&3 with values20335, 19481and 14939mg/l respectively. Whereas the lowest COD value obtained at sample 6 with value 2891mg/l. it was observed that a by-product from steelmaking process, the steelmaking slag, could be used as an efficient alkaline medium alternative to lime, for the stabilization of sewage sludge. High dosages of slag, up to 20%, were able to produce a mixture with a high pH, and a low content of volatiles, moisture and pathogens. As a result, the proposed method could be used for the stabilization of sludge, taking into consideration that its implementation might have an additional benefit [12].

A.4.The biochemical oxygen demand (BOD)

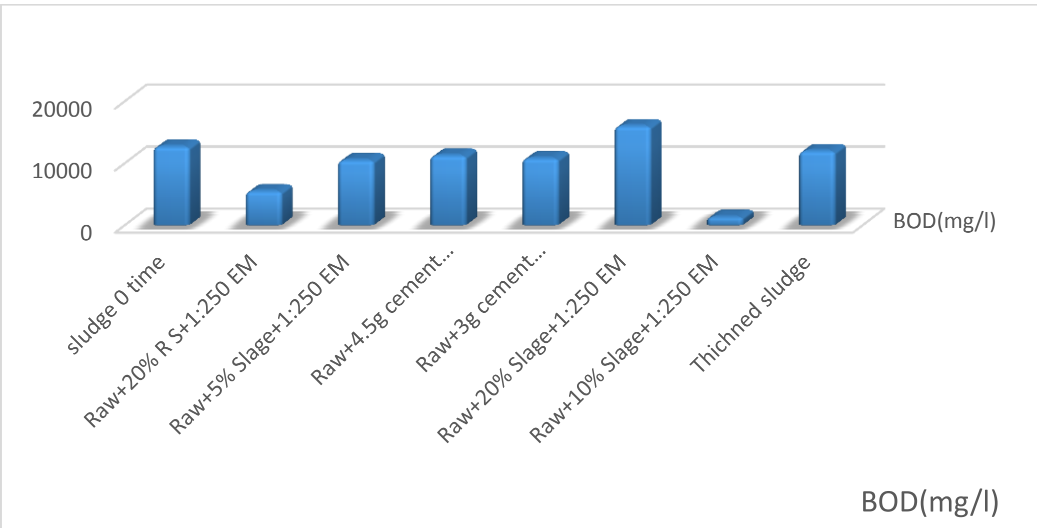

Figure (5) which represent the BOD of selected samples with different concentrations of additives.

The high values for BOD were observed for samples 5, 0&7 with values16005, 12700and 11987mg/l respectively. Whereas the lowest BOD value obtained at sample 6 with value 1321mg/l. it was observed that a by-product from steelmaking process, the steelmaking slag, could be used as an efficient alkaline medium alternative to lime, for the stabilization of sewage sludge. High dosages of slag, up to 20%, were able to produce a mixture with a high pH, and a low content of volatiles, moisture and pathogens. As a result, the proposed method could be used for the stabilization of sludge, taking into consideration that its implementation might have an additional benefit [12].

Bacteriological analyses:

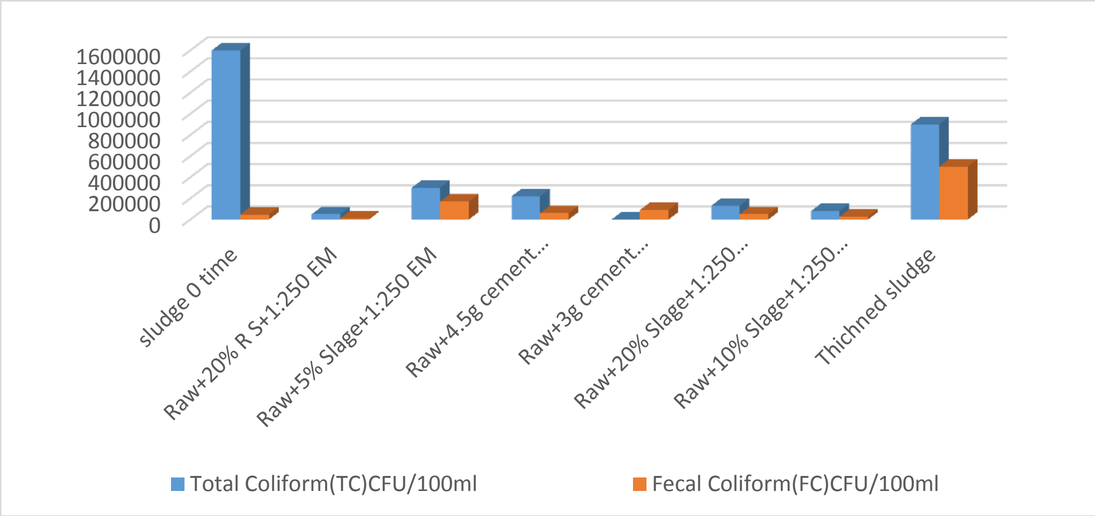

Figure (6) which represent the *Total Coliform* and *Fecal Coliform* of selected samples with different concentrations of additives.

The best removal for total coliform and fecal coliform was obtained at sample (6) with cfu/100 ml $80*10^3$ and $26*10^3$ comparing with (0) time $1600*10^3$ and $47*10^3$ respectively, whereas the highest count with low removal obtained at sample(7) with count $900*10^3$ this agreed with[12].that slag and quicklime eliminated the coliform bacteria.

Finally, The addition of 20 % of the total volume of steel slag to the mixture of sewage sludge, EM1 and rice straw which already has good removal percentage for TSS, COD and BOD, We find that the removal % of TSS is 90 % , COD 86% , BOD 90%. Also addition of rice straw and EM result in removal of 96% of total coliform and 76% of fecal coliform

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