

## Potential of Sewage Sludge as Soil Amendment

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**Abstract.** Nowadays, the volume of sewage sludge is increasing parallel with the increases in population of Malaysia. The cost to treat the sludge is very high and longer time is needed for the treatment. One of the methods that is generally use in Malaysia to treat the sludge is composting but unfortunately this method takes longer duration for the sludge to be treated for used as soil conditioner. Thus, soil amendment is introduced to improve the existing method. Sludge as soil amendment seems to become the ultimate solution for sludge management. This study was conducted to assess the suitability of sewage sludge as soil amendment for plant. Three samples have been prepared for each ratio of dried leaves and lime powder: dried sludge. Proportions of sewage sludge to the dried leaves as used in study are 1:2, 1:3 and 1:4. The results indicated the decreased in heavy metals in the sludge. The additional material for soil amendment is dried leaves and the best mixing proportion is 1:4.

**Keywords:** Sewage sludge, Soil amendment, Plant, Removal, Heavy metal

### 1. Introduction

Management of sludge from wastewater treatment facilities is one of the most critical environmental issues in Malaysia, due to the rapid increasing in sludge production as a result of sewerage extension, new installations and upgrading of existing facilities. Thus, it is necessary to develop a comprehensive plan for different kinds of sludge deriving from wastewater treatment which are produced under different technical, economic and social contexts, which in turn needs different approaches to manage the sludge.

With the rapid developmental growth in the country, volume of wastewater generated will increase annually and volume of sludge produced from wastewater treatment processes will proportionately increase. Based on the perspective sludge production factor (SPF), about 5.3 million m<sup>3</sup> per year sewage sludge was produced by a national sewage company, i.e. Indah Water Konsortium (IWK). The situation concerning sludge treatment and disposal differs as population density and the percentage of inhabitants connected to a wastewater treatment facility varies widely. Therefore, regional sludge production depends not only on the number of inhabitants, but also on the development of wastewater treatments. The combination of both factors results in different solutions for sludge management [1].

While most of treated sludge in Malaysia is still disposed of in landfills, forestry, composting, or agricultural applications of sludge have been studied and gaining acceptance. The amount of sludge produced and treatment options in Malaysia are shown in Table 1.

Sludge as soil amendment seems to become the ultimate solution for sludge management. The product can be useful for reconditioning of sandy and degraded soils for agricultural and forestry development. Due to the hazardous components in sludge, sufficient knowledge is required on the types and characteristics of sludge produced to make an informed judgment on the long-term impact of its utilization [2].

Sludge amendment improves soil properties such as porosity, bulk density, aggregate stability and water retention capacity. The problem related to sewage sludge application arises when it contains high concentrations of potentially toxic heavy metals. The release of heavy metals associated with sewage sludge is strongly influenced by soil pH, cation exchange capacity, organic matter, mobility and speciation of

specific metals. Excessive application of sewage sludge to soil has been found to increase the bioavailability of heavy metals, but the low doses of sewage sludge did not cause a significant increase in heavy metal concentrations. In addition, sludge amendment results in the enhancement of activities in the soil enzymes, as well as soil microbial activity, due to higher organic matter and nutrients availability [3].

Table 1: Amounts of sludge produced, and treatment options in Malaysia [4]

Sludge	Generation rate (million m <sup>3</sup> )	Treatment options (million m <sup>3</sup> )	
		Centralized facilities*	Non-centralized facilities
Sewage sludge	7.40	5.30	2.10
Industrial sludge	9.90	6.40	3.50

\* Bio-Soil (BS), Bio-Filter (BF), Rotating Biological Filter (RBC), Sewage Aeration Treatment System (SATS), Hi-Kleen (HK), Fine Bubble Activated Sludge (FBAS)

The study will focus on the characteristics of sewage sludge and appropriate mixing proportion for the production of soil amendment from sewage sludge. In order to decrease the total quantity of the sludge production in Malaysia, the most feasible and appropriate method to treat the sewage sludge must be determined. Government had been spending more than RM66 million to dispose the sewage sludge. So the method to treat the sludge indirectly can save the cost.

## 2. Methodology

The dried sewage sludge was collected from a local wastewater treatment plant (WWTP), and dried leaves were collected from UTM campus area. Soil and samples were dried and sieved (2 mm) for analytical purposes. Three samples have been prepared for each ratio of dried leaves and lime powder: dried sludge. Addition of lime powder acts as buffer to increase the pH level. Proportions of sewage sludge to the dried leaves as used in the study are 1:2, 1:3 and 1:4. Testing involves determination of metals, characterizing and analyzing representative samples of sewage sludge amendment to meet process optimization safety, compliance and market standard. For this study, the level of metals has been measured to compare the initial and final levels after the sludge have been used for soil amendment. The appropriate method of adjustment must be determined to identify the best mixing proportion for soil amendment. The pH adjustment has been chosen because the sludge is acidic.

Three samples plant have been prepared for each ratio. The plants are planted in the plastic bag with the mixing proportion. The plants are sprinkled three times per day to ensure that the plant have enough supply of water for their growth. The landscape plant (*Coleus blumei*) which is normally easy to grow has been chosen for this study. The plants have been located under the net roof to control the quantity of sunlight and this research has been carried out for three months. The Nitrogen content in the sludge sample was determined by the Kjeldahl method and Phosphorus was measured by spectrophotometer. The levels of metals that have been measured are Copper (Cu), Chromium (Cr) and Zinc (Zn). All analytical measurements performed in this study were conducted according to *Standard Methods for the Examination of Water and Wastewater* [5].

## 3. Results and Discussion

Sewage sludge is a residual product from the treatment of municipal wastewater [6]. Due to seasonal fluctuations and variation wastewater sources, the characteristics of sewage sludge vary both in locale and time [7]. The typical characteristics of raw dried sewage sludge used in this study are shown in Tables 1.1. Sewage sludge usually contains high levels of organic matter and the sludge is also rich in nutrients and heavy metals. In general, the soil pH decreases due to the high organic matter in the sludge.

In order to determine the best mixing proportion of soil amendment, three different ratios have been chosen for the mixing proportion. The ratios are 1:2, 1:3 and 1:4. The ratios represent the quantity of dried leaves and lime powder: sludge. The quantity of dried leaves is fixed, but the quantity of dried sludge is

increases to determine the best mixing proportion for the different quantity value of dried sludge. Three samples plant have been prepared for each ratio. The size of leave and trunk will be measured in order to determine the best mixing proportion of soil amendment. The diameter of leave and trunk of *Coleus blumei* are shown in Table 1.2.

Table 1.1: Characteristics of raw dried sewage sludge obtained from local WWTP

Parameters	Unit	Value
pH		2 to 4
<i>Escherichia coli</i>	MPN	129
Nitrogen (N)	mg/L	24.4
Phosphorus (P)	mg/L	2.50
Copper (Cu)	mg/L	2.10
Chromium (Cr)	mg/L	0.15
Zinc (Zn)	mg/L	1.67

Diameter of trunks and leaf area are important characteristics for growth development and the filling of the landscape plant. The diameter of leave and trunk is increasing for each ratio. After sixth weeks, the diameters of leave and trunk with ratio 1:4 showed the highest increment and that data may represent the growth of the plant. Another two plants also increase in the size of leave and trunk but not as high as ratio of 1:4. The reason for the slower growth is that at the period of time, the quantity of nutrients in the sludge is decreasing. This can be attributed to the differences for each ratio is due to varying quantities of the sludge used. The ratio of 1:4 has the highest increment of the size of trunk and leave because the quantity of sludge in ratio 1:4 is highest. The high quantities of sludge provided more nutrients to the plants. This can lead to the increment of the size of leave and trunk of the plant.

Table 1.2: Diameter of leave and trunk during experiment

Parameters	Ratio	Weeks			Percentage of growth
		1	3	6	
Diameter of leaves	1:2	7.0	7.5	9.5	26
Diameter of trunk		0.4	0.5	0.5	20
Diameter of leaves	1:3	7.0	7.5	9.0	22
Diameter of trunk		0.4	0.5	1.0	60
Diameter of leaves	1:4	7.0	9.0	11.0	26
Diameter of trunk		0.4	0.5	1.2	67

The plant test showed that application of dried sewage sludge as soil amendment lead to a significant increase of diameter of leaves and trunk, which is attributed to the fertilizing effect of the compost in phosphorus, nitrogen, and humic substances. Sewage sludge contains essential plant nutrients, primarily nitrogen and phosphorus. Depending on treatment method; sludge also contains approximately 30% organic matter. The organic matter in sludge is a key component to its success as an organic amendment. Other trace nutrients are potassium, calcium, magnesium, sulfur, and sodium, boron, manganese, copper, molybdenum, and zinc [6]. Sewage sludge is a convenient amendment because it has many fertilizer constituents in one application.

Problems associated with sewage sludge are the presence of trace elements, toxic organics, and pathogens, such as bacteria and viruses [6, 8]. Pre-treatments at wastewater plants can often minimize these contaminants. Trace elements of concerned are those not essential for plant growth, including cadmium, chromium, mercury, nickel, and lead. Some trace elements (lead and mercury) are highly insoluble or are adsorbed in the organic matter or plant roots and become unavailable. Accumulations of the metals in plants

are unlikely, except for plants that actively uptake the metals through their roots or leaves. The other elements can be accumulated in plant tissue [8].

The concentrations of Cu and Cr, and Zn in sludge have been determined before the sludge was used as soil amendment. Cu was the most abundant metal, followed by Zn and Cr. After six weeks, the concentrations of trace metals in sludge were decreased. The ratio 1:4 shows the highest difference between the initial and final reading. However, other two ratios also showed decreasing values although the values are slightly difference with the value of ratio 1:4. Table 1.3 shows the percentage difference between initial reading and final reading after six weeks.

Table 1.3: Concentration of heavy metals in the dried sludge

Parameters	Ratio	Initial concentration (mg/L)	Concentration (mg/L)		Percentage of removal
			3-weeks	6-weeks	
Cu	1:2	1.23	1.15	0.55	55
	1:3	1.47	1.35	0.52	64
	1:4	1.55	1.50	0.30	80
Cr	1:2	0.10	0.10	0.08	20
	1:3	0.08	0.07	0.05	38
	1:4	0.07	0.05	0.03	57
Zn	1:2	0.83	0.61	0.43	48
	1:3	1.35	1.17	1.09	19
	1:4	1.44	1.10	0.60	58

Copper is one of the most important, essential elements for plants and animals. The decrease in Cu concentrations in the soil during the experiment is possibly due to the absorption of Cu in the roots that can be used for the growth of the plant. Alloway [6] reported that much of the Cu taken up into the roots might not be translocated into the shoot.

The differences of removal concentration of both trace metals (Cr and Zn) for each ratio are quite similar to that of Cu concentration. Most of plants absorb relatively slight Cr and compared to the other heavy metals. But the plants still absorb Cr to grow. According to Clapp *et al.*, [9] although it is generally considered that Cr is not essential for plant growth, there have been several reports of slight yield increases due to Cr additions. These increases may be associated with release of other ions for example manganese that plants require as nutrients. In addition, the results showed this metal and its toxic products did not affect plant growth after the application of sewage sludge as soil amendment.

#### 4. Conclusion

Application of sewage sludge in landscape provides essential nutrients for plant growth and it reduces environmental and economic considerations that limit disposal in landfill or incineration. In this study the effect of sewage on landscape plant growth on different ratio of dried sludge and dried leaves was monitored. The sludge contains heavy metals such as Cu, Cr and Zn, and the level of heavy metals are 2.10mg/L, 0.15 mg/L and 1.67mg/L. The mixing proportion is suitable with the plants as the size of leaves and trunks of plants are increasing by days. The additional material that can enhance the quality of sludge as soil amendment is dry leaves. Dry leaves are material that easy and faster to degrade and contain a lot of nutrients. The best mixing proportion of dried leaves:sludge is ratio of 1:4. The growth of plant for this ratio is faster than another two ratios.

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