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PREPARATION AND UTILIZATION OF BIOSOLID FERTILIZER USING MUNICIPAL SEWAGE SLUDGE*

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Abstract

In the present work, biosolids were prepared from municipal sewage sludges. Municipal sewage sludge was treated to form biosolids by processes such as dewatering, sludge pasteurization, anaerobic digestion, aerobic digestion, composting, and storage. The different sewage sludge fertilizers, S1 and S2 were prepared. S1 contained only biosolid and S2 contained in the weight ratios of (1:1:1) of biosolid, rice husk ash and cocopeat. And then, some physicochemical properties and micro-macro nutrients of biosolids fertilizers were qualitatively and quantitatively characterized by EDXRF, AAS methods, and other conventional methods. By using biosolids fertilizer, a field experiment was conducted to test with mung beans. These mung bean seeds were collected from Yezin Agricultural University, Pyinmana Township, Naypyidaw. The field experiment was laid out using a randomized complete block design (RCBD), with six treatments (T1-T6). Physicochemical parameters and micro-macro nutrients of soil samples before sowing and after harvesting were analyzed. The results from the study indicated that the prepared biosolid fertilizers can effectively reduce the use of chemical fertilizers for the growth and production of mung beans. To know the presence of beneficial or non–beneficial microbes in biosolids, microbial tests were studied by total plate count methods.

Keywords: biosolids fertilizer, sewage sludge, mung beans, micro-macro nutrients

Introduction

Farmers have known for centuries that animal manures spread on pastures and cropland can improve soil fertility (Gupta, 2000). They began to use sludge from municipal wastewater treatment plants as a fertilizer. “Sewage Sludge” refers to the solids separated during the treatment of municipal waste water. “Biosolids” refers to treated sewage sludge that meets the EPA pollutant and pathogen requirements for land application and surface disposal (Adamtey, *et al.,* 2010).

The scientific and agricultural communities have come to understand that municipal sludge or "biosolids" contain valuable nutrients and organic matter that improve the soil in a way similar to animal manures (Kone *et al*., 2007). Biosolids are organic solids that have been treated to stabilize organic matter and reduce disease-causing organisms or pathogens. The greatest advantage is a reduction in fertilizer costs (Nikiema *et al*., 2013). Biosolids also contain nitrogen, phosphorus and many micronutrients that can be beneficial to crop growth (Cofie *et al*., 2009). Other advantage is the addition of organic matter to the soil (Nair, 2008). Organic matter reduces surface runoff, reduces erosion and improves the water holding capacity and nutrient of the soil. Mung beans are a nutritionally various food that belongs to the legume family. Other names for mung beans include green gram, maash, moong, monggo, or munggo. They are mainly cultivated in Asia, Africa, and South America, but mung beans are enjoyed by people all around the world.

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Mung beans are a rich source of plant-based protein, complex carbohydrates, fiber, and other nutrients. Mung beans that are usually green, but can also be yellow or black. Add them to soups, salads, and casseroles (Sayed, 2020). They are widely used in India to make curries. In Myanmar, mung beans are among the types of bean that are exported abroad. The aim of the research work is to prepare effective biosolid fertilizers using municipal sewage sludge for agricultural productivity.

Materials and Methods

Sample Collection, Preparation and Application

The sewage sludges were collected from Yangon City Development Committee (YCDC), Botahtaung Township, Yangon Region. The raw materials (cocopeat and rice husk ash) were collected from Hlaing Thar Yar Industrial Zone, Yangon Region. Municipal sewage sludge was treated by processes that included dewatering, sludge pasteurization, anaerobic digestion, aerobic digestion, composting and storage. The fertilizers were packaged in bags, stored in a cool place. By using biosolids fertilizers, the trials were carried out during the 2022 winter season in Kha Yaung Village, Hlegu Township, Yangon Region. The average maximum and minimum temperatures of the experimental sites were 34 and 19 ℃, respectively. The experiment was laid out using a randomized complete block design (RCBD). The area of each plot was (30×24) sq ft. The row spacing and plant spacing were 10 and 6 inches in six treatments, respectively. The treatments used in this research were

T1 = control,

T2 = compound fertilizer (NPK 15:15:15) [50 kg/ac],

T3 = biosolid [200 kg/ac],

T4 = biosolid: cocopeat: rice husk ash (1:1:1) [Used 200 kg in 1 ac],

T5 = biosolid [200 kg/ac] + compound fertilizer [33.3 kg/ac],

T6 = biosolid [200 kg/ac] + compound fertilizer [25 kg/ac].

Determination of Physicochemical properties, Nutrient Values, Elemental Analysis and Microbial Analysis of Prepared Fertilizers

Some physicochemical properties (pH, moisture content, electrical conductivity, NPK contents) of biosolids (S1) were determined. Measurement of pH was carried by a pH meter and the moisture content was determined by moisture analyzer. The electrical conductivity of biosolids fertilizers was determined by conductivity meter. The nitrogen content was determined by Kjeldahl’s method. The potassium content was determined by Flame photometric technique and the phosphorus content was determined by UV-visible spectrophotometric technique (Thet Su Min, 2018). Elemental contents of raw materials and biosolids fertilizer were semi-quantitatively determined by using EDXRF technique and also quantitatively determined by AAS technique. Six treatments T1 to T6 were analyzed by conventional and modern techniques before sowing and after harvesting. Soil texture was determined by international pipette method. Available potassium, exchangeable calcium, magnesium and potassium in the soil were determined by AAS. In the analytical procedures of the experiment, recommended methods and technique were applied (AOAC, 2000). Microbial population in S1 was determined by total plate count method. Figure 1 shows the photographs of sewage sludge and biosolid (treated sewage sludge).

(a) **(b)**

Figure 1. Photograph of (a) sewage sludge (b) biosolid (treated sewage sludge)

Results and Discussion

Some Physicochemical Properties, Nutrients and Microbial Analysis of Biosolids

Table 1 represents the moisture content, electrical conductivity, pH, bulk density, organic carbon content, humus and C: N ratio of biosolids. It was found that acceptable value of moisture content, electrical conductivity, and pH. The pH value (7.70) of biosolids are found to be suitable for the preparation of biosolid fertilizer. The bulk density was found to be 0.87. So, it has high porosity. Both bulk density and porosity give a good indication of the suitability for root growth, and soil permeability is vitally important for the soil-plant atmosphere system and medium organic carbon and humus percent. The C: N were calculated at the value of 32.50. Total organic matter plays a very important and sometimes spectacular role in the maintenance and improvement of soil properties.

Table 2 shows that biosolid contains 1.26 % nitrogen, 2.10 % phosphorus, and 0.04 % potassium. It was found that the amount of nitrogen and phosphorus is high in biosolids. From these data, biosolids contained the macronutrients (NPK) for plants and soil fertility. Therefore, biosolid was used for the preparation of biosolid fertilizers.

Table 3 shows the determination of microbes in biosolids. It was found that yeast and mould population were found to be 5 x 10^5 cfu/g and *Bacillus subtilis* was 5 x 10^3 cfu/g. The complex plant-microbe could be beneficial for both crop productivity and the well-being of soil microbiota. The harmful bacteria such as, *E. coli*, *Coliform*, and *Salmonella* were not detected.

Table 1. Some Physicochemical Properties and Nutrients of Biosolid

Parameters	Content
moisture (%)	19.15
electrical conductivity (µ S/cm)	158.00
pH	7.70
bulk density (g/mL)	0.87
organic carbon (%)	40.95
humus (%)	70.59
C:N	32.50

Table 2. N, P and K Content of Biosolid

Nutrient	Content (%)
Nitrogen	1.26
Phosphorus	2.10
Potassium	0.04

Table 3. Microbial Analysis of Biosolid

Microbes	Population (cfu/g)
yeast and mold	5×10^5
E. coli	ND
Coliform	ND
Salmonella	ND
Bacillus subtilis	5×10^3

Relative Abundance of Some Elemental Contents in Biosolid

The relative abundance of some elements in biosolid from sewage sludges was determined by EDXRF technique. It was observed that biosolids contained fourteen elements (Si, K, Ca, Mn, Fe, Zn, Cu, S, Ti, Pb, Zr, Sr, Ni and Cr) as shown in Table 4. It can be said that biosolid can supply, multi nutrients to soil and plants. And then, the exact amount of some nutrient elements determined by AAS method. Fe (5.64 ppm) Cu (1.13 ppm) and K (1.04 ppm). The sufficient amount of macro-and micro nutrients were found to be present in biosolid fertilizers. So, it can be summarized that biosolids may be a good source of elemental nutrients for plants.

Figure 2. EDXRF spectrum of treated sewage sludge (Biosolid)

Table 4. Relative Abundance of Some Elements in Biosolid by EDXRF

Element	Relative abundance (%)
	Biosolid
Si	28.28
K	4.47
Ca	6.69
Mn	1.47
Fe	49.14
Zn	2.96
Cu	1.25
S	2.22
Ti	2.97
Pb	0.45
Zr	0.42
Sr	0.36
Ni	0.19
Cr	0.15

Table 5. Elemental Contents of Biosolid by AAS

Element	Content (ppm)
Ca	0.17
Cu	1.13
Cr	0.02
K	1.04
Zn	0.51
Fe	5.64
Mn	0.67
S	17.00
Pb	ND

Analysis of Five Treated Soil and Control before Sowing

The physicochemical properties of treated soils before sowing of the mung bean plant were studied. These soils were subjected to five different treatments (T2 – T6) by using cocopeat, rice husk ash, and chemical fertilizer. The soil without any fertilizers treatment (T1) was kept as a control. These trial farm soils were analyzed for their physical and chemical properties. The results are shown in Table 6. From these results, based on the soil texture diagram, all farm soils (before sowing) falls in the loam. The pH values of treated soils were found to be in the range of 5.99 to 6.86, slightly acidic type of soil. Soil pH may influence nutrient absorption and plant growth.

Table 6. Analysis Data of the Soil before Sowing

Analytical Item	Content					
	T1	T2	T3	T4	T5	T6
texture- sand (%)	43.40	43.75	40.91	39.62	41.00	41.68
silt (%)	36.90	36.85	40.95	39.98	39.87	39.00
clay (%)	19.70	19.40	18.14	20.40	19.13	19.32
moisture (%)	4.89	5.00	3.45	3.00	3.20	2.55
pH	6.86	6.10	6.14	6.09	5.99	6.00
electrical conductivity (µS/cm)	51.00	75.00	70.90	82.1	70.00	69.20
organic Carbon (%)	0.75	2.00	1.50	1.76	1.75	1.40
humus (%)	1.29	3.45	2.59	3.03	3.02	2.41
total N (%)	0.16	0.30	0.20	0.23	0.38	0.25
C/N ratio	4.69	6.67	7.50	7.65	4.60	5.60
available P (ppm)	20.00	36.00	33.35	31.35	32.50	31.95
available K_2O (mg/100 g)	15.60	19.00	17.75	18.10	18.23	18.00
exchangeable Ca (meq/100 g)	11.31	18.00	15.45	14.50	14.80	15.00
exchangeable Mg (meq/100 g)	0.67	0.50	0.39	0.49	0.52	0.55
exchangeable K (meq/100 g)	0.33	1.60	0.70	0.85	1.50	1.10

Analysis of Soil after Harvesting Mung Bean

Based on the soil texture diagram, all types of soils (T1- T6) are loam and so they cannot be changed before and after harvesting. The pH values of these soils were increased from 6.40 to 7.00. In addition, the amounts of total N, available P and K, and exchangeable Ca. Mg, K in all treatments(T1-T6) were reduced as compared to treated soil (T1-T6) before sowing. It can be said that, the mung bean plants consumed the necessary nutrients from treated soils (T1-T6).

Table 7. Analysis Data of Soil after Harvesting Mung Bean

Analytical item	Content					
	T1	T2	T3	T4	T5	T6
texture-sand (%)	43.00	43.10	40.76	39.54	40.31	41.11
silt (%)	36.40	36.50	40.00	39.76	39.47	38.31
clay (%)	20.60	20.40	19.24	21.20	20.22	20.58
moisture (%)	3.15	4.95	2.38	2.35	2.85	2.25
pH	7.00	6.40	6.50	6.40	6.50	6.70
electrical Conductivity (µS/cm)	47.20	74.20	75.70	55.30	59.50	62.50
organic Carbon (%)	0.72	1.90	1.20	1.50	1.70	1.32
humus (%)	1.24	3.78	2.06	2.59	2.93	2.28
total N (%)	0.10	0.22	0.16	0.17	0.20	0.19
C/N ratio	7.20	8.64	7.50	8.82	8.50	6.94
available P (ppm)	16.00	30.00	27.05	25.00	28.90	27.45
available K_2O (mg/100 g)	14.00	16.50	15.98	15.36	15.42	15.33
exchangeable Ca (meq/100 g)	10.00	14.00	13.65	13.00	14.21	14.10
exchangeable Mg(meq/100 g)	0.50	0.49	0.34	0.40	0.42	0.45
exchangeable K (meq/100 g)	0.33	1.50	0.68	0.80	1.20	0.92

Effect of Biosolid Fertilizer on Growth and Yield of Mung Beans

The time interval from transplanting to harvesting was 82 days. The growth factors of the mung bean were evaluated in terms of the plant height (cm), number of branch, number of pod/plant, number of seed/pod, 100 seed weight (g), yield (g/m^2) yield (basket/ac) and shown in Table 8. It was significantly different in plant height, number of pod/plant, number of seed/pod between (T2- T6) soil and control (T1). It was slightly different in branch and 100 seeds weight for all treatments. From this research, it was clearly observed that the yields of mung beans (T2-T6) were higher than control (T1). The yield of mung beans in T2 was the highest. The second and third highest yields were observed in T5 and T6. So, it can be said that sewage sludge (biosolid) can be used to reduce the use of chemical fertilizers in mung beans planting.

(a)

(b)

Figure 3. Photographs of (a) field of mung beans and (b) growth of mung beans

Table 8. Effect of Biosolid Fertilizer on Growth and Yield of Mung Bean

Treatment	Plant height (cm)	No. of branch	No. of pod/ plant	No. of seed/pod	100 seed weight (g)	Yield (g/m^2)	Yield (basket/ac)
T1	53.6	1.0	9.1	9.2	2.18	63	7.70
T2	63.3	1.2	14.3	10.8	2.24	91	11.12
T3	64.1	1.2	13.5	11.0	2.21	79	9.53
T4	61.4	1.2	17.8	11.6	2.25	75	9.17
T5	65.6	1.4	16.4	11.2	2.30	90	11.00
T6	62.6	1.2	14.1	12.0	2.26	86	10.51

Conclusion

In this research, municipal sewage sludge was treated to prepare biosolid by processing such as dewatering, sludge pasteurization, anaerobic digestion, aerobic digestion, composting and storage. The three different fertilizers (T4 -T6) were prepared using biosolids from sewage sludge, chemical fertilizer (compound 15:15:15). In addition, T1 (control), T2 (only compound 15:15:15) and T3 (only biosolid) were also used to study. According to the physicochemical properties and micro- and macro--nutrients, it can be said that, all fertilizers are suitable for plant growth. In this work, field experiments using (T1-T6) were conducted to know the effect of biosolid on plant growth and yield of mung bean. From the results, the yield of T2, T5 and T6 are leading runners (11.12, 11.00, 10.51 basket/ac). The yields of T5 and T6 (Biosolid plus compound fertilizers) are not significantly different compared to T2 (compound fertilizer). So, it can be concluded that biosolid obtained from sewage sludge can effectively be used as a partial substitute for chemical fertilizer in mung bean planting fields. Moreover, the biosolid from sewage sludge only contains beneficial microbes; but non-beneficial microbes are absent.

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