Nutrients Content of Sewage Sludge and Its Utilization towards Horticulture Plant

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Abstract
This study focused on the content of nutrients in sewage sludge as well as to study the feasibility of sludge application as fertilizer by comparing the nutrient content in sludge and chemical fertilizer. The chosen plant is Abelmoschus esculentus. The results shown that the contents of nitrogen, phosphorus, potassium and sulphur of sludge obtained from MSTP were 60.4 mg/L, 45.3 mg/L, 3.5 mg/L and 15.9 mg/L respectively. The values of concentrations were much lower than the concentrations of nutrients in fertilizer sold in the market. The contents of nutrients in sludge had indicated significant results as it facilitates the growth of Abelmoschus esculentus throughout the study

Keywords: Sewage sludge, nutrient; fertilizer, Abelmoschus esculentus, plant growth

INTRODUCTION
Generally, the components of sewage sludge can be categorised into 3 which are human, animal and food waste. Even though the implementation of direct application of the wastes on the plants are being practised nowadays, but the systematic application of treated or untreated sewage sludge remains a problem to the community surround the world. In 1559 at Germany, sewage was allowed to flow out onto the land used for the purpose of growing crops (Cecil et.al., 1998). Starting from that year, the concept of sewage farm which the farm is being irrigated and further fertilised by raw sewage was then being introduced (Casado-vela et.al., 2007). Cecil et.al. (1998) had also claimed that there were large areas of cropland that being irrigated with raw sludge in Berlin, Germany as well as in Melbourne, Australia. The concept eventually gained wide acceptance throughout the region in Europe and mainly in United States. Upon the implementation, there is still a lot of debate regarding the safety of treated sludge application on land (Emongor and Ramolemana, 2004; Singh and Agraval, 2007; Wang, 2008). In 1997, United States oversaw 54% of sludge and biosolids in land application while in 1999 in Europe, 36.4% of the biosolids was being used in agriculture (Spellman, 1997; Epstein, 2001; 2003).

In Malaysia, domestic wastewater is treated separately from industrial wastewater, which later generates safer sewage sludge in terms of environmental and human health aspects. According to IWK (2008), there are so far a total of 9000 sewage treatment plants serving a population of 15,000,000 in Malaysia. However, the treated sludge is commonly being disposed either at landfills or being burned in incinerators (Bradley and Dhanagunan, 2004). Based on 9th Malaysia Plan, the government is now moving towards the promoting the agro-based industries, so there will be a rise on the demand of fertiliser. With full utilisation of nutrient content in treated sewage sludge, it would provide significant cost reduction in fertiliser acquisition while minimising overall disposal of solid wastes to landfills or incinerators (L’hermite, 1991; Dhir, et.al., 2001). It is therefore crucial for studies on the characteristics of sludge to be conducted as to formulate an efficient land application which will give benefit to the country’s agro-based industries and economy as well.

This study aims to identify the nutrient content from selected Sewage Treatment Plants in Malaysia and to study the feasibility of sludge application as fertiliser through the comparison of nutrient content between sludge and selected fertiliser sold in the public market. The potential of the utilisation of sludge also will be assessed through the observation and analysis on the growth of Abelmoschus esculentus.

METHODOLOGY
There are multiple layers of sludge formed at the bottom of pond, thus the targeted samples would be a composite of sludge layers with different depth. According to Gomez et al., (1986) nutrient distribution is not homogeneous due to hydraulic condition that later prevailing the formation of deposit. Due to the situation, some of the nutrients could be found upstream while some could be found downstream prior to discharge. For sampling purposes, Municipal Sewage Treatment Plant (MSTP) that caters for a PE of 30,000 was being
selected. Random sampling was being performed as to determine the variation of nutrient concentration. The whole research was mainly conducted in Laboratory of Environmental Engineering, Universiti Teknologi Malaysia.

Wet sludge that had been collected was later being heated at 105°C for 24 hours in an oven to eliminate pathogens. In order to obtain accurate comparison between nutrients in sludge samples and granular fertiliser, standardisation was required. The dried sludge samples were grinded with mortar and pestle to obtain fine powder form. The sludge powder and the fertiliser granules were later being measured in weight and mixed with distilled water to have a ratio of 1:20. The solution was prepared daily for chemical analysis of nutrients as well as plant feeding. Sludge and fertiliser samples were being analysed directly without undergoes any digestion process. This was to determine the freely available nutrients loading those plants could absorb immediately without having a need for either chemical or biological conversion by soil microbes. However, for plants, it needs to be firstly digested before conducting further analysis.

Actual soil condition was being emulated in this study. The media used for crop planting were aggregates, sand and red soil with the ratio of 1:6:3. The aggregates, sand and red soil will be filled into 4 polystyrene boxes. During the setup, 1 portion of aggregates will be layered at the bottom followed by 6 portions of sand and 3 portions of red soil that formed on the top layer. In this study, 6 portions of sand were being used in order to prevent water clogging within the soil which can boost harm to the roots of the plants. Excessive solution that not being absorbed by roots will flow downwards thus, stored at the bottom layer. The holes under the polystyrene box were not being punched purposely as to avoid occurrences of water loss. The idea was to allow feed solution to be stored at the bottom of the layers in order to emulate ground water condition. This was to ensure that the roots would develop vertically in search of water sources instead of developing horizontally that can cause competition among the plants to absorb water. The total volume of the media per polystyrene box was 0.04725 m$^3$.

An edible plant of *Abelmoschus esculentus* was selected for the study. This species requires minimal attention and able to grow fast compared to the other edible plants as long as there is sufficient water supply both in soil and atmosphere (Mohd Hafizan, 2009). This species is less likely to get attacked by vectors or bacteria. Before germination of *Abelmoschus esculentus*, 20 mL of distilled water was poured to all 4 boxes daily. The actual experiment was started as soon as the seeds from all the boxes had completely germinated and this would be counted as 1$^{st}$ week. Starting from 1$^{st}$ week, all 4 boxes of *Abelmoschus esculentus* were daily fed with respective designed solution starting with a minimum level of 20 mL. Additional 20 mL of feed was added weekly until the total feed solution reached 100 mL at 5$^{th}$ week. The explanation that can support this flow methodology was that this plants were required more nutrients as well as moisture during their growth development. Throughout the experiment, all plants were received the same volume of designed feed solution.

Instead of designed feed solution which being obtained through the mixing of the dried sludge and other materials, the experiments also covered on the testing of fertiliser on the sample plants. To obtain its actual critical concentration, a minimum of 20 mL fertiliser solution was fed to the plant on the 1$^{st}$ week as the starter. An increment of additional 20 mL per week was being included so that the critical concentration can be well detected. It was only after the 4$^{th}$ week plants receiving fertiliser feed began to die off and hence, the volume of feed was fixed at 100 mL level. After the volume of fertiliser critical concentration had been identified, the 100 mL feed remained constant throughout the period of experiment and the plants were still being fed on daily basis. The reason of this is to examine the plant reaction due to limited nutrient supply. Finally, starting from 6$^{th}$ week to 8$^{th}$ week, the growth of *Abelmoschus esculentus* was being measured weekly using plastic ruler and threads. The growth is being defined as the increment in stem height and leave length.

**RESULTS AND DISCUSSIONS**

**Content of nutrient in both fertiliser and sludge**

All measurements were done in the same solution concentration which is 1 g of dry matter in 20 mL distilled water. The analysis of fertiliser and MSTP sludge are summarised in Table1.

<table>
<thead>
<tr>
<th>Element</th>
<th>Fertiliser</th>
<th>MSTP Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen, Nitrate (NO$_3$-N)</td>
<td>13600</td>
<td>42.0</td>
</tr>
<tr>
<td>Nitrogen, Ammonia (NH$_4$-N)</td>
<td>2490</td>
<td>18.4</td>
</tr>
<tr>
<td>Phosphorus, Orthophosphate (PO$_4^{3-}$)</td>
<td>16350</td>
<td>45.3</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>6900</td>
<td>3.5</td>
</tr>
<tr>
<td>Sulphate (SO$_4^{2-}$)</td>
<td>11000</td>
<td>15.9</td>
</tr>
</tbody>
</table>

From the overall analysis that had been conducted, it was found out that the plant being supplied by fertilizer had dead at early stage which is on 4$^{th}$ week. Thus, the plant growth measurement (as being indicated in Figure 1 and 2) can only being done on plant being feed by MSTP sludge and distilled water as a control. This was due to the overload content of the nutrients in the fertiliser. Theoretically, daily sludge application using the designed concentration...
will not cause any major problem to the plant but differ to the daily fertiliser application which caused harm and toxicity to the plants (Bertoncini et al., 2007). As to have a good view of comparison between fertiliser and sludge, a same comparison factor is required. Table 2 indicates the comparison of NPKS ratio between all samples used in the experiment with reference to K listed on fertiliser packet label. Among the nutrients, potassium (K) will always be the smallest portion in soil as it is leached away due to its high mobility. In fact, potassium is also required in low concentration by plant in order to promote the photosynthesis, but larger dosage can cause insignificant towards the growth. Thus, K will be chosen as the comparison factor.

Table 2: Comparison of NPKS ratio with reference to K of Fertiliser Packet Label (Loon, 2007)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fertiliser Packet Label</th>
<th>Fertiliser MSTP Sludge</th>
<th>Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>15</td>
<td>14.0</td>
<td>103.5</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>15</td>
<td>14.2</td>
<td>77.7</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>N/A</td>
<td>9.5</td>
<td>27.3</td>
</tr>
</tbody>
</table>

Based on Table 2 above, the NPK ratio in the fertiliser solution is almost similar to the ratio listed on the fertiliser packet label with a difference of 6.67% in N and 5.33% in P. The ideal N:P ratio is between 5:1 to 10:1 (Johannesson, 1999). However, the ratio obtained for MSTP sludge was 1.33:1, therefore it can be confirmed that N is the limiting factor. Similar to the N:S ratio at which Ahmad et al. (2005, 2008) claimed that the ideal ratio is 10:1 to 15:1 for most crops, but the obtained N:S ratio for MSTP sludge was 3.8:1. Again, it was confirmed that N is the limiting factor for the optimum plant growth.

Content of Nutrient in Plants

2 sets of data were obtained during the analysis as the plants that being fed with fertiliser were dead due to excess supply of nutrients. The nutrient content in plants receiving MSTP sludge solution feed and distilled water are shown in Figure 1 while ratio between nutrients cater by plants fed with MSTP sludge and distilled water is being presented in the Table 3 below.

Table 3: Comparison of nutrients between sewage sludge and plants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MSTP Sludge</th>
<th>**MSTP Sludge</th>
<th>**Distilled Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO3-N</td>
<td>42</td>
<td>16.00</td>
<td>11.00</td>
</tr>
<tr>
<td>NH4-N</td>
<td>18.4</td>
<td>12.43</td>
<td>5.44</td>
</tr>
<tr>
<td>Total N</td>
<td>60.4</td>
<td>28.43</td>
<td>16.44</td>
</tr>
<tr>
<td>PO4-3</td>
<td>45.3</td>
<td>4.69</td>
<td>2.47</td>
</tr>
<tr>
<td>N:P Ratio</td>
<td>1.3:1</td>
<td>6.1:1</td>
<td>6.7:1</td>
</tr>
<tr>
<td>SO4-2</td>
<td>15.9</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>N:S Ratio</td>
<td>3.8:1</td>
<td>1.4:1</td>
<td>1.4:1</td>
</tr>
</tbody>
</table>

** The summation of leaves, stems and roots for the plant receiving the respective feed

As being stated previously, the optimum N:P ratio for most plants ranges from 5:1 to 10:1. According to Table 3 above, it can be clearly seen that plants which receiving MSTP sludge exhibited the N:P ratio of 6.1:1 while for plants receiving distilled water...
exhibited ratio of 6.7:1. Though the plant ratios generally fit into the optimum range, the content of nitrogen in MSTP sludge is clearly the limiting factor for the *Abelmoschus esculentus* to grow optimally. Lacking of nitrogen can cause problem to the process of protein synthesis, thus lead to the occurrences of the plant growth stunning. Instead of N:P ratio, the N:S ratio also play a role in this study. As being conveyed previously, the optimum range of N:S ratio for majority of edible plants was 10:1 to 15:1. However, the N:S ratio of both feeds were only 1.4:1. These indicated that the plants were having heavily deprived from N supply as high level of sulphur (S) concentration will interfere with N intake by plants. Through the comparison of both ratios; N:P and N:S ratio, it was recommended that additional N should be added to the plants in order to ensure the optimum growth as well as to cater the lack of N content in the plants’ intake.

**Growth Development of *Abelmoschus esculentus***

Germination phase of *Abelmoschus esculentus* was completed in the 1st week. For 2nd and 3rd week, plants receiving fertiliser feed were growth at faster rate compared to the plants that being fed with MSTP sludge and distilled water. However, at 4th week which was at 80 mL fertiliser feed level, the plants started to dehydrate and finally die-off. Some of the visible signs were curling up and dropping of the leaves one at a time. This situation had indicated that the plants which being fed with fertiliser had achieved its critical volume level.

For the last 3 weeks of the experiment, the growths of *Abelmoschus esculentus* were being monitored by measuring its stem height and leaf length. There were several types of leaves to be measured for signs of growth. The first one was the primary branch, followed by the secondary branch. After the growth of primary and secondary branch of leaves, there will be the last part of plant which is top leaf. The shape of top leaf was different from both primary and secondary branches and it will only grow at later stage. This will indicate the level of maturity of the sample growth plants. All measurements regarding the growth of plants were plotted graphically in Figure 2.

By observing the graphs presented at Figure 2, it is noted that the soil itself contains some of the existing nutrients that enough to promote the growth. This statement had been proved through the development of *Abelmoschus esculentus* even with the feeding of the distilled water which is well known of not containing respective nutrients for the growth purposes. Though the feeds of distilled water were applied daily, the actual nutrients absorbed by plants were fairly low compared to plants receiving MSTP sludge, thus causing lower growth of plant. Due to that, it is well confirmed that MSTP sludge does have a capability as a fertiliser in enhancing the plant growth as all the components of plants had shown positive trend through week by week.
CONCLUSION

- Sewage sludge potentially contains nutrients which can be used as fertiliser in order to enhance the plant growth.
- Nutrients that contain in MSTP sludge were nitrogen, phosphorus, sulphur and potassium, whereby nitrogen is the most significant among others towards plant growth.
- Through the utilisation of sewage sludge, it can eventually help in minimising the sludge disposal (Arceivala, 2000) and provides the cost effective alternative of the agricultural activity as the use of fertiliser can be replaced with the use of sewage sludge that can easily obtained at MSTP.

ACKNOWLEDGEMENT

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REFERENCES


