Research article

Conditions of Bio-Slurry Application in Crop Production in Kampong Cham Province, Cambodia

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Abstract Bio-slurry is an organic fertilizer produced from the decomposition of organic waste or residues in anaerobic digestion. It is applicable for improving vegetable production as it contains necessary nutrients such as nitrogen (N), phosphorus (P), and potassium (K) for plant growth and organic matter that improves soil structure and water-holding capacity. About 29,000 biodigesters have been installed across Cambodia using animal waste to produce biogas, so huge quantities of bio-slurry are produced. Therefore, this study aimed (1) to assess the conditions of bio-slurry application in crop production in rural areas, (2) to determine NPK content in the bio-slurry, and (3) to estimate annual bio-slurry production and NPK production from biodigesters. The research was conducted between April and September 2022 by selecting 30 farming households that have biodigesters and use bio-slurry for crop cultivation in Prey Chhor District, Kampong Cham Province. It was found that 70% of the farmers used bio-slurry for rice cultivation and 16.7% for backyard vegetables, basically before planting. The nutrient content of slurry produced from cow manure consists of 0.20% N, 0.22% P, and 0.44% K. Most farmers preferred to use solid slurry for rice cultivation and liquid slurry for vegetables such as chili peppers, sweet peppers, eggplant, spinach, mustard greens, and cucumbers. However, bio-slurry was commonly mixed with chemical fertilizer in the crop growth stage. Farmers are willing to use both slurry and chemical fertilizers as this helps the plants to grow well and have higher yields.

Keywords bio-slurry, biodigesters, crop production, vegetables, chemical fertilizer

INTRODUCTION

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The installation of biodigesters has increased in rural Cambodia due to the need to help small-holder farmers manage animal waste and convert it into energy for cooking and other applications in their livelihoods. They also utilize bio-slurry, a by-product produced from biogas production, as organic fertilizer for crops. According to a 2019 assessment report released by the National Biodigester Program (NBP), almost 29,000 digesters have been constructed across Cambodia in the period 2006-2012. Farmers normally raise cattle and use animal manure as a substrate for the biodigesters, and apply slurry, sometimes mixed with compost or other organic fertilizer, to their backyard vegetable garden and rice cultivation (Hyman and Bailis, 2018). In 2020 alone, of the planned 1,500 biodigesters, 703 were constructed, which was equivalent to 47% (NBP, 2019). Among all the installed biodigesters, it is reported that there are approx. 2,353 digesters used by small-holder farmers in Kampong Cham Province, which is well-known for agricultural production on a large landscape. Among all the districts in this province, Prey Chhor, Choeung Prey, and Kong Meas had the highest number of biodigester installations compared to others (PDAFF, 2021).

In Cambodia, vegetable production was reported to be approx. 716,000 tones in 2020, even though this country experienced covid-19 pandemic and strict lockdowns. Yet, it was seen as a great opportunity for the agricultural sector to increase local production by reducing dependency on agricultural imports from the neighboring countries. Until now, it is also noticed that chemical fertilizer has still been in high demand, as farmers consume it in their crop production when compared to organic fertilizer in the form of compost or bio-slurry (Phnom Penh Post News, 2021). Technically, bio-slurry is considered one of the most efficient organic fertilizers, when applied to crops, since it is produced through anaerobic digestion. Therefore, it can be used instead of chemical fertilizer in every stage of crop growth. Furthermore, slurry also helps increase crop yield by 30%, when compared to chemical fertilizer, which leads to a reduction in production costs of 50% (Hyman and Bailis, 2018). One study showed that a 25 m^3 digester can produce 9,780 kg of bio-slurry annually, consisting of 76 kg of nitrogen (N), 107 kg of phosphorus (P), and 107 kg of potassium (K), respectively (Kissan, 2019). That finding also indicated that bio-slurry contains 93 % water and 7% dry matter of which 4.7% was organic matter and 2.5% was inorganic matter (Kumar et al., 2015). In addition, the utilization of bio-slurry was efficient in accelerating crop growth and increasing vegetable yield in both seasons. Aina (2018) illustrated that 50% bio-slurry mixed with 50% chemical fertilizer was more efficient than 100% of chemical fertilizer in promoting crop growth and yield because the bio-slurry had only high N content, whereas other nutrients were obtained from chemical fertilizer.

Bio-slurry can be a major solution for farmers who intend to use organic fertilizer to improve their crop production, and this comes at the right time due to the increase of biodigesters in rural areas.

OBJECTIVE

This study aimed to (1) to assess the conditions of bio-slurry application in crop production in rural areas, (2) to determine NPK content in the bio-slurry, and (3) to estimate annual bio-slurry production and NPK production from biodigesters.

METHODOLOGY

The study was conducted between April and September 2022 by starting with collecting basic information and designing a questionnaire for a survey. The study employed purposive sampling as a case study by selecting 30 households with biodigesters in Svay Prey commune, Prey Chhor District, Kampong Cham Province (Fig. 1) due to high household biodigester consumption. To obtain sufficient information, data such as type of bio-slurry application, size of the biodigester, type of substrates used for biodigesters, and crop type were collected.

To determine the NPK content in bio-slurry, samples were collected from 3 different household digesters in the studied area, packed, and stored at 5 ^{0}C for laboratory analysis. For the lab's activities, these three samples were mixed then using reagents (TN, TP, TK diluting with a sample with a mass

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of 100 g for each parameter to determine NPK content following ISO 11261, 11263, and 17319 respectively whereas, total organic carbon (TC) also measured by Walkley and Black method.

Estimation of daily and annual bio-slurry production from biodigester using cow dung as a substrate can be calculated based on the following Eq. (1). This estimation is based on the research by Kumar et al. (2015), who found that 1 kg of cow dung produces 0.3 kg of bio-slurry, or 30%, daily. Technically, daily manure fed into biodigesters sized 4, 6, and 8 m^3 is equal to 30, 50, and 70 kg/day, respectively (Hyman and Bailis, 2018).

$$Q_{slurry}\left(\frac{tons}{year}\right) = Daily\ manure\ (\frac{kg}{day}) \times\ percent\ of\ bio-slurry\ x\ 365\ days \quad (1)$$

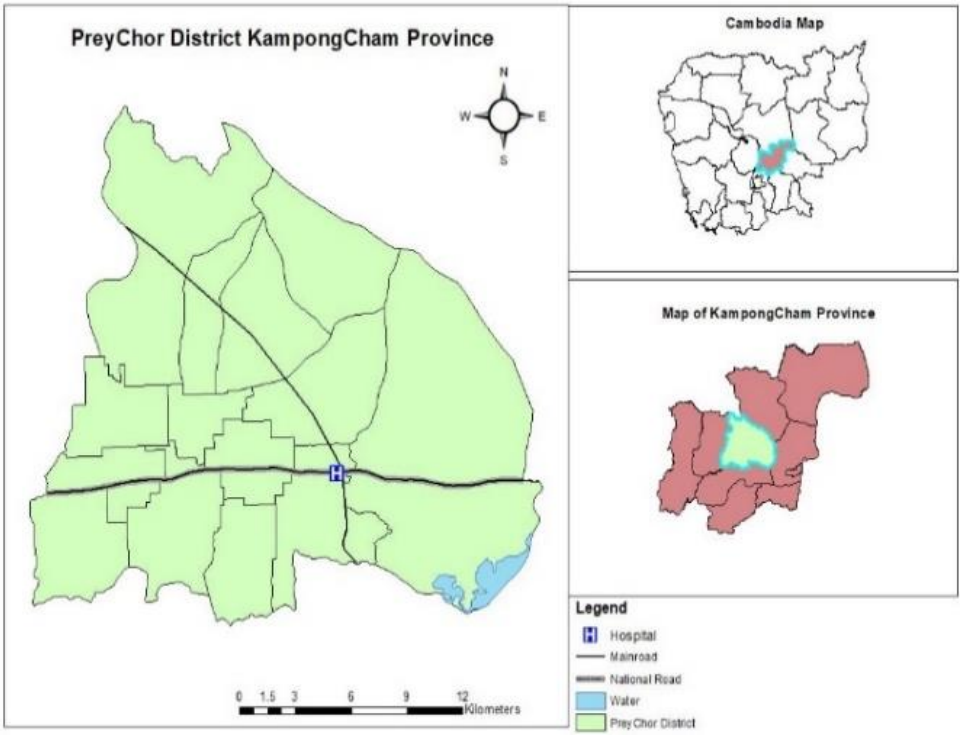

Fig. 1 A map of Prey Chhor District, Kampong Cham Province

Data Analysis and Interpretation

Descriptive statistics were employed to analyze quantitative data collected in the survey, and frequency tests were also used in the hypothesis to examine the relationship between two variables to determine the significant difference in data. Besides this, data was also organized in tables and graphs based on the types of questions and responses in Microsoft Excel.

RESULTS AND DISCUSSION

General Characteristics of Farm Households

Among 30 households, there are 50% of female farmers and 50% of male farmers whose age was 57±12.17 years (Table 1). The average household size was 4 ± 1.35. For the education status, 56.7% of farmers were at the primary school level, whereas only 26.6 % went to high school, and 16.7 % were illiterate. Regarding biogas installation, 100% of biodigesters are concrete fixed-dome digesters, of the sizes 3, 4, 6, and 8 m^3, 53% of biodigesters had a volume of 6 m^3, while 20% were 4 m^3 biodigesters. The farmers mostly raised cows, so that cow manure could be used as a main substrate for biogas production. Of all the interviewees, 97% used cow manure as a substrate.

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Nutrients in Bio-Slurry / Substrate Source (Cow)

Table 2 shows that bio-slurry contained 0.2% total nitrogen (TN), 0.22% total phosphorus (TP), 0.44% total potassium (TK), and 2.77% total organic carbon (TOC). With this result, the C/N ratio was calculated to be 13.9, while the pH was 7.11. In contrast, based on the study of (Kumar et al., 2015), the nutrient content of bio-slurry from cattle was between 1.4% and 1.8% of TN, 1.1-2% of TP, and 0.89-1.2% of TK. The result of low NPK content in this study might be due to different cow species and feed types used for cows in Cambodia, whereas they raised the local breed of cattle and mostly fed their local grass and brewery waste with a high protein content.

Moreover, the nutrient content of compost consisted of 0.5-1.5% TN, 0.4-0.8% TP, and 0.5-1.9% TK, while the nutrient content of fresh cattle manure contained 0.5-1% TN, 0.5-0.8% TP, and 0.5-0.8% TK in the same study. Additionally, Bonten et al. (2014) indicated that cattle slurry consists of 1.3-1.5% of N, 0.3-2.8% of P, and 0.3-1.4% of K, whereas swine slurry consists of 1.8-2.7% of N, 0.8-3.3% of P, 0.5-0.8% of K, respectively.

Table 1 General characteristics of the farmers

Variables	Mean ± SD	Number of interviewees	
		Person	Percentage (%)
Sex	-	-	-
Male	-	15	50.00
Female	-	15	50.00
Age (year)	57 ± 12.17	-	-
Household size (person)	4 ±1.35	-	-
Education	-	-	-
Illiteracy	-	5	-
Primary school	-	17	56.70
Secondary school	-	0	0.00
High school	-	8	26.66
Type of biodigester	-	-	-
Concrete fixed dome	-	30	100.00
Other types	-	0	0.00
Digester size (m^3)	-	-	-
3	-	1	3.00
4	-	6	20.00
6	-	16	53.00
8	-	3	10.00
Type of substrate	-	-	-
Cow manure	-	29	97.00
Others	-	1	3.00

Table 2 Nutrient content in bio-slurry freshly produced from cow manure

No.	Parameters	Unit	Testing result (%)
1	Total nitrogen (TN)	g/100g	0.20
2	Total phosphorus (TP)	g/100g	0.22
3	Total potassium (TK)	g/100g	0.44
4	Total organic carbon (TOC)	g/100g	2.77
5	C: N Ratio	g/g	13.90
6	pH	-	7.11

Estimation of Daily Bio-slurry Production

Table 3 compares the annual bio-slurry production by three sizes of biodigesters. Generally, the 8 m^3 digester requires 70 kg/day of cow manure and can produce 21 kg of bio-slurry daily or 8 tons/a. For a 6-m^3 sized digester, the daily and annual bio-slurry production would be 15 kg and 5 tons/year respectively for the 4-m^3 digester, about 9 kg of bio-slurry is produced per day, or 3 tons/year. In comparison with Kumar et al. (2015), animal manure generated 256.2 Mt each year, and total annual biogas slurry was 76.8 Mt/year which was a huge amount of bio-slurry produced from biodigesters and they were recoverable approx. 60% of total produced dung (resourced from cattle+ buffalo) while

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the total estimated potential of biogas plants was in total 12 million plants for generating biogas and bio-slurry daily in India.

Table 3 Estimation of daily and annual bio-slurry production

Digester volume (m^3)	Daily slurry production (kg/day)	Annual slurry (ton/year)
4	9	3
6	15	5
8	21	8

Figure 2 shows the comparison of NPK content in bio-slurry annually produced in the three sizes of biodigesters. It is seen that the annual TK yield in bio-slurry was higher than the others. Starting with annual TK production in bio-slurry, it varied from 1.45 to 3.37 tons/year of P produced from an 8 m^3 sized digester, while TN of 0.66 tons/year was obtained from one unit of a 4 m^3 sized digester, 1.1 tons/year for a 6 m^3 sized digester, and 1.53 tons/year for an 8 m^3. However, the finding was relatively low when compared to Kumar (2015) who found that nitrogen content was 1.15 Mt in 76.8 Mt slurry produced annually. Additionally, Martinez-Suller et al. (2010) found that the average TN, TP, and TK yields from cattle slurry were 3.43 kg/m^3, 0.56 kg/m^3, and 4.41 kg/m^3 respectively.

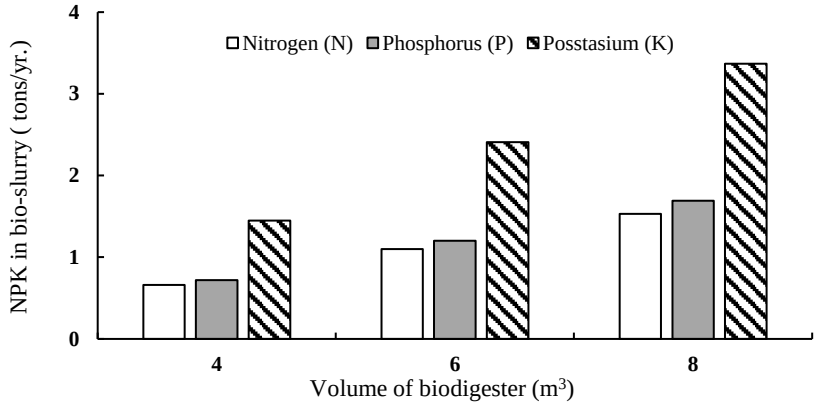

Fig. 2 Comparison NPK content in bio-slurry annually produced in different sizes of digester

Proportion of the Farmers Applying Bio-Slurry for Crop Production

It is observed that most of the farmers applied the slurry in solid state (Fig. 3). About 63.3 % of the farmers applied solid slurry for their crop production, whereas only 13.3% consumed liquid bio-slurry, and around 23% (Table 4) used both solid and liquid bio-slurry in their crop production.

Table 4 Type of slurry application

Type of slurry application	Numbers	Percentage (%)
Wet	4	13.33
Dry	19	63.33
Both	7	23.33

Nevertheless, all the interviewees were willing to utilize dry or solid slurry for their rice production, and they all also applied liquid slurry for leafy vegetables such as water morning glory, lettuce, onion leaf, mustard greens, and spinach. Additionally, 70% of the farmers utilized solid slurry for fruity vegetables like eggplants, cucumbers, sweet peppers, and chili peppers, whereas 30% preferred liquid slurry. On the other hand, it is observed that before having biodigesters, the respondents used chemical fertilizer only, for both rice and vegetables. After the installation of bio-digesters, the consumption of chemical fertilizer for rice production was reduced by 39% and by 35%

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for vegetable production. Concerning the liquid slurry application, one study (Musse et al., 2020) reiterated that a mixture of bio-slurry in liquid state and N-inorganic fertilizer applications provided a high yield of green bean (fruity vegetable) and improve both soil physio-chemical properties.

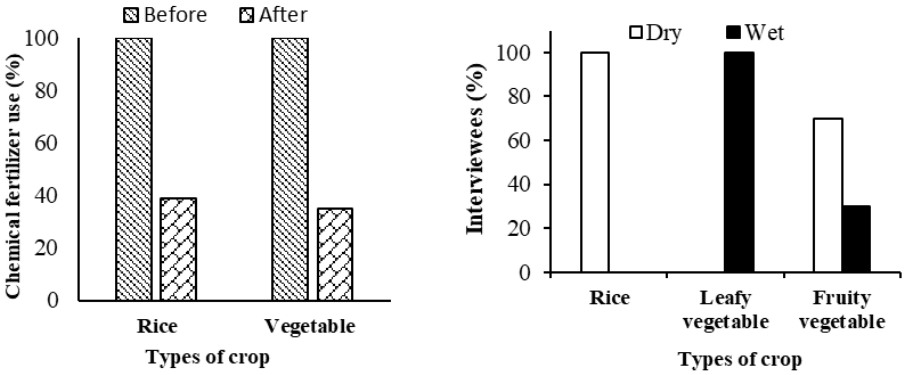

Fig. 3 Types of slurry application and percentage of chemical fertilizer use in different crops

CONCLUSION

In conclusion, bio-slurry production varies based on the amount of cow dung fed into biodigesters daily. In the meantime, the nutrient content of bio-slurry had higher potassium (K) than other sub-nutrients such as nitrogen (N) and phosphorus (P). For bio-slurry application, most farmers always applied solid bio-slurry for crops, and all farmers prefer to use solid slurry for rice and liquid forms for vegetables. Furthermore, the use of slurry can replace and reduce chemical fertilizers in crop production. Finally, the farmers still mix chemical fertilizer with bio-slurry because they think it is key to obtaining good quality and high-yield crops. Therefore, further research should be performed to identify the impacts of bio-slurry on crop growth and yield for better documentation and wider adoption.

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