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# Faecal sludge briquettes production as a viable business in Kampala: a case study of a partnership between Water for People and National Water and Sewerage Corporation

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## ABSTRACT

Production of faecal sludge (FS) briquettes is not a new technology and is often used in the sanitation value chain as part of resource recovery efforts. Water for People in its mandate to develop appropriate and sustainable sanitation technologies sought to optimize the process of faecal sludge based briquette production. This was done by testing the different compositions of faecal sludge (100%, 80%, 60%, 50% and 40%) with other materials such as wood charcoal dust, agricultural waste and market waste to come up with a briquette that could compete favorably with charcoal and traditional briquettes on the market. The testing phase indicated that such briquette was at a composition of 40% faecal sludge and 60% charcoal dust and adequately provided the fuel properties required as well being safe from any pathogens or emissions. A briquette production facility was set up in collaboration with National Water and Sewerage Corporation, Uganda at their treatment plant in Lubigi and has to-date produced more than 10 tonnes of briquettes and sold more than 3 tonnes since its inception. Further research is being carried out in production process efficiency and use of other raw materials such as agricultural waste and market waste to offset the wood charcoal.


**Keywords:** Briquettes production, faecal sludge, reuse, Kampala, Water for People, National Water and Sewerage Corporation.

## INTRODUCTION

For many years in Africa, faecal sludge has remained regarded as a hazardous material, given little attention about energy recovery from the bio solids (Semiyaga et al., 2015).The most common reuse option has concentrated on direct application of bio solids onto garden- risk of pathogens



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especially for vegetables eaten raw (Jimenez et al., 2009; BIOHAZ, 2014; Dickin et al., 2016). One product of faecal sludge that is most likely to be free of pathogens is the briquettes (Atwijukye et al., 2018; Andriessen et al., 2019). The pathogens are killed during the carbonization or pyrolysis process that requires high temperatures (Cao and Pawlowski, 2012; Jin et al., 2016). Faecal sludge briquettes can be used to replace the wooden charcoal briquettes hence reducing pressure on the forests in search for charcoal (Ward et al., 2014; Nantambi et al., 2016; Karahalios et al., 2018). Faecal sludge products are normally challenged by community attitudes due to various beliefs and taboos around faeces handling (Strenstrom, 2004; NETWAS, 2011). Faecal sludge briquettes are a good reuse option because they burn longer than wood charcoal and are more cost effective, making them a much cheaper option as a fuel source.

Following the success of faecal sludge briquette production in Kole district as a viable business with SAWA SAWA under a project supported by UNICEF Finland, Water For People embarked on a setup of a briquette production facility in Kampala since it has the biggest charcoal market. This was done in partnership with National Water and Sewerage Corporation, the national utility responsible for treatment of sewerage. The objectives of this project is to identifying the most suitable sludge to use for briquette productionin water, testing of physical and emission properties of different compositions of sludge combinations to come up with a briquette that can compete favorably on the market, setup of a briquette production facility and market testing of faecal sludge briquettes.

## MATERIALS AND METHODS

As part of Water for People's efforts to ensure market driven approaches in sanitation, we planned to scale-up the production of briquettes from faecal sludge as an alternative fuel source with the setting up of a production plant in Kampala. Faecal sludge briquettes are not new to the market and while a lot of research has been carried out on the physical and fuel properties (Kiwana and Naluwaaga, 2016), there was need to optimize the process for large scale production. In this process, we tested briquettes made from two types of faecal sludge that is top scum and bottom settled sludge with different composition as follows; 100%, 80%, 60%, 50% and 40% with wood charcoal dust. The production of these test briquettes was done in collaboration with Sustainable Energy Answers Company Limited and Canaan Pioneering Innovations Development Agency, one of the existing briquette manufactures in Uganda.

The two types of FS are collected from National Water and Sewerage Corporation's (NWSC) Treatment Plant in Lubigi that is top scum (collected and scooped from the top of the sedimentation tank) and bottom settled sludge (collected from the bottom of the tank). The parameters tested for include: fuel properties test; calorific value, ash content, moisture content, volatile matter and fixed carbon, Water Boiling Test (WBT), emission test; CO, $CO_2$, PM2.5 (that is particulate matter having a diameter of less than 2.5 micrometers), black soot, oxides of Sulphur, Nitrogen and Phosphorus organic pollutants (Joseph et al., 2012). These parameters were tested by the Centre for Research in Energy and Energy Conservation laboratories in Makerere University and Central Government laboratories.

A briquette production plant focussed on producing stick and honeycomb faecal sludge briquettes with a faecal sludge/wood charcoal dust compositon of 40%/60% was intially set up in Nyanama and has since been moved to National Water and Sewerage Corporation Treatment Plant in Lubigi following the MOU signed between the two entities with facilities on the site such as production machinery, a solar dryer, greenhouse and carbonizer unit. The production unit currently has a staff of 6 people with a target of 3 tonnes of faecal sludge briquettes produced per week by the end of December 2019.

A market assessment study was carried out by Whitten & Roy Partnership to evaluate the market potential within Uganda for a

partially fecal sludge-based eco-briquette. In addition, recommendations for production, value chain participation, marketing and sales were sought. Following this assessment, Water For People embarked on small sales to test the market and gain insight into consumer perception of the product as well as develop business models that would build this into a viable business.

## RESULTS AND DISCUSSION

Faecal sludge briquettes are technically viable as a cooking fuel when blended with other char from agro-waste, market waste or char dust. However, they cannot be used as 100% faecal sludge given the low calorific value. Top sludge is more suitable for use in faecal sludge briquettes as it is lighter and has less inorganic matter (Table 1). Briquettes with higher percentage of charcoal dust have better fuel properties hence the briquette with 40% FS ; 60% CD compares well and this was our starting combination. The briquettes proved to be durable, having a shorter lighting time, taking shorter time to boil water although burning out faster. Organic emissions such as PCBs, Furans and Dioxins were at non-detectable levels with $SO_2$, $SO_3$ levels detected below 5% and this reduced with reduction in faecal sludge composition, $NO_2$ levels at below 1% reducing with decreasing faecal sludge compositon and $P_2O_5$ levels at below 10% reducing with decreasing faecal sludge content.

Fuel briquettes made from 40% faecal sludge performed comparably well to wood charcoal with a calorific value of 24,000 KJ/kg (Figure 1) and close-in range fixed carbon and volatile matter to wood charcoal (Figure 2). The faecal sludge briquettes still have a lot more ash than wood charcoal however this improves its properties to burn longer with clay as a filler material and some clients have indicated that the ash can still be used as a soil amendment. The faecal sludge briquettes and wood charcoal used the same time to boil 5 litres of water (Figure 3) which is an indicator that they can be used effectively as a fuel source.

The briquette production facility started production in October 2018 and has to-date produced more than 10 tonnes of faecal sludge briquettes with the highest weekly production at 2.7 tonnes and averaging weekly at 1.5 tonnes (Figure 4a and b). The biggestbottleneck in the production process has been the carbonization process which has a low efficiency of approximately 30% and this greatly affects the volume of briquettes that can be produced.

The market assessment report by Whitten &Roy Partnership indicated that the market is large. The potential market for eco-briquettes using faecal sludge as a component ingredient is large enough to accommodate any volume that could be produced in the near-term if not long-term. Both business and consumer markets appear willing to adopt the product. Thus, the primary concerns lie with operational issues such as production and distribution, as well as marketing and sales details. Despite the potential demand being significant, selling product will still require building brand awareness through marketing to convert sales prospects into actual buyers. For some consumers, both marketing and sales will need to address habit change due to the unique characteristics of using fecal sludge-based briquettes. There is limited faecal sludge available at the quality and accessibility levels required. Therefore, Water for People should focus on one key B2B market (chicken farmers) and one key B2C market (middle-class consumers purchasing in supermarkets) to start.

With the informal sales carried out by Water For People, more than 3 tonnes (Figure 5 a and b) of briquettes have been sold with an indication of repeat and new clients monthly. Water For People has teamed up with a distributor Sheercare Cleaning Services (U) Limited who have managed to sell about 1 tonne of briquettes. This was to test the dyanmics of the distributorship model as a way of increasing sales. It has presented challenges with most clients preferring to buy the briquettes at the source production unit and not willing to pay more at the distributor regardless of the transport cost implication

**Table 1:** Physical Fuel Properties and Emission Test Results for FS Briquettes (Using Top Sludge) with Charcoal Dust.

| **Briquette Composition** | **100%FS** | **80%FS 20%CD** | **60%FS 40%CD** | **50%FS 50%CD** | **40%FS 60%CD** |
|---|---|---|---|---|---|
| **Weight of Briquettes (kg)** | 4.57 | 1.30 | 1.60 | 1.38 | 1.47 |
| **Moisture Content (%)** | 10.08 | 6.28 | 6.50 | 6.54 | 6.74 |
| **Calorific Value (kJ/kg)** | 5,875.50 | 9,628.50 | 17,747.50 | 23,823.76 | 24,495.37 |
| **Analytical Ash Content (%)** | 60.73 | 57.01 | 46.44 | 43.22 | 18.58 |
| **Fixed Carbon (%)** | 11.22 | 18.90 | 30.40 | 31.28 | 39.94 |
| **Volatile Matter (%)** | 17.96 | 17.81 | 16.65 | 18.96 | 19.83 |
| **Water Boiling Test** | 192 minutes | 34.5 minutes | 39 minutes | 34 minutes | |
| **CO emissions-g/MJ** | 180.01 | 42.75 | 32.75 | 36.76 | |
| **CO2 emissions-g/MJ** | 491.29 | 533.44 | 552.84 | 555.09 | |
| **PM 2.5 emissions-mg/MJ** | 39.06 | 2,848.99 | 1,236.70 | 1,411.41 | |
| **Sulphur emissions (SO3)-%** | 4.13 | 4.11 | 4.09 | 3.45 | 3.28 |
| **Nitrogen emissions (NO2)-%** | 0.96 | 0.72 | 0.76 | 0.81 | 0.66 |
| **Phosphorus emissions (P2O5)-%** | 9.11 | 8.16 | 8.42 | 8.30 | 7.09 |
| **Organic Emissions (Furans, Dioxins, PCBs)-g** | Not Detectable | Not Detectable | Not Detectable | Not Detectable | Not Detectable |

**Table 2**: Physical fuel properties and emission test results for FS briquettes (Using Bottom Sludge) with Charcoal Dust.

| Briquette Composition | 100%FS | 80%FS 20%CD | 60%FS 40%CD | 50%FS50%CD | 40%FS 60%CD |
|---|---|---|---|---|---|
| **Weight of Briquettes (kg)** | 4.57 | 1.58 | 1.61 | 1.63 | 1.37 |
| **Moisture Content (%)** | 14.40 | 5.08 | 5.06 | 6.00 | 5.67 |
| **Calorific Value (kJ/kg)** | | | | 12,037.21 | 18,281.80 |
| **Analytical Ash Content (%)** | 58.91 | 53.61 | 50.54 | 41.19 | 39.93 |
| **Fixed Carbon (%)** | 11.23 | 19.30 | 25.23 | 29.36 | 34.93 |
| **Volatile Matter (%)** | 15.45 | 22.00 | 19.17 | 23.44 | 19.47 |
| **Water Boiling Test** | Briquettes fail to light | 80 minutes | 37 minutes | 50 minutes | 43 minutes |
| **CO emissions-g/MJ** | Briquettes fail to light | 54.01 | 33.09 | 47.91 | 41.75 |
| **CO2 emissions-g/MJ** | Briquettes fail to light | 749.47 | 490.91 | 614.38 | 1380.51 |
| **PM 2.5 emissions-mg/MJ** | Briquettes fail to light | 1937.39 | 1238.35 | 1380.51 | 1209.73 |

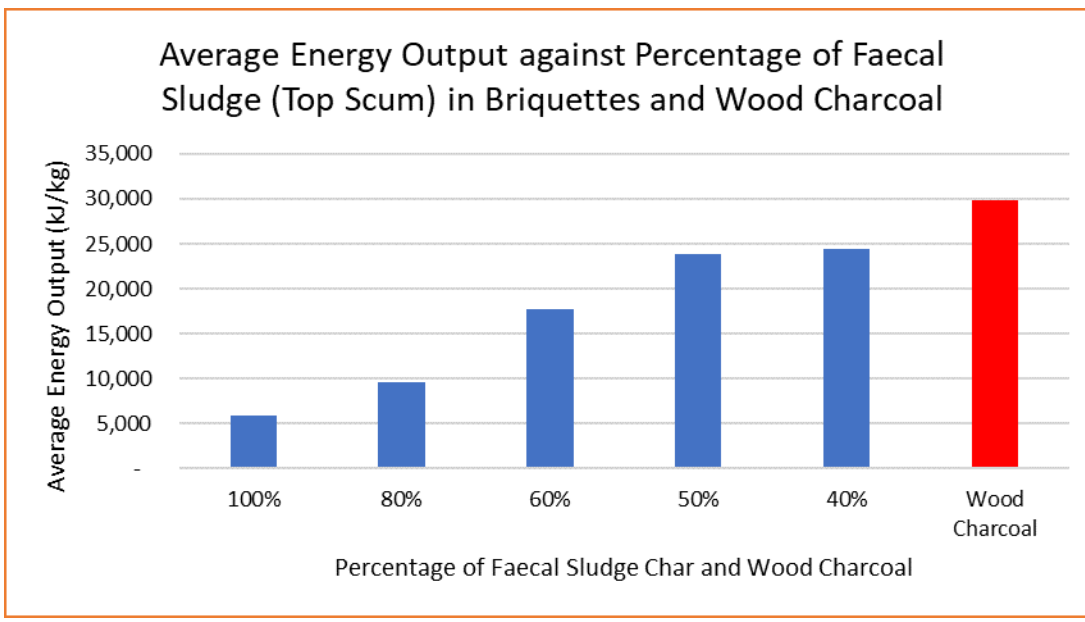



**Figure 1:** Average energy output in faecal sludge briquettes and wood charcoal.

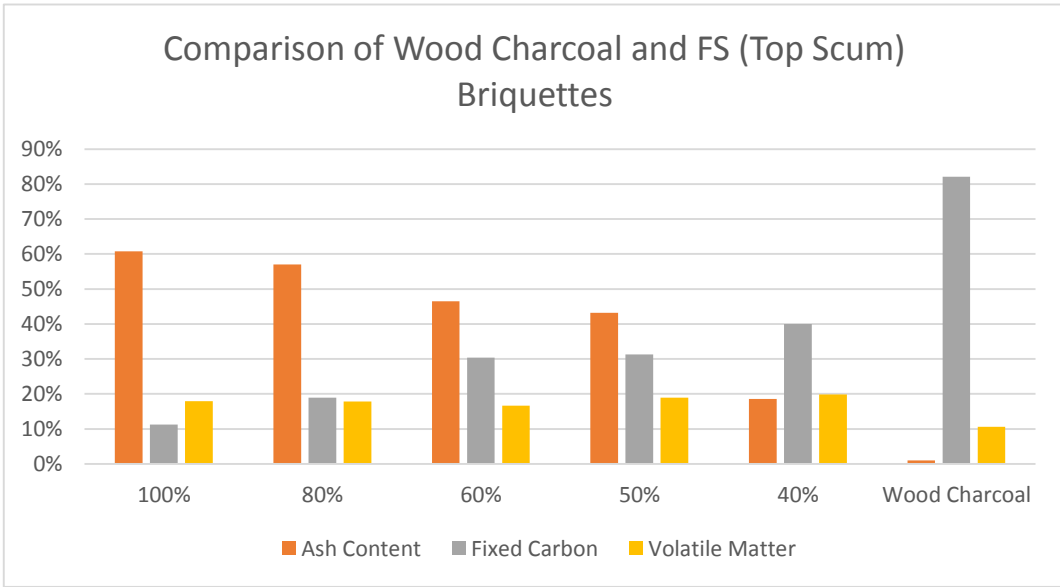



**Figure 2:** Ash content, fixed carbon and volatile matter percentages for faecal sludge briquettes and Wood Charcoal.

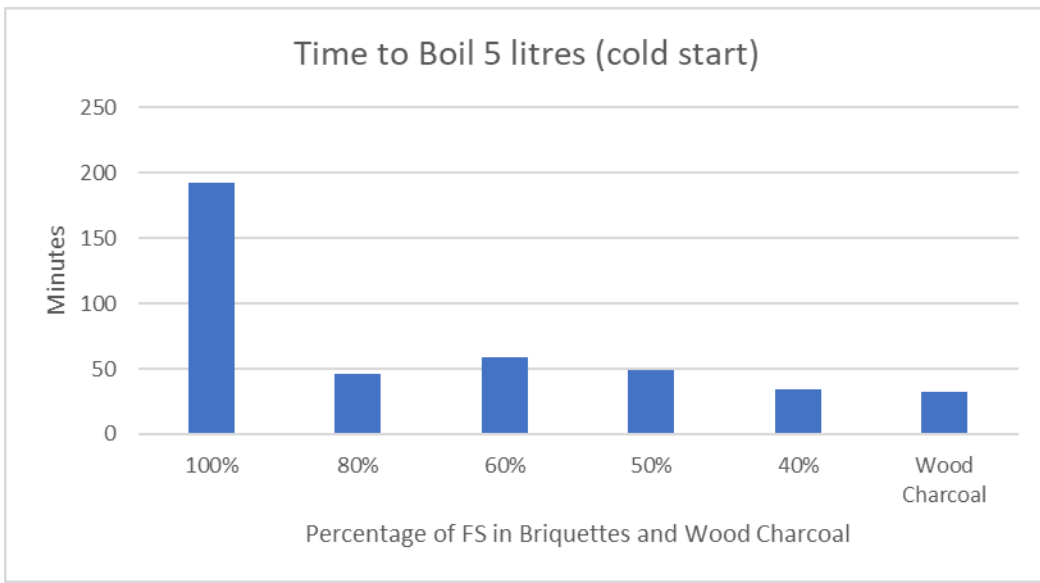
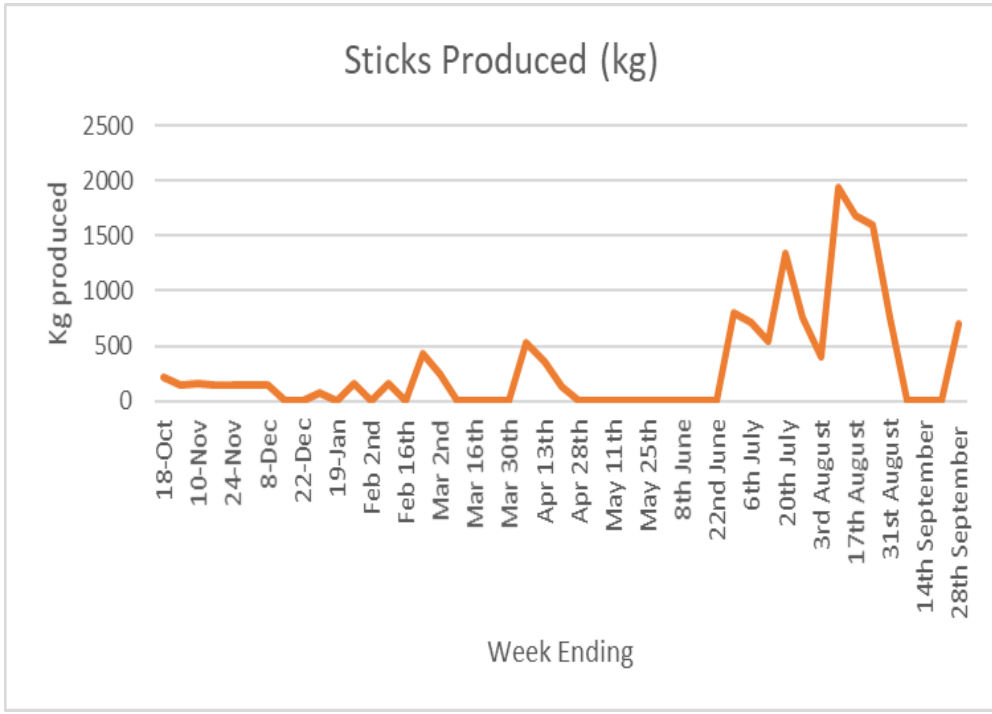
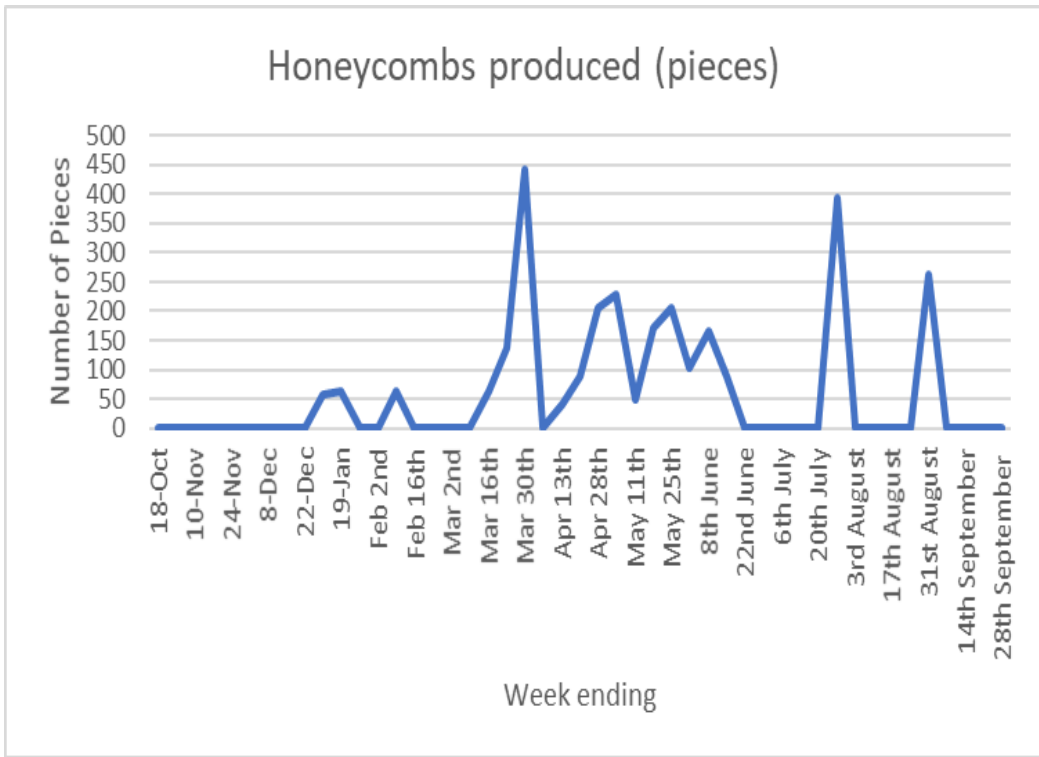



**Figure 3:** Comparison between faecal sludge briquettes and wood charcoal in time taken to boil 5 litres of water.

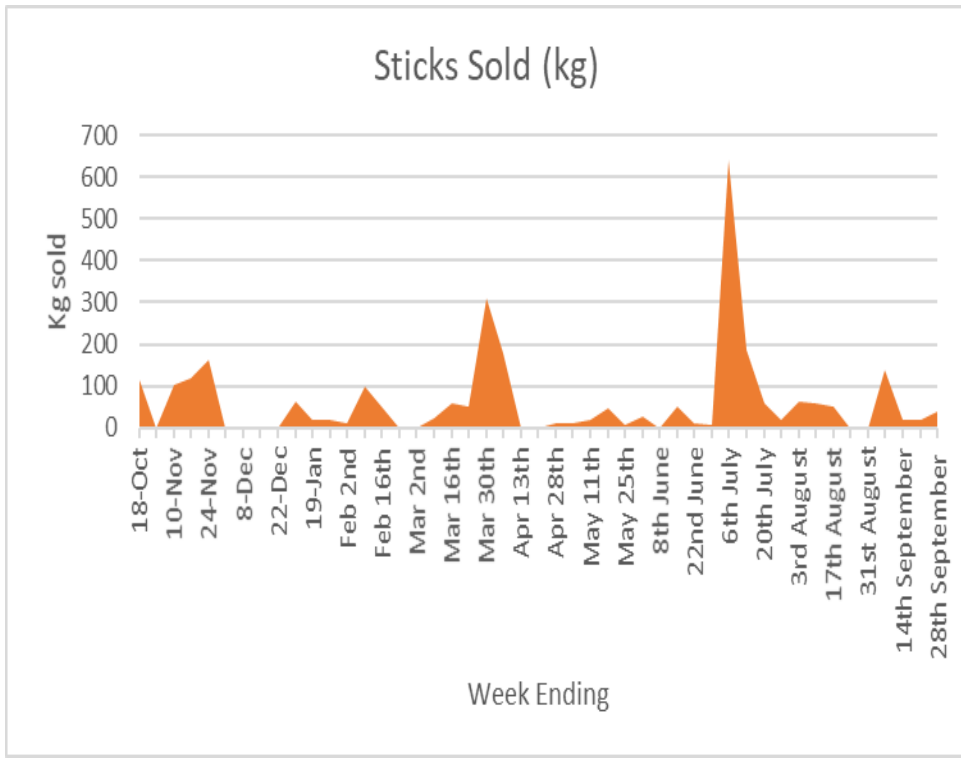



**a)**

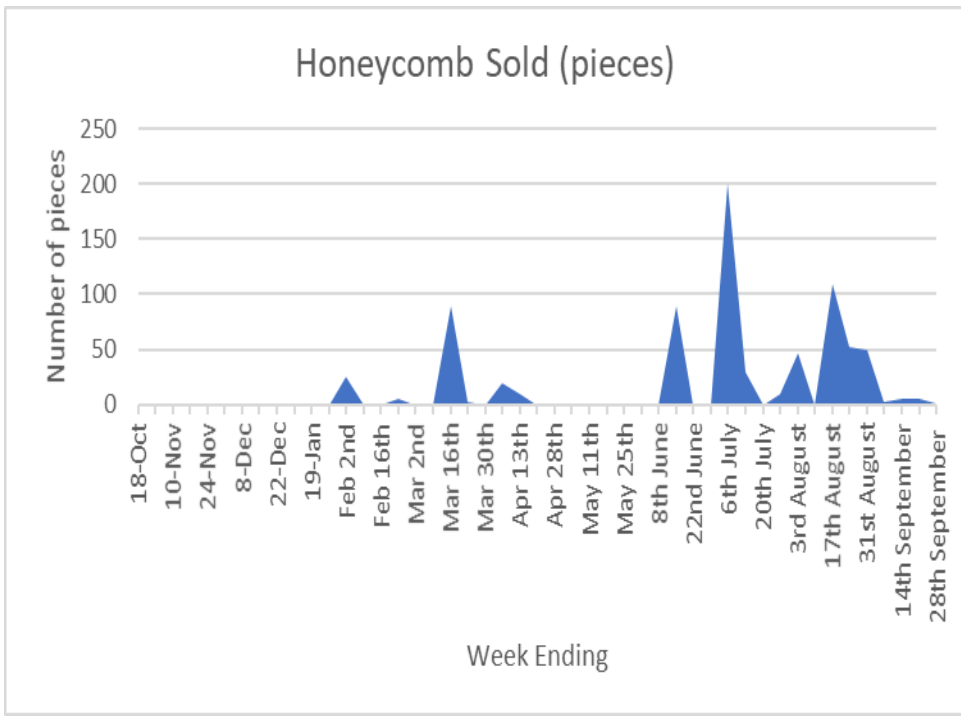



**b)**

**Figure 4 a and b:** Faecal sludge production trend from October 2018 to September 2019.




**a)**




**b)**

**Figure 5 a and b:** Faecal sludge production trend from October 2018 to September 2019.

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## Conclusion

Previous tests and current research has proved that FS briquettes with 40% FS are most viable to compete with charcoal and charcoal dust briquettes. New information has shown the most viable sludge to use is the top scum given that it does not have a lot of sand that is picked up in the bottom sludge from the drying beds. Setting up of a briquette production plant in Kampala has informed the project on the availability of local fabricators in the market and the strives being taken in automation of the briquette production process. At the start, assumptions were made that sludge and charcoal dust are a waste product and therefore would be available free of charge or in the very least at a minimal cost. We have, however, since learnt that the sale of FS feeds into the income stream of the treatment plant and charcoal dust is very much in demand, hence reducing the profit margins of the entire venture. Today, there is no clearly defined supply chain for the raw materials and this needs to be developed in future. There is also a need for further research into reducing the percentage of charcoal dust in the briquette with other materials such as agricultural and market waste. The other major lesson has been understanding the production process of faecal sludge briquettes, especially the efficiency of certain processes like carbonization. Further research is needed in the production process engineering for optimization as well as meeting the current market demand.

## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

All authors participated in the project design, data collection and data analysis. They produced and approved the final submitted manuscript.

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