ACTION RESEARCH PAPER

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Faecal sludge reuse: producing fuel briquette and charcoal by carbonisation process

SNV

SNV

SNV is a not-for-profit international development organisation that makes a lasting difference in the lives of people living in poverty by helping them raise incomes and access basic services. We focus on three sectors and have a long-term, local presence in over 25 countries in Asia, Africa and Latin America. Our team of more than 1,300 staff is the backbone of SNV.

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Citywide Inclusive Sanitation Engagement (CWISE)

The CWISE project is SNV and Bill & Melinda Gates Foundation's pledge to enable the delivery of safe emptying services to 1 million people in Bangladesh and increase household uptake of safely managed sanitation services by 30% in the slum communities of Khulna. It is an urban sanitation project, that builds on the success, findings and results of an earlier partnership, which established the willingness of different consumer segments to pay for sanitation services; introduced an end-to-end desludging service; contributed to the development of the national government's Institutional and Regulatory Framework (IRF) for Faecal Sludge Management (FSM); installed a faecal sludge plant in Khulna; and reanimated existing faecal sludge plants in Jhenaidah and Kushtia.

Started in January 2018, CWISE is a three-year project implemented with the Khulna City Corporation, Jhenaidah and Kushtia Paurashava, and in coordination with the national FSM Network.

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Photo (Cover): Briquettes are burning inside the improved cookstove, innovated by SNV, for test (@SNV/Sk Shaker Ahmed)
Photos: @SNV in Bangladesh

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List of abbreviations

CO_2	Carbon Dioxide
NDC	Nationally Determined Contribution
GHG	Greenhouse Gas
FSM	Faecal Sludge Management
KCC	Khulna City Corporation
NAWASSCO	Nakuru Water and Sanitation Services Company Ltd
NCSP	Nakuru County Sanitation Programme
VEI	Vitens Evides International
FGD	Focus Group Discussion
ICS	Improved Cookstoves
BDT	Bangladeshi Taka
LPG	Liquefied Petroleum Gas
3R	Reduce, Reuse, Recycle

1. Introduction

1.1 Background and context

Biochar[1] has been proven to be a more environmentally friendly fuel than the common biomass fuels found around us. Biochar is enriched in carbon which results in higher burning capacity.

Figure 1: Carbonised briquette

In 2019, carbon (CO_2) emissions per capita in Bangladesh were 0.6 tonnes[2]. CO_2 emissions per capita in Bangladesh increased from 0.05 tonnes in 1971 to 0.64 tonnes in 2020 growing at an average annual rate of 5.48%. And, the updated Nationally Determined Contributions (NDCs) of Bangladesh states 169.06 million tonnes of greenhouse gases (GHG) emission in 2021 and it will be 409.41 million tonnes by 2030, indicating a sharp rise in the coming years[3]. It's a matter of fact that the amount of GHG released into the atmosphere is 62.37% from energy consumption.

The world's non-renewable energy resources have been fading out rapidly. Hence, countries and organisations are emphasising renewable energy sources such as solar, wind, hydro energy, and of course biomasses. In harmony with that, SNV Netherlands Development Organisation, as a part of its Faecal Sludge Management (FSM) project in Khulna City Corporation (KCC), established a sub-project on using dried faecal sludge as fuel considering its potential biomass.

1.2 Initiation

The initiative of briquetting as fuel was taken in 2018 with a vision of reusing the dried faecal sludges. The briquettes were made without a carbonisation process and mixed with different materials like rice husk, sawdust, cow dung, and molasses as the bindings matrilateral. Initially, round-shaped briquettes were made by hand presses. Two female workers were involved in production without any mechanical fabrication. A drying shade (as like greenhouse) was made for drying the briquettes. However, the result was not satisfactory in terms of energy efficiency.

[1] Biochar is the lightweight black residue, made of carbon and ashes, remaining after the pyrolysis of biomass. Biochar is defined by the International Biochar Initiative as "the solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment".

[2] Climate Watch Data, 'Climate Watch Historical GHG Emissions', *World Resources Institute*, Washington, DC, 2022. https://www.climatewatchdata.org/ghg-emissions (accessed 20 September 2022).

[3] Haque, Mahfuzul, 'Carbon Emission Scenario: Following the Right Path for Climate Mitigation in Bangladesh.' *The Business Standard*, 27 Jan. 2022. https://www.tbsnews.net/supplement/carbon-emission-scenario-following-right-path-climate-mitigation-bangladesh-363013 (accessed 21 Sep. 2022).

1.3 Learning Visit to Kenya

NAWASSCOAL, established in 2018, is a subsidiary of the Nakuru Water and Sanitation Services Company Ltd (NAWASSCO)[4] in Kenya who transforms human waste into fuel briquettes as an alternative to charcoal and firewood. This production facility was designed locally by a range of stakeholders under the Nakuru County Sanitation Programme (NCSP)[5] from 2013 to 2018. NAWASSCO implemented the NCSP with the support of Vitens Evides International (VEI), SNV, Umande Trust, and the Nakuru County Government. NAWASSCOAL is producing and selling carbonised briquettes successfully and currently producing 10 tonnes per month[6].

In 2019, SNV and KCC representatives participated in an exchange programme in NAWASSCO where the team learnt the technical process, management system and marketing of briquette produced using faecal sludge aiming at replicating in Bangladesh. As a part of sharing knowledge, SNV in Kenya and NAWASSCOAL also supported the visiting Bangladeshi technical team in manufacturing carbonised briquette machinery, provided virtual training on the production process, shared their learnings, and organised a weekly review meeting with the production team. Those technologies and learnings are practiced in Khulna on a small scale to understand all the details of the technological process aiming at establishing a large-scale automated carbonised briquette production.

2. Upgradation of the process

After returning from Kenya, the team applied their learning to upgrade the production process.

KCC introduced several mechanical devices for producing round-shaped carbonised briquettes. The devices included a hammer mill, rotating drum, different carbonisation kiln and sludge dryer chamber. All devices were made locally. Besides, several tests were conducted with the combination of different input materials in the carbonisation kiln (Figure 2). The materials included dry sludge, rice husk, sawdust, and dry cow dung for ensuring a better carbonisation.

Figure 2: Carbonisation kiln

[4] To more about NAWASSCO, please visit https://nakuruwater.co.ke/

[5] The Nakuru County Sanitation Programme (NCSP) is an EU-funded public-private partnership that applies a behavioural change and market-based model of accelerating sanitation improvements. To know more abouth the programme, please visit https://snv.org/project/nakuru-county-sanitation-programme-ncsp

[6] ISF-UTS and SNV, *Treatment technologies in practice: On-the-ground experiences of faecal sludge and wastewater treatment*, The Hague, SNV Netherlands Development Organisation, 2021.

3. Testing of carbonisation value

SNV engaged a masters-level student from Khulna University for analysing data to find out the better carbonisation process amongst different materials, different mixing ratios, and materials with carbonisation of sludge for producing briquettes with high calorific value. The best results after conducting 70 trials are given below (Table 1).

The highest calorific value i.e., 14618j/kg was obtained for the briquettes made of 50% coal combined with 50% sludge and the second-best results were 50% cow dung and 50% sludge with a calorific content of 14427j/kg.

Table 1: Best Carbonization result after 70 trials

Moisture	Material	Volume (cft)	Smoke Color	Oxygen Flow	% of Carbonisation	Result Product
3.5	Sludge (Thin)	2.86	Transparent	Moderate	80	Carbon
9.0	Sludge (Thick)	2.86	Transparent	Moderate	90	Carbon Ash: 10
3.4	Rice Husk	2.86	Whitish	Moderate	92-95	Carbon
2.5	Rice Husk	2.86	Whitish	Moderate	100	Carbon
5.5-7.0	Saw Dust 1/3 Rice Husk 2/3	2.86	Transparent	Moderate	80	Carbon
4.0-5.5	Saw Dust 1/3 Rice Husk 2/3	2.86	Transparent	Moderate	100	Carbon

4. Production and marketing

4.1 Production

In mid-2020, SNV, with support from EnDev[7], kicked off production and market promotion engaging a local organisation named Sundarbans Foundation. They engaged three female and one male worker who received online training from NAWASCOAL. After the training and several trials, they succeeded to produce better-carbonised briquettes (Figure 1) from the faecal sludge. This briquette produced high heat without any smoke or smell.

4.2 Market Demand Analysis

According to Sundarban Foundation, the market demand for briquettes is low as most people do not know its usage, efficiency and other benefits due to the lack of awareness. On the contrary, these briquettes require a particular type of cookstove for burning efficiently, so people are unwilling to spend some extra money for buying the cookstove.

These carbonised briquettes take more time in ignition comparing the other available cookstoves in the market run by LPG and other fuel that make the users more reluctant to adopting this echo-friendly fuel.

[7] EnDev is a strategic partnership of likeminded donors and partners to support access to modern energy. Access to modern energy is a prerequisite for social and economic development. EnDev works in more than 20 countries around the globe. To know more about EnDev please visit https://endev.info/

4.3 Marketing Procedures

The Sundarban Foundation has adopted an in-person marketing approaches like 'Uthan Baithak' which resembles to FGD at the home premises. Especially, they provided the cookstoves along with the briquettes to households to popularise the benefits and acculturise the users.

Sundarban Foundation took many other measures like exhibiting how and for how long the briquettes burn, what can be cooked with one kilogram of briquette, miking along the locality, outgiving leaflets, postering, and other outdoor activities. Eventually, the market is expanding. Cookstoves and briquettes are displayed in the display centres to inspire the potential customers buy the product. Besides, SNV is promoting the market for briquettes and ICS towards access to clean cooking solutions[8].

5. Briquette Production Process

The overall production process is quite linear. One step has to follow the previous one and wait for the former one to be completed.

The following schematic diagram (Figure 3) shows the overall workflow from collecting waste to briquette production.

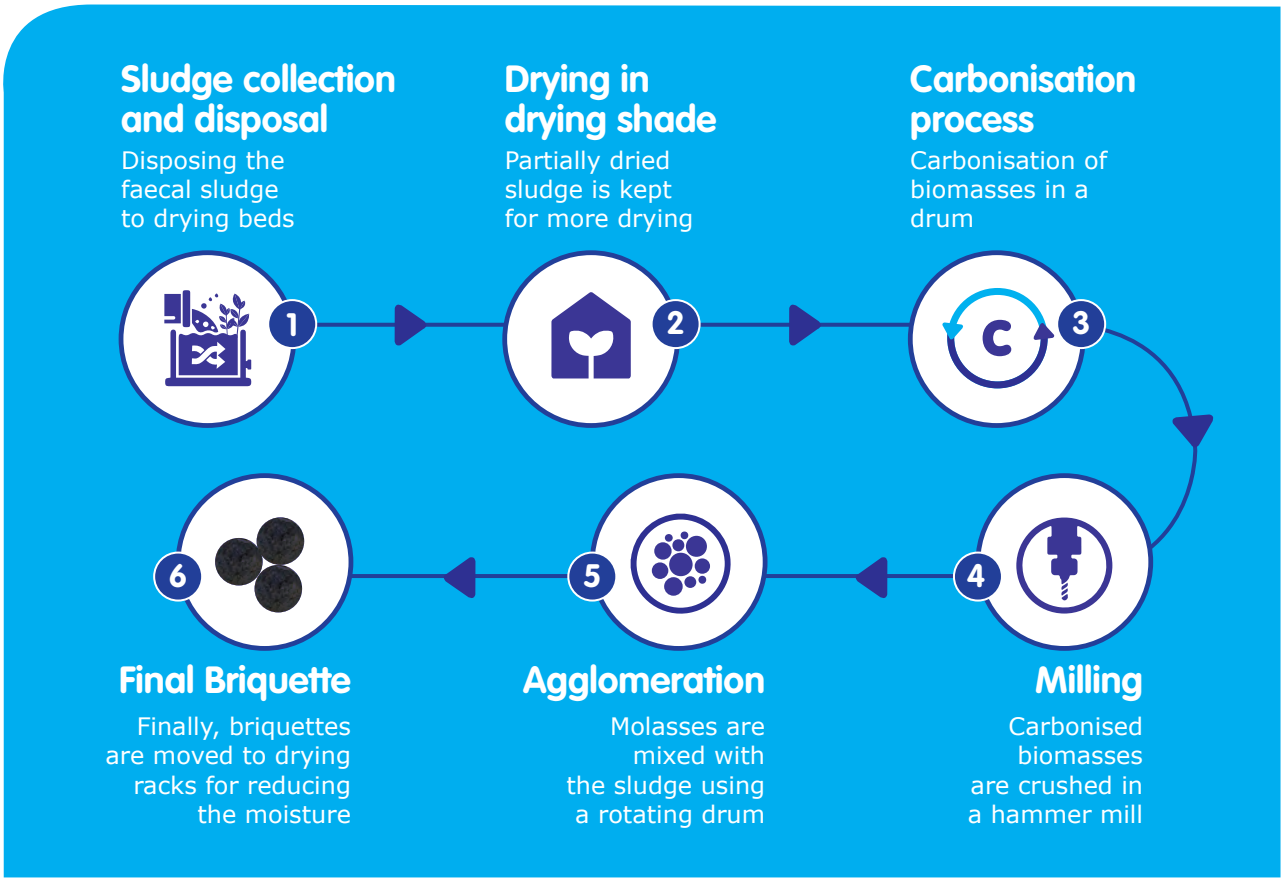

Figure 3: Workflow of briquette production

[8] To know more about SNV's initiatives on providing access to clean and affordable household energy in increasing living standards and good health by promoting ICS and briquettes, please visit https://snv.org/project/promotion-market-briquettes-and-ics-towards-access-clean-cooking-solutions

6. Processes and associated results

Numerous processes in different steps are the cornerstones of the overall process. After umpteen tests and experiments, appropriate and feasible solutions have been finalised for the project to run efficiently exerting the utmost efforts. The processes and results are stated below (Table 2).

Besides, the overall cost of production has been calculated. For producing per kilogram of briquette (Cow Dung 50% : Sludge 50%) the cost is 14.37 BDT including the cost of molasses.

Table 2: processes and results

Process	Details	Details
Carbonisation	This is the process of sequestration of the carbon content contained in the raw organic materials.	**Rice husk:** Various moisture – Carbonisation within 2 hours. **Saw Dust:** Mixed with two third of rice husk – moisture 4.0-5.5% – Carbonisation within 3 hours. **Cow Dung mixed with sawdust:** Moisture 10-15% - carbonisation within a hour. **Thin Sludge:** Moisture 10-15% - 90% carbonisation within 3.5 hours
Milling Process	The machine grinds the carbonised materials and releases the powdered materials through the cyclone.	Both sludge and coal can be powdered at the same RPM.
Mixing with molasses	Molasses acts as binding material or adhesive and keeps the dust particles intact.	The best ratio of water and molasses is 15:1.
Agglomeration	The rotator drum revolves and being mixed with molasses produces round-shaped briquettes (Figure 4).	
Water boiling test	The water boiling test represents which briquette is suitable for what type of cookstoves.	Among different cookstoves the one that SNV developed (cover photo) appeared to be the appropriate one.
Calorific value and proximity analysis	These tests are run to find out briquettes with highest calorific value.	Coal: Sludge = 1:1 CV = 14618 kj/Kg Cow Dung: Sludge = 1:1 CV = 14427 kj/Kg

Figure 4: Rotating drum

Figure 5: Ensuring he occupational health and safety

7. Challenges and Limitations

The challenges and limitations of the whole initiative are:

- People are still cynical to sludge and sludge products
- Everyday production is low
- The surface area of the drying shade (as like greenhouse) is not sufficient for large-scale production
- There are six drying beds, which is insufficient
- The product is echo-friendly except the packaging
- Maintaining proper safety measures needs to be assured (Figure 5)
- Briquetting requires a long time that should be reduced to maximise the production

8. Current Status

In 2020, KCC managed a grant worth USD 0.64 million (BDT 50 million approx.) from the central government for purchasing equipment for briquette production as a part of scaling up the initiative. Currently, KCC is in the process of outsourcing the briquette production and market promotion to a private operator.

9. Conclusion

The available fossil fuels (coal, oil, natural gas, LPG, etc.) have higher climate footprints, and their cost is increasing rapidly both in the international and domestic market. So, it has become costlier to afford for cooking.

On the contrary, Biochar could be the echo-friendly fuel of the future for many purposes which ensures the 3R process by reusing of fecal sludge, the wasted human excreta, combining with other biomasses.

KCC took this brave step with SNV to initialize this kind of project which could be sustainable. Most importantly, these biomasses come free of cost having very lower or no climatic footprints when converted into carbonised briquettes. Thus briquettes can be an better solution for cooking in coming days.

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