Financially Sustainable Processing

of

Fecal Sludge

Feasibility Study

Supported by

IRC Wash and BRAC Wash Program

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Executive Summary

Objective: Can fecal sludge from pit latrines based in rural areas be processed in a financially sustainable manner?

Findings:

1. From a systems perspective, looking at collecting and processing of fecal matter, the using of pit latrines is inefficient. Larger containers such as 5 to 10 latrines connected to one septic tank should be considered. The collection cost of obtaining fecal sludge from pit latrines, is expensive and prevents the cost effective and safe processing of fecal sludge.

2. Nonetheless, by using anaerobic processing of agri-waste combined with fecal sludge the process can be made financially sustainable. This requires that three products related to anaerobic processing are sold. These products are: (i) electricity, (ii) heat generated from a gas engine fueled with biogas that drives the generator for the production of electricity, and (iii) the digestate, processed into an organic fertilizer. The income from these three outputs should be documented in a legally binding manner before investments are made in the plant. Electricity is sold through a Power Purchase Agreement either to the Rural Electricity Board or through an agreement with an individual off-taker, such as a garment factory. Heat in the form of hot water is sold to either an icemaking factory or a cold storage using an absorption cooling system, while the organic fertilizer is sold as part of a barter agreement in which large farms supply corn-stovers and get a high quality fertilizer with a guaranteed chemical composition. In case the barter system is not possible as the suppliers of corn stovers are different than the clients for the fertilizer, separate contracts need to be put in place. Only when there is certainty regarding the income from the proposed unit, should investment in developing the unit be considered.

3. One important parameter is that such a unit should be located very near or adjacent to the source of agricultural waste, which is the major feedstock. This can be corn stovers, rice straw, water hyacinth, or a combination of products.

4. Our research shows that a biogas unit using corn stovers and chicken manure only can be a profitable investment in Bangladesh. The profit from this unit will cross subsidize the logistical cost of collecting the fecal sludge from pit latrines. Our recommendation is therefore that the unit will be designed and constructed for processing corn stovers (or other agri-waste or even water hyacinth) with chicken manure, and fecal sludge (which requires the installation of a "hygienic unit" or helminth killer), but that the unit starts up only with corn stovers/chicken manure. This would allow for an organic growth of the fecal sludge collection from pit latrines, which would gradually replace part of the corn stovers. In the model presented in the report, the initial feedstock would be 7,000 Metric Ton (MT) of corn stovers/year, 3,000 MT of chicken manure. However this would gradually (over a period of 3 to 4 years) change to 1,000 ton fecal sludge (content of 40,000 pit latrines), 6,000 MT of corn stovers and 3,000 ton of chicken manure.

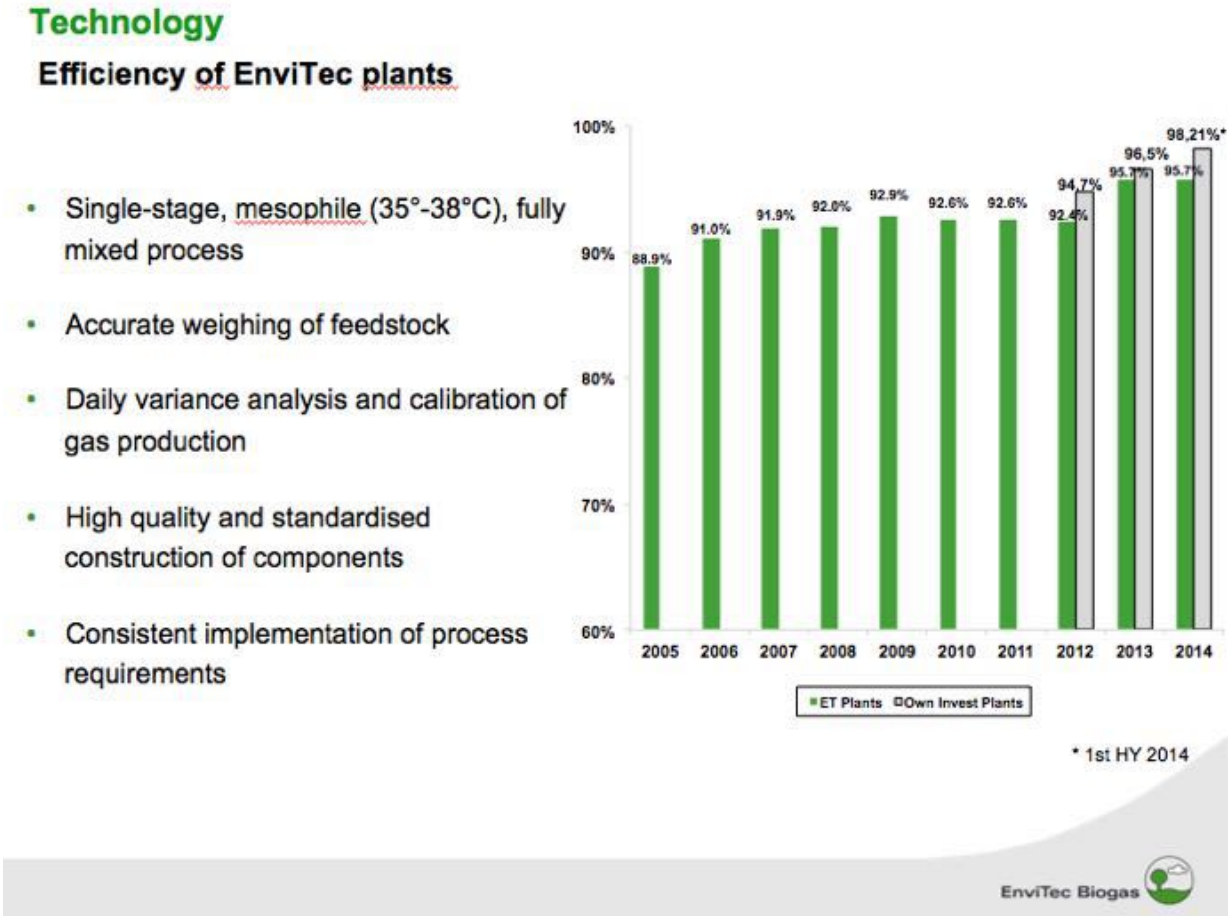
5. In spite of the fact that biogas or gobar gas is well known, the modern application to produce gas or electricity at a commercial scale, has been made possible only recently through an advanced engineering solution. There are a few manufacturers with solid track records in the form of plant availability for 5 years or longer for 95% of the time. Non-professional experiments have given modern anaerobic digestion a bad reputation. These engineering solutions have gone hand-in hand with new developments in controlling the process through specially designed enzymes. These are produced in highly advanced chemical companies such as DSM Netherlands (see Annex 1) and Novazyme.

6. Enzymes would be an interesting solution for the feedstock in Bangladesh. The expectation is that the corn stover will be quite dry and fibrous when harvested. This will result in lower gas production as can be expected from similar biomass, which is harvested at the best moment (freshest) for biogas production. For the corn stover it would therefore be advisable to use enzymes to ensure a better breakdown of the biomass and thus an increase of the production of biogas.

7. To fully check the advantages and disadvantages of using enzymes for this project, can only be done when the plant is in operation to measure the real effect. This is because it is very difficult to use the results from other tests on other feedstock. The advantages for corn stover could be, lower amounts of biomass needed for the same production of biogas. A lower overall energy consumption due to a decrease in viscosity and as a result less energy needed for agitating the digester. Also the nutritious value of the digestate might be influenced, as more biomass will be broken down, which will result in more nitrogen being detached from the biomass and thus be more easily available for the plants direct uptake. The disadvantage will be the costs of the use of enzymes. It is not possible to measure the effect of the positives against the negatives and give a final statement on the feasibility of the use of enzymes now without a test on the actual biomass, we therefore have not taken the enzyme costs into account in the financial model.

8. These innovations have made it possible for several companies to guarantee plant availability for over 95% of the time for five or more years. Figure 1 below shows the plant availability factor, also called plant load factor of the ENVITEC portfolio of plants built for others as well as plants owned and operated by ENVITEC itself. From a few plants in 2002, ENVITEC has now built 467 plants with a combined capacity of 366 MW.

Figure 1: Plant availability factor for biogas plants



9. More than the technical requirements, commercial processing of pit latrines is foremost a logistical problem. Efficient logistics make this a go or, if it is not efficiently organized, a failure.

10. The use of local agricultural waste provides additional income to local farmers

11. Successful large scale implementation is a win-win solution: a win for improved health, improved environment due to significant reduction of greenhouse gas emission, a win for local economic development, and, through cold storage and/or ice-making, a significant reduction of post harvest losses,

12. Last but not least the organic fertilizer produced is of high quality and renews the Bangladesh soil, which has been depleted of nutrients due to excessive use of chemical fertilizers only.

Background

13. It is undisputable that access to and use of adequate sanitation, together with good hygiene and safe water, are fundamental pillars of good health and of social and economic development. The global disease burden that can be associated with poor sanitation alone, is 10%[i]. Diarrheal diseases alone cause up to 2.5 million deaths annually, and are therefore some of the most important faecal-oral diseases globally[ii]. Diarrhea hits children under 5 particularly hard. In 2008, diarrhea was the leading cause of death among children under 5 in sub-Saharan Africa, with 19% of all deaths in the under 5 age group[iii]. Poor sanitation also leads to other health problems such as the parasitical infections caused by helminths. Helminthic infections negatively impact the nutritional status of infected individuals through stunted growth in young children and through anaemia, especially in pregnant women[iv]. Exposure to diarrheal diseases is also linked to both childhood and maternal malnutrition in a vicious cycle, since exposure to diarrheal diseases affects nutrition and malnutrition increases vulnerability to diarrheal diseases[v].

14. For women and girls, access and use of household and school sanitation facilities is of extra importance. The provision of household sanitation reduces the risk of rape and/or attack when going to public latrines or when practicing open defecation, which is an actual threat to women and girls world-wide today. The existence of appropriate school sanitation, and with appropriate measures for menstrual hygiene, for girls and young women, is a very important tool to keep girls in school once they start menstruating[vi].

15. One can of course put figures on all the negative effects of poor sanitation, hygiene and water. It has been estimated that the prevention of sanitation and water-°©-related diseases could save around USD 7 billion annually in averted health costs and another USD 3.6 billion if adding the value of deaths averted[vii]. It has also been shown that investments to counteract poor sanitation pay off. It has been estimated that one dollar spent on sanitation can generate about ten dollars' worth of economic benefits, mainly by productive work time gained from not being ill[viii].

16. Given the above, it is crystal clear that access and use of adequate sanitation is of prime importance to good health, social and economic development. This is reflected in the Millennium Development Goals where there is a specific sanitation target to halve, by 2015, the proportion of the population without access to improved sanitation. Improved sanitation, as defined by the MDG target, focuses on a hygienic barrier between the user of the sanitation facility and the excreted feces, but unfortunately ignores the future fate of the collected feces. With 2.6 billion people world-°©-wide today without access to improved sanitation, it is perhaps not so strange that many sanitation programmes and projects focus on building latrines to provide improved sanitation to people, as per the MDG definition. BRAC has been very successful in providing Bangladesh's population with access to improved sanitation, as it has provided access to improved sanitation for 25 million people under the BRAC WASH program.

17. However, the access to improved sanitation can only be sustained over time if there are mechanisms in place to empty the existing latrines in a hygienically safe way, in order to avoid "delayed open defecation" which will take place if the fecal sludge from emptied pits is disposed of in an unhygienic way. Thus, current sanitation projects and programmes are faced with the double challenge of both increasing coverage of improved sanitation as well as ensuring services of safe emptying and disposal of fecal sludge, where the latter challenge is ever increasing with the success of addressing the former. The complexity of the sanitation challenge does not end there. Sanitation is also linked to food security and energy production. The human excreta contain both nutrients and organic matter, which originate from the food we consume. In fact, a full-°©-grown adult excretes all nutrients ingested[ix], although the energy value in excreta varies considerably, according to a person's diet. An average adult's excreta from a high fiber diet contains 23,000 kJ/kg. Based on the average wet-stool production per adult per day of 349 grams, the daily energy value of an average adult equals 2.22 kWh.[x]. Sanitized excreta thus represent a huge potential value in terms of nutrient and energy content. Thus, disposal-only of excreta, even if done safely, leads to a loss of both nutrients and energy, which is especially undesirable for poor countries with low access to both food and energy supplies. It is estimated that currently over 925 million people are chronically hungry[xi], and according to UNEP[xii], globally some two billion hectares of vegetated land have been degraded since 1945, representing 17% of global productively used land.

18. BRAC is recognising the complexity of sanitation and its links with both food and energy production through a number of activities undertaken under the BRAC WASH II programme and so is reaching beyond just achieving the sanitation target of the MDG. In looking for solutions BRAC has initiated a number of activities:
    - Investigation of possibilities to establish micro-production of bio-fertiliser and retailing in cooperation with the BRAC agriculture programme.
    - Investigation of possibilities to process pit latrine content in a commercially viable way by combining the excreta with agriculture waste, chicken and or other animal manure, to produce biogas and bio-fertiliser.
    - Action research into low-cost treatment technologies for sludge from single pit latrines. This report deals with the findings of combining human sludge with agricultural waste and chicken manure to produce biogas at a commercial level.

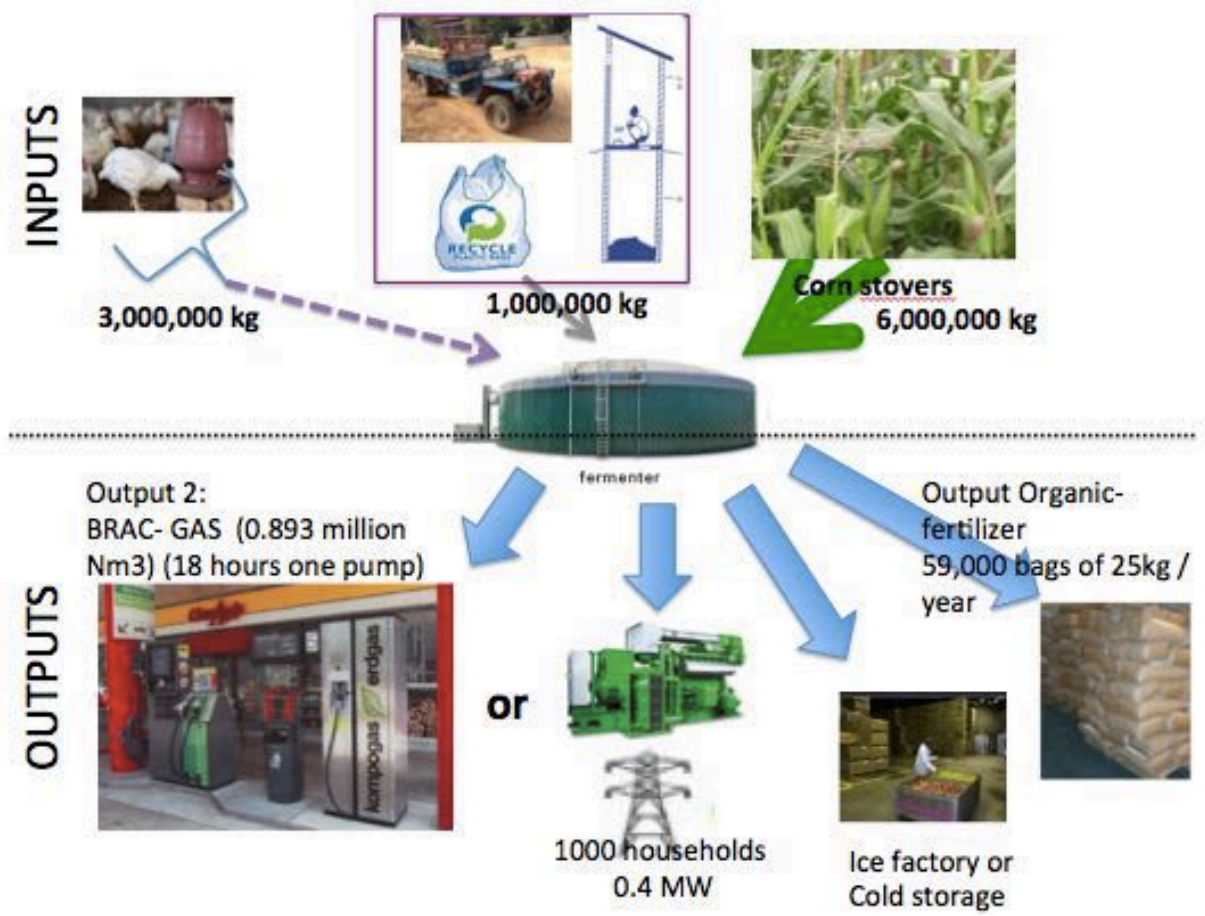
The Theory

19. **Reducing greenhouse gas emission through the processing of human fecal sludge, animal and agricultural waste into biogas**. The biogas is used in a special gas engine/generator, which produces electricity and hot water. The heat-energy is used in a cold storage facility. The digestate that produces the biogas is made of a mixture of human fecal sludge (5- 15%), chicken or cow-manure (25-35%) and agri-waste 60%. The processed digestate is used to produce a certified organic fertilizer which complies with all local and international regulations and health standards, so that it can be used both for large-scale seed farms, as well as high value vegetables and cash crops. Reducing the traditional power requirements for cold storage will reduce the use of fossil fuel. Similarly replacing fully or partially the need for chemical fertilizer will reduce the greenhouse gas emissions involved in the production and use of chemical fertilizer. The use of organic fertilizer will restore the soil nutrients of highly depleted Bangladesh agricultural areas. The process will provide employment for local people in the collection of agri- and animal waste, managing the biogas plant, operating the cold storage and organic fertilizer production plant. It also will strengthen local village economies by reducing post-harvest losses and add value to local agri-products due to access to cold storage facilities and a reliable electricity supply.

20. Figure 2 below is a schematic diagram of one of the solutions studied. Fecal sludge would be collected, and after treatment in a hygienic unit to kill all bacteria, including e-coli and/or eggs of bacteria (helminths), it is mixed with chicken manure and green matter, in this case corn stovers. Annex 2 gives a detailed description of the work done by the International Centre for Diarrheal Disease Research (ICDDR,B) under this program, which shows that the human sludge should be heated for 30 minutes at 75° Celsius, to have all helminthes and bacteria killed, before the sludge is mixed with the other feedstock

21. Commercial farms can produce two yields a year, while the BRAC seed farms have one yield a year. The corn stover would be shredded and stored as silage (see Annex 3 for a guide for silage making). This would facilitate storing over 9 months of feedstock, which would guarantee a continuous operation, as the digester can in principle run on 100% on corn stover inputs. The other input normally used is chicken manure. This will help solve another current problem, when the manure is not treated and as a result significant amounts of methane are unnecessarily released in the atmosphere. The third input will be fecal sludge collected from pit latrines.

Figure 2: Schematic Diagram of Digester



The Practical Aspects

22. As mentioned above, even in Bangladesh, where fossil fuel is subsidized and therefore the real cost of electricity or gas is not paid by the customers, theoretically it is possible to operate a small commercial size financially sustainable biogas unit. However it requires both effective logistics in collecting the feedstock, as well as professional management in selling the three products that such a unit can produce: electricity, organic fertilizer and heat to be used in cold storage or for ice-making.

Logistical and Market issues regarding feedstock

Pit latrines

23. While pit latrines have provided a temporary solution for the health problems associated with rural sanitation, now that the latrines have filled up, these problems are re-surfacing. Thus if we look at rural sanitation from a systems point of view, which would include the environmentally and healthy processing of pit latrine contents, pit latrines were and are not

a good solution. The cost of emptying individual pit latrines and transporting the contents is comparatively very costly. Even when the owners contribute for the cost of emptying their pit latrines, the logistics cost of emptying pit latrines and transporting it is a drain on an enterprise which would make a reasonable profit if it would just operate based on chicken manure and green waste input such as corn stovers or water hyacinth. The capital investment of connecting 5 to 10 pit latrines to a larger septic tank would go a long way to supporting a more sustainable rural sanitation solution.

Figure 3: Manual emptying of pit latrine

Manual emptying of Pit Latrines

24. Traditionally pit latrines are emptied when families have some cash, mostly at harvest time. The person who will do the emptying is provided with a bottle of local liquor, a bottle of kerosene, used to fire up the pit to avoid the stench, and BTD 600. The latrine is emptied manually, with the person doing the emptying scooping up the fecal sludge as shown below. This is then put on top of a plastic sheet. Sometimes the contents are emptied in a hole dug for that purposes, sometimes the sheet is emptied and washed in the river nearby.

Use of liners or buckets for efficient manual emptying

25. After an extensive review considering plastic liners, as well as liners made from jute and cotton, these were all rejected due to difficulty of securely fastening the liners around or in the pit-latrine. A technically more reliable solution seemed to be the use of some form of plastic bucket. Annex 4 gives a report of the not successful field-testing of the use of these buckets in pit latrines. After some research a small but strong bucket (buckets used as paint

containers) was found. Two different methods of attaching the buckets in the pit latrine were tested: These were: (a) bucket with metal clamps from the pit latrine slab - hanging from the slab, (b) steel frame on the ring – lying on the top ring. A third method using a steel truss to hold the bucket with it sitting on the floor of pit latrine could only be used in so-called offset pit latrines, of which up to now only a few have been installed.

a. Bucket with metal clamps from the pit latrine slab**:** Steel clamp supported bucket hanging, the original idea for pit latrine emptying method – perceived to be the most convenient and cost-effective was field tested in Shariakandi Upazila in Bogra. Field testing findings of steel clamp supported bucket hanging reveal the following:

    - Slab strength (being made from slim wire-mesh) does not support steel fastener (hook, clip, buckle, etc) hanging bucket, which will gradually reach 20 kg weight. Pit latrine masons and waste keeper workers observed that this method carries high risk, as it would cave-in to the pit.
    - The method would require doctoring the slab; fixing a steel hinge into the slab and the subsequent hanging, together with holding a fecal sludge filled-in bucket, will weaken the slab strength. The problem will be compounded with repeated removing of the bucket. Lifting filled-in bucket (20 kg weight) would cause the already weak slab to collapse – the pit latrine masons observed.
    - Steel frame on the ring – lying on the top ring**:** WASH Committee members suggested an alternative to hanging type, which was tested in Sharakandi, Bogra. The following sketch illustrates the steel frame to hold the bucket and placement of the steel frame on the top ring of the pit latrine.

    b.The steel frame was fabricated from steel bar, weighing 2.89 kg in a local micro enterprise in Bogra, and cost Tk. 250/- each (Euro 2.5).

    This method requires a series of steps – the installation of a steel frame on the ring would need first removal of the top ring and the slab; in the second step the ring and the buckets are installed, in the third step a new ring has to be placed on the steel frame. While executing these steps the latrine house made of bamboo and bamboo thatch would need to be removed and replaced with a new one. Consultations with pit latrine owners' show that they prefer that corrugated iron sheets on the side and the top are needed to replace the old bamboo structure. Next with the frequency of emptying the filled in bucket and reinstalling an empty one will require the replacement of the slab after 3 or four times of use.

b. Taking note of all the technical requirements and clients expectations, a costing of the process for 100 units of pit latrine have been worked out. The costing found that for installation of 100 units it would require BDT 5,990 per pit, which is say BDT 6,000 or Euro 6 per pit latrine (exchange rate Tk 100 = Euro 1).

c. During interviews with 7 different BRAC WASH committees, it was found that local community regards the buckets as a non attractive alternative. BRAC WASH members commented it was going back to old days of bucket-based fecal sludge emptying especially keeping in view the behavioural practice change which investment in a mass campaign had brought.

The Vacutag

26. In Bangladesh, various types of the original UN-Habitat developed Vacutag have proven to be quite successful in urban areas. At the time of our work in rural areas, Practical Action carried out a series of field tests of the use of Vacutags in semi-urban areas[1]. Two types of Vacutags were used in this survey a Nashimon pulled, with a 2,000 kg capacity, and a truck mounted tank with a capacity of 5,000 kg. In addition to the results from the survey from Practical action, BioSol as part of the IRC sponsored research project did their own survey in coordination with the BRAC WASH program focusing on more rural and the deeply poor communities. While in urban and peri-urban areas the Vacutag operators can demand PDT 600.- for a pit latrine emptying, in remote areas, people can not afford more than BDT 200.- per pit latrine, in spite of the fact that the logistical costs of bringing the Vacutag to and from these areas are more expensive.

27. Annex 5 describes the detailed experience, from focus group discussions with the BRAC WASH community, an analysis of the number of pit latrines which can be reached by Vacutag, the willingness to pay for the service, as well as the actual results of emptying the pit latrines in the remote villages.

28. The field trials were executed using existing equipment. From the trials it is clear that significant improvements can be made by using heavier pumps, which can collect sludge from pit latrines more than 100 feet away from the Vacutag.

29. From a cost efficiency point of view, the recommended solution is to install septic tanks in each village, and have a local Vacutag empty the pit latrines in each village and dump the sludge in a septic tank, which is than in turn emptied once or twice a year by a large 10 ton septic tanker.

30. The financial model is built on the assumption that the program will build septic tanks in each ward and/or Upazila.

Chicken Manure

31. Of the three proposed feedstock ingredients, chicken manure appears to be easiest to handle. There is an existing trade in chicken manure and it is already widely used for fertilizer. If a significant program like the one now proposed comes off the ground, one needs to expect, as happened in Thailand, and Indonesia, that the higher demand will drive up the cost. It is therefore advisable to close long term supply agreements with farmers. The contract would stipulate a penalty in case a farmer can not supply the contracted amount of chicken manure.

32. The test was done with a rather small 2.5 ton truck. In the financial model, the costs are based on the use of a 10 ton truck. A10 ton truck will not face logistical problems in reaching the chicken farms. All the farms have reasonable road access.

33. Annex 7 provides a description of the field test in collecting chicken manure. The experience shows that chicken manure is widely available. As chicken manure is not a

[1] Annex 6: BioSol Storyboard: Sourcing of Vacutag: Experiences from Fecal Sludge Management Programmes

seasonal activity, the manure is available 365 days of the year, and the required 3000 MT, can easily be collected by a ten ton truck making one to two routes a day.

Corn stovers

34. The field trial in collecting corn stovers encountered extreme difficulties, which therefore made it a good trial as these conditions can reoccur regularly when a plant is up and running.

35. Arrangements were made to collect the corn stovers from farmland at a distance of less than 12 km from the point were silage would be produced for storage for later use in organic fertilizer. However a week before the test was planted the entire Shariakandi char land was submerged by flood water.

36. The ultimate corn stover collection site was relocated in Krishnarampur village, Union: Bulakipur,Upazila: Ghoraghat, District: Dinajpur about 60 km from the GKSS organic-fertilizer Enterprise. However, the volume was limited and the corn stovers dried in the field.

37. The farmers were identified, contacted and contracted for supply of 510 stalks of corn stovers. To meet the supply commitment, the farmers employed 17 laborers to cut and bundle 510 stacks of corn stovers working in the field from 8 am in the morning till 3 pm in the afternoon on the 27 August 2014. Specification of the corn stover lot collected was as follows:

    - Each stack consisted of 40 corn plants/stacks;
    - Weight of one stack ranged from 13 to 16 kg; so average weight of each bundle was 15 kg;
    - Length ranged from 6 to 7.5 feet;
    - Circumference of a bundle is 29 inches.

38. With an average weight of 15 kg each bundle, the total target was to collect 7,650 kg. However, the small (and cheaper) truck could carry only 370 bundles or 5,550 kg. The larger truck can carry more than 600 bundles;

Table 1: Payment at Farm Gate and Labor for movement to truck at Ghoraghat

Particulars	Total Units/ Quantity	Unit Definition	Unit Cost /BDT	Total Cost /BDT
Payment to farmers	510	bundles of 15 kg each	21.57	11,000
Van transportation	28	van trips	50.00	1,400
Horse cart transportation	48	horse cart trips	60.00	2,880
Total weight:	7,650	kg	1.99	15,280

510 stacks @ 15 kg/bundle				
Unit Cost in Taka (rounded	01	kg	2.00	2.00
Cost Per MT excluding Trucking				2,000

39. As corn is a seasonal crop, and corn stovers for biogas production should be harvested as early as possible after the ears are removed, the transportation costs are excessive. The financial model showed that logistical cost would be so high that the project would not be sustainable. It is therefore not only recommended that the unit is established on or near the supply of corn stovers, but this is a financial requirement. Without a site close to the corn stover supply, it is not worth investing in a plant of this nature.

40. Another important consideration is the fact that corn stovers are also extensively used as fuel and considered an important household fuel safety resource. Other uses are coming up fast like particle board making. The price, which is currently estimated at Tk. 0.50 per plant/stack by the farmer, is likely to increase.

41. Annex 8 provides a detailed description of the corn stovers logistics tests. The method of silaging as shown in the description needs to be replaced using specialized equipment and follows the process described in Annex 3: A guide for silage making and utilization in tropical regions.

Operational Plan/Technical Design

42. This chapter focuses on an overview of proposed technology, a technical review of major plant equipment and civil construction and the proposed scope of work of the sponsor and the technical consultant including the cost of the plant and civil works.

Technology

43. The proposed plant will produce biogas based on anaerobic digestion, which converts energy stored in organic waste present in manure into biogas. The feedstock namely fecal sludge, chicken manure and corn stover will be fed into an inlet at a ratio of 1:3:6 with proportional water for mixing. The mixture is pumped to the digester. Anaerobic digestion takes place in the digester, which is the modern technology for waste-to-energy. The technology is widely used in the treatment of different organic wastes.

44. Anaerobic treatment is comprised of the decomposition of organic material in the absence of free oxygen and the production of methane, carbon dioxide, ammonia, traces of other gases and organic acids of low molecular weight. The gas possesses about 50-70% of

methane. It is considered that the optimum retention period for production of biogas from the feedstock is 27 days. However, the retention period depends upon the loading rate of the feedstock. In this project a retention period of 38 days has been considered. After the digestion, the remainder of indigestible material,which the microorganisms cannot consume, and the leftovers of the dead bacterial constitute the slurry. The generated slurry is wet and has high solid contents.

Process Flow Diagram

45. The mixture is held in a digester or reactor. The gas is produced from a four phase process namely, (i) Hydrolysis (ii) Acidogenesis (iii) Acetogenesis iv) Methanogenesis. (Figure 3) It is a biological engineering process in which a complex set of microorganisms are involved. These microorganisms are environmentally sensitive and the anaerobic treatment process eliminates the harmful microorganisms.

46. The flow chart Figure 4 and Annex 9 show the actual projected intake and processing scheme. Fecal sludge is collected in a 20m3 steel tank. From there it moves by badges into a hygienic unit, which will keep the sludge for 30 minutes at a temperature of 75C, and from there it flows to the mixing tank. The heated sludge will help to keep the digestate on the mesophillic process temperature of 38 to 40C in the digester.

47. The broiler dung is taken into the manure pit were it is mixed with water and taken to the mixing tank.

48. The corn silage which is loaded through a Terbrack Vario intake (shown in Annex 10), is screened, pulverized and weighed before it is transported into the mixing tank (shown in Annex 11)

Figure 3: Simplified Process Diagram of Anaerobic Digestion

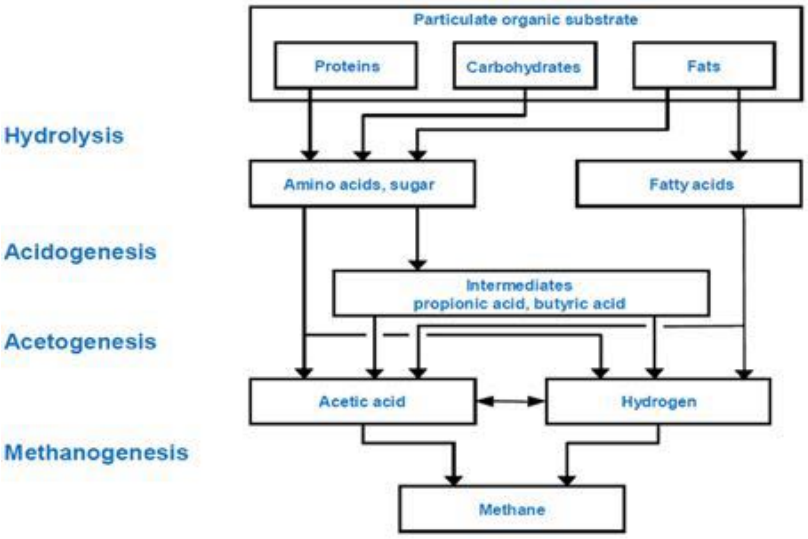
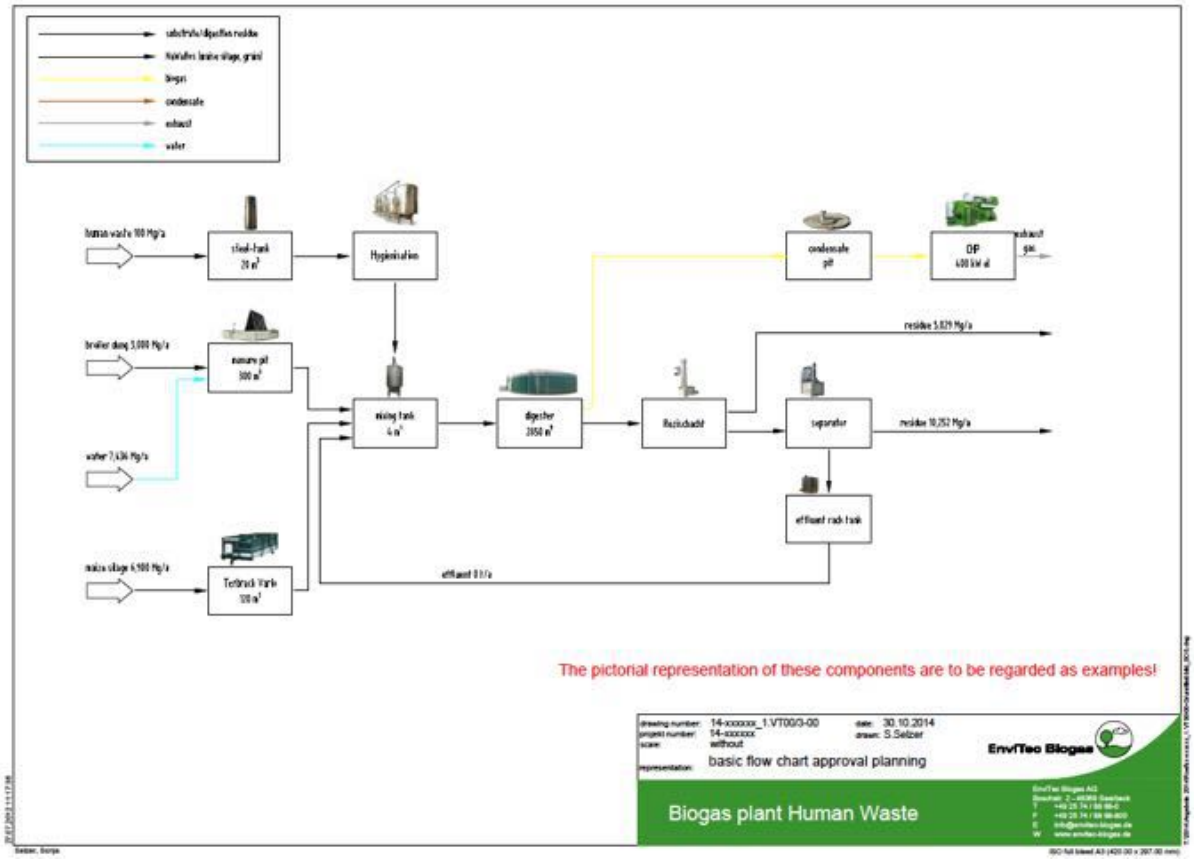


Figure 4: Flow chart



49. The digester is equipped with the latest Envitec licensed technology including back-flow, aerinators to obtain the most efficient gas extraction from the digestate.

50. Digestate processing takes place by taking the digestate through the separator as shown in Annex 12. The separator takes the solids out of the digestate, the liquid fraction, the

effluent, is then taken back through the mixing tank into the digestor reducing water requirements of the process.

Land and Land Requirement:

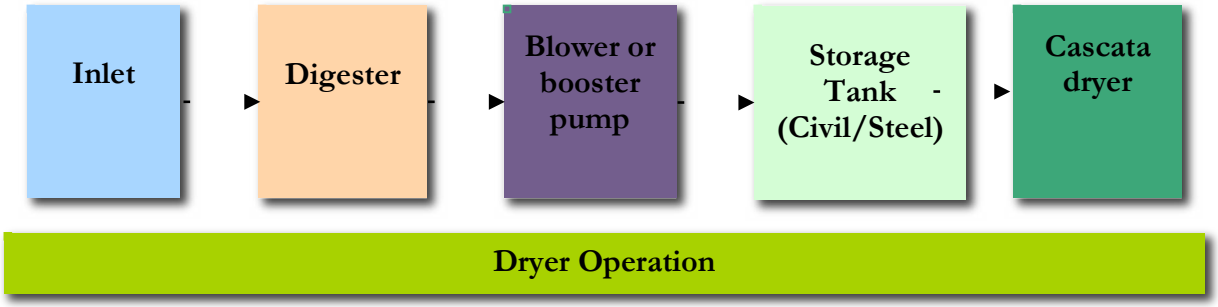
51. The plant will be set up on a piece of land in Bogra measuring 5,885 square meters for the plant itself and 4,125 square meters for the silage storage, or in Bangladesh units a total of 247 decimal are required. The estimated cost taken in the financial model is BDT 50,000 per decimal for a total of BDT 9,857,072.

Operational Plan

52. Uses of Produced Biogas: The produced gas from the plant will be used for generating electricity and heat for the drying of organic fertilizer, and production of ice, which is a byproduct.

53. Operating Dryer: Some of the heat from the plant will be used for operating a dryer for drying organic fertilizer. (Annex 13: Cascata Dryer) .

Figure: Process Flow Diagram for Gas Supply to Dryer



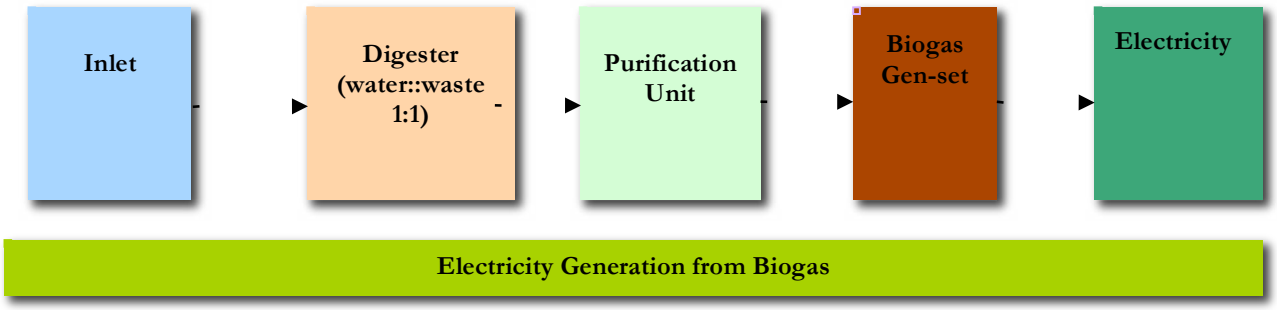
Electricity Generation

54. The produced gas will be used for operating a 400 KVA biogas generator for producing electricity. There are a number of manufacturers that now produce highly efficient engines using biogas (50 CH4). The Jensbacher machines are widely used and well tested, but might not be supported in Bangladesh, where Kirloskar engines might be available. The engine selection will be an important part of the selection of an Engineering Procurement, Commission contract (EPC) which would be required if BRAC decides to continue with the project.

55. For the generation of electricity, the biogas is also passed through a purification unit. Produced biogas contains a small percentage (usually less than 1%) of hydrogen sulfide, which degrades engine performance and lifetime substantially. The purification unit also known as the desulphurization unit ensures efficient use of the gas generator. The purified

biogas is then passed to the generator set and, thus, electricity is generated. The generator set is a combination of gas engine and alternator.

Figure: Process Flow Diagram for Electricity Generation



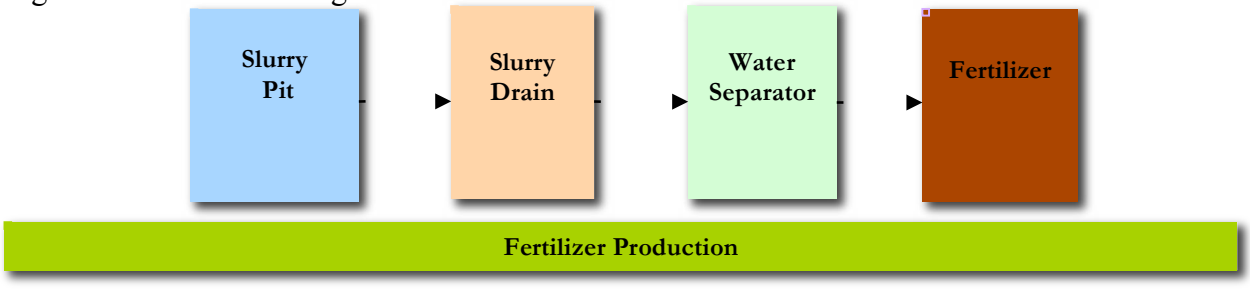
56. In this project, a 400 kVA generator will be used for generation of electricity which can produce 3,013 MWh of electricity per year considering the losses.

Fertilizer Processing:

57. Fecal sludge, chicken manure and corn stover are sources of nutrients including Nitrogen, Phosphorus, and Potassium etc. However, Nitrogen is often the main nutrient of concern to be used in fertilizers. The nitrogen content in fresh feedstock is about 2.8%, which can be increased up to 3.01% after controlled treatment.

58. In this project, the slurry generated in the digester remains in semi-liquid state and needs processing to be utilized as fertilizer. From the digester, slurry will be collected through a hydraulic chamber to a slurry pit. The slurry will be sent to the water separator through a slurry drain. In this project, a water separator will be used to take out the water from the liquid slurry. The water separator will take about 40 to 60% of the water from the slurry. The end product from the water separator will be dried and then used as fertilizer for corn production.

Figure: Process Flow Diagram for Fertilizer Production



59. Based on the chemical analysis done under this project, and taken the transformation that will take place in the fermentation process, the following are the output characteristics for the Organic fertilizer (Quantities in Metric Ton)

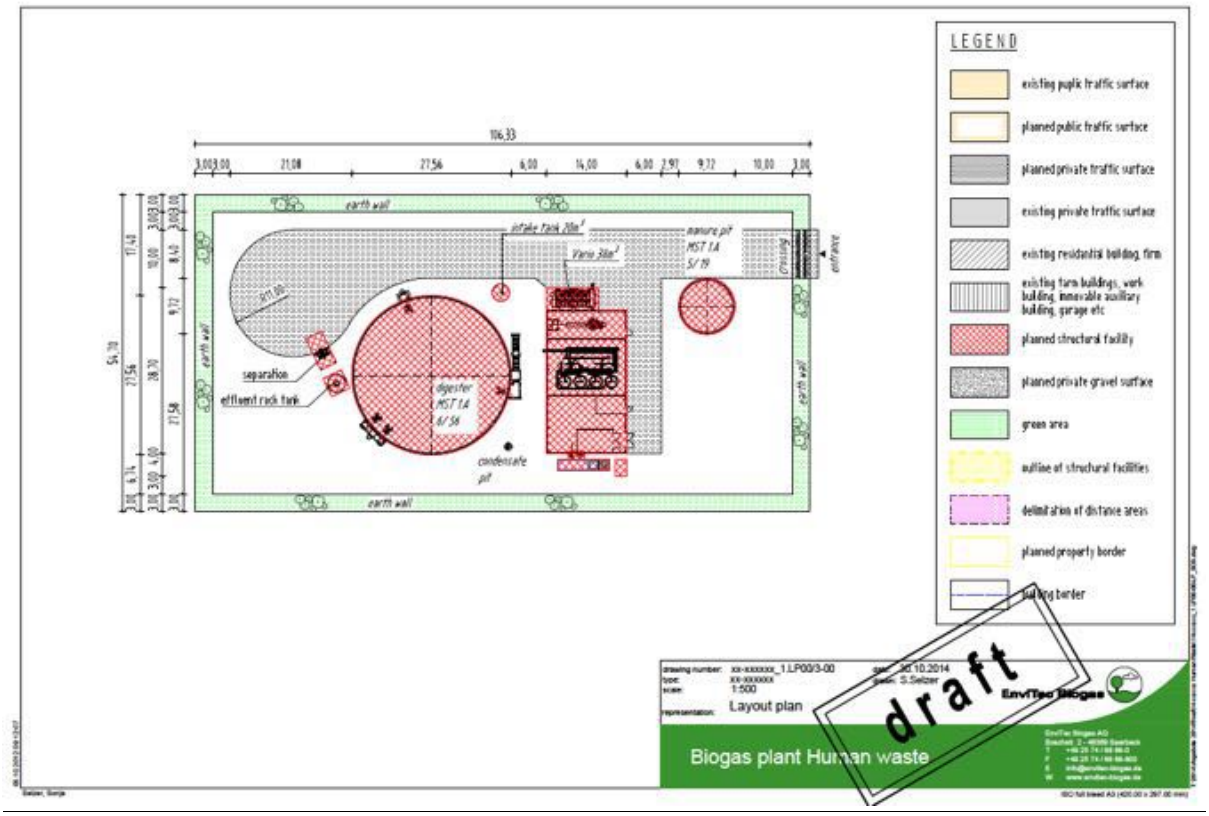
Table 2 Chemical content of organic fertilizer

	digestate	N	P	K
Digestate total	15,282	115,245	12,957	35,319
kg/ton		7.54	0.85	2.31
DM kg/ton	1,957	58.88	6.62	18.04
% (DM)		3.01%	0.34%	0.92%

Civil Construction/ Plant layout

60. The major components of civil construction are shown in the plant layout below and Annex 14. They consist of :

- Manure Pit and Hydraulic Chamber
- Vario intake for corn stover and other silage (Annex 10)
- Hygienic unit and mixing / weighing units
- Engine room
- Control room,
- Intake tank for fecal sludge
- Condensate pit
- Digester
- Separation unit (see annex 12)
- Affluent Rack Tank



Engineering, Procurement and Construction/Commissioning (EPC)

61. Given the size of the project, it is strongly recommended that the project is executed by an experienced EPC contractor. Only those contractors with a track record of producing over 50 units, which can be shown to have at least 90% plant availability, should be selected. In the selection it is important that the contractor can give an operational guarantee both from a technical and financial point of view to operate the plant at 90% capacity for at least one year. Financial investors might consider the extention of that period by paying a guarantee fee.

62. The financial model is built using European prices for the main components, while Bangladesh quotes have been obtained for most of the components that can be fabricated or purchased locally. This includes the costs for civil works.

Fecal Sludge Use in China

63. The project included a trip to visit fecal sludge processing in China. There is actually a long tradition of either processing and producing biogas and compost, as proposed in this proposal or without biogas production, straight compost making. Often the fecal sludge is mixed with other organic material as proposed here. The use of hygienic units was not observed in every instance, but in order to meet international WHO standards this is highly recommended for this project.

64. The use of hygienic units is actually quite common in the processing of animal waste in abattoirs in Europe. The temperature for bacterial cleaning is 70° C. However based on the results of the lab test in International Centre for Diarrheal Disease Research, Bangladesh (icddr,b) it is recommended haing the temperature be 75° C .

65. Annex 15, gives a brief overview of the sites visited by the BRAC/ IRC team.

Financial Model

66. **Warning:** The model is built using verified data for the inputs. However the assumptions used for the price of the outputs: electricity at BDT 12/kWHe, Heat at BDT 10 KWHt and Organic fertilizer at BDT 25 /kg are based on discussions with prospective buyers, - for the fertilizer a detailed market survey was conducted (Annex in Final report).

67. Thus before a final investment can be made, BRAC management needs to consider the ownership and management of such an enterprise. Inquiries by the team shows that there are private Bangladeshi investors interested in co-investing with BRAC in such an enterprise. But this has to be worked out in detail.

68. Once the investors are known, agreement needs to be reached regarding the management of the operation. The EPC contractor will need to train these operators and provide at least for one year biological backup services to make sure that the operators are familiar with the various inputs, and the use of enzymes.

69. Last but not least, a power purchase agreement approved by the energy regulatory committee needs to be signed. The team presented the proposed configuration to the full committee, who, as formulated by the chairman, expressed their full support for this project. The estimated sales price is actually based on estimates provided by the ERC and IDCOL.

70. Similarly to avoid market risks the team recommends that an annual contract - if possible a multi-year contract - is negotiated with a large scale buyer of the organic fertilizer. This could potentially be part of a barter agreement in which the farm supplies corn stovers and receives discounted organic fertilizer in return. The financial model supplied separately allows an estimation of the potential savings for such an operation.

71. Another important assumption is that the project will sell heat to a cold storage or ice making plant, which would be independently financed and built by a third party. Again the team has discussed this with several potential investors, who expressed willingness to invest in such an operation. If this investment did not materialize and the heat can not be sold, the project IRR would dive to 7.9% with return on equity still a favorable 18.9%.

72. The model has not taken into account the capital cost required to install collection septic tanks. Logistics assumptions are based on 1 septic tank per 100 families or 500 person. It would take approximately 160 days for a tank to fill up (assuming high liquid content). Thus in the financial model as presented, the fecal sludge would be collected every 150 days from local septic tanks.

73. This proposal has assumed that financed by a third party, the BRAC WASH program might install 50 septic tanks a year. The volume of human sludge collected and processed would increase from 181 MT Metric Ton (9,000 pit latrines) to 400 MT in year 2 (20,455 pit latrines) to 636 MT or 32,000 pit latrines in year 3. The emptying and filling of pit latrines at the community level would be organized in separated self-financing or partially subsidized sanitation enterprises.

74. The cost included in this program includes the collection of sludge from community septic tanks twice a year.

Capital Costs:

75. Table 3 shows the required Capital Cost for a 400 KW plant. These costs are conservative and savings of nearly 25% can be made once development finance costs are available to explore the engineering cost of local components.

Table 3: Projected Capital Cost

Description		EUR'000
biomass dosing feeder Vario		121,000
Intake tank stainless steel 1		37,000
Manure pit		71,000
Mixing tank with agitator		44,000
OU 2: Fermentation		322,750
Separation fermenter		63,000
OU 3: Condensate shaft		5,000
OU 5: Biogas utilisation CHP		522,000
Hygienisation		78,000
Heating, water exhaust piping		43,600
Piping in field for substrate etc.		42,000
Controlling installation, cabling, E part		170,000
small parts/ others / unforseen		20,000
Engineering		200,000
Start up and commisioning		30,000
Biofertilizer dryer		125,000
Total		**1,894,350**

76. Additional cost for civil/ works, equipment handling and land acquisition are shown in Table 4. They bring the total project cost to EUR 2,810,000 . These costs include working capital and interest during construction, but do not include price escalations

77. Financing, shown in Table 5, assumes a 30/70% equity debt ratio with the debt based on 10% discount rate. It assumes that all the interest during construction is financed from equity. The loan would need to be for a term of 9 years with a 2-year grace period. These parameters are based on financial market inquiries where a loan might be provided by social investors and climate funds. If however financing would be sought from Japanese climate funds, the discount rate could drop to 3% or, if all goods were tied to Japan, for as low as 1%.

Table 4: Total Project Costs

	PROJECT COST			EUR'000	BDT'000
	EPC of power plant, digester, fertilizer			1,894	190,003
	Civil/Electrical works			123	12,345
	Equipment handling, taxes, permits			101	10,117
	Transmission cost with right of way			16	1,600
	Site acquisition (land)			98	9,857
	Trucks and machineres			132	13,275
	EIA			15	1,500
	Application permission			20	2,000
	Capital cost			**2,400**	**240,698**
			Note: tangible/ depreciable costs	*2,267*	*227,341*
			Working capital	89	8,914
			Commissioning cost	2	200
			Project development fee	10	1,000
		Project cost before IDC		2,501	250,811
			Interest during construction	197	19,757
			Success fee	112	11,274
	TOTAL PROJECT COST			**2,810**	**281,842**

Table 5: Project Financing

PROJECT FINANCING				
PROJECT FINANCING	**EUR'000**	**BDT'000**	**Share**	**WACC**
Equity	755	75,689	26.9%	17.0%
Debt	2,055	206,153	73.1%	10.0%
Total	**2,810**	**281,842**	**100.0%**	**11.1%**

78. Electricty sales are projected to only start to come in in the third year of the project, the first year of commercial operations. The volume is based on 400kW * 24 hour * 365 days * 86% (due to own consumption need of 7% and plant load factor of 93%), in other words 7% or 25 days a year can be used for repair and maintenance. The total amount of electricity sold would be 3,013,440 kWh per year.

79. The fertilizer income is based on net sale of 1,460,000 kg of fertilizer a year. Although in the budget, an investment cost for a 10 ton truck to transport the fertilizer is included, as the truck can also be used for other required purposes, it is assumed that the buyer will take care of the cost for fuel.

Table 6: Electricity and Price Sales

ELECTRICITY AND FERTILIZER SALES			
Electricity Sales			
	Contracted Capacity	400	kW
	Effective plant Factor	93%	
	Contracted energy	3,013	MWh
	Contracted Price	12.00	BDT/kWH
Fertilizer Sales			
	Volume sales per year	1,460	Tons
	Price	25,000	BDT/ton
		0%	p.a.
Heat Sales		300	kW_t
Effective sales		93%	
Contracted energy		2,444	MWh
Contracted Price		10	BDT/kWh_t

Table 7 : Feedstock Cost

FEEDSTOCK REQUIREMENT AND COST		
Feeedstock requirements		
Human sludge	1,000	tons
Chicken manure	3,000	tons
Rice Straw / Corn Stalk	6,000	tons
Feedstock cost		BDT'000 p.a.
Human Sludge	0	0
Chicken manure	1,000	3,000
Corn Stovers	1,467	8,800
Feedstock collection cost	BDT ('000)/Ton	BDT'000 p.a.
Human Sludge	2,300	2,300
Chicken manure	290	870
Corn Stovers	200	1,200

Table 8: Operations and Maintenance Cost

O&M		EUR/kWh	BDT/kWh	BDT'000 p.a.
Engine		0.01	1.00	
Others		0.01	1.00	
Total O&M		0.02	2.01	6,045

Sensitivity Analysis.

80. As all biomass to energy projects, the project is extremely sensitive in regard to all costs incurred in the transport of the feedstock. As already explained, if the project can not be located right near the largest volume of feedstock, in this case corn stover, the profitability of the project is in danger.

81. Even the prices for electricity or heat are less sensitive that the transport costs for feedstocks.

82. The financial model is conservative, the project can generate significant amounts of Carbon reduction certificates as it replace diesel and bunker fueled generators. However a careful emission balance needs to be produced as the transport of the feedstock can add considerable emissions to the project.

83. This project will not attract the commercial finance that traditional commercial projects with payback periods of 2 to 3 years are able to attract. This is a longer term infra structure investment. Compared with other biomass projects, the feedstock supply risk is actually minimal. Corn stovers in the form of silage can be stored for 7 or more months. Corn stovers can at any time substitute for the chicken manure or fecal sludge, which allows flexibility and reduces dependency on daily supplies.

84. The projected IRR based on the assumptions as discussed is 18.1%, while the equity IRR is actually quite high at 40.1% . But as shown for the transport costs of corn stover, these ratios can fall back to respectively 5% and 13% if higher transport costs are assumed.

85. The financial model is provided in a separate spreadsheet, which will allow potential investors to immediately adjust data when contracts are signed or field data from operation come in.

Table 9: Sensitivity Analysis

BRAC WASH Human Sludge into Electricity and Heat for Cooling

Key variables:		
EPC + Cap. Cost	**1,894**	EUR'000
Total project cost	2,810	EUR'000
Total project cost	281,842	BDT'000
Price (without VAT)	**12.00**	BDT/kWh
Profit share	**0%**	
Key results:		
Project IRR	18.1%	
Equity IRR after free carry	40.1%	
Average DSCR	1.79x	
Minimum DSCR	1.78x	

SENSITIVITIY ANALYSIS

Tabulates key results given changes in a single key variable; other key variables are held constant.

CAPITAL COST	**Current**					
EUD'000	**1,894**	**1,500**	**1,670**	**1,900**	**2,000**	**2,200**
Project Cost EUR'000	**2,810**	**2,343**	**2,544**	**2,817**	**2,935**	**3,172**
Project Cost BDT'000	**281,842**	**235,024**	**255,207**	**282,513**	**294,385**	**318,12**
Project IRR	**18.1%**	**23.3%**	**20.9%**	**18.0%**	**16.9%**	**14.9%**
Equity IRR after free carry	**40.1%**	**53.0%**	**46.9%**	**40.0%**	**37.4%**	**32.9%**
Average DSCR	**1.79x**	**2.14x**	**1.97x**	**1.78x**	**1.71x**	**1.59x**
Minimum DSCR	**1.78x**	**2.13x**	**1.96x**	**1.77x**	**1.70x**	**1.57x**

PRICE	**Current**			Base		
BDT	**12.00**	**10.00**	**11.00**	**12.00**	**13.00**	**14.00**
Project IRR	**18.1%**	**15.8%**	**17.0%**	**18.1%**	**19.2%**	**20.3%**
Equity IRR after free carry	**40.1%**	**34.7%**	**37.4%**	**40.1%**	**42.9%**	**45.6%**
Average DSCR	**1.79x**	**1.64x**	**1.71x**	**1.79x**	**1.86x**	**1.94x**
Minimum DSCR	**1.78x**	**1.62x**	**1.70x**	**1.78x**	**1.85x**	**1.93x**

Transport cost of Corn Stover						
transported over 1 km/MT	300	100	200	300	3,000	5,0(
project IRR	18%	19%	18%	18%	11%	5
equity IRR	40%	41%	41%	40%	24%	13

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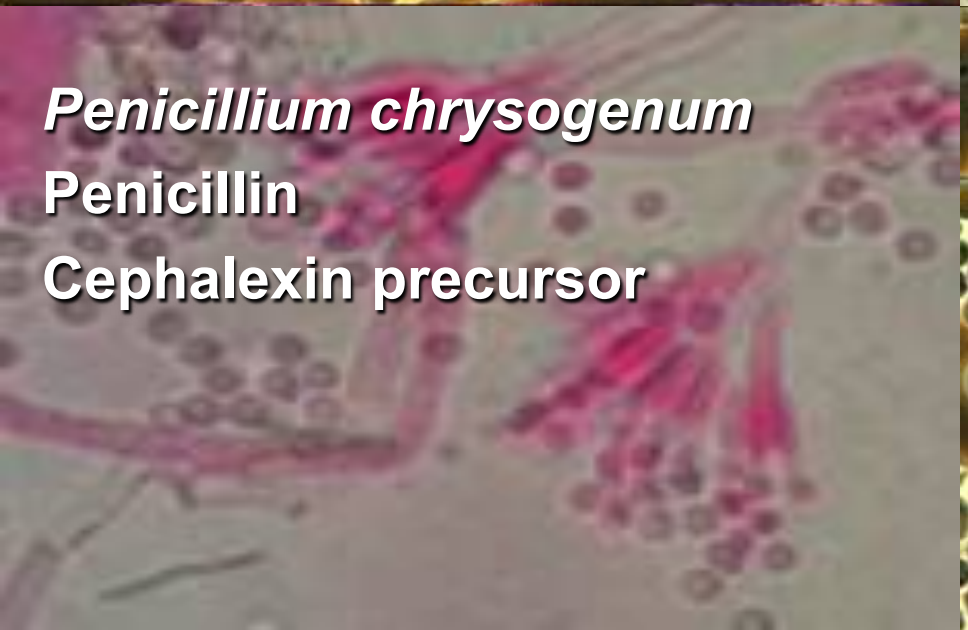
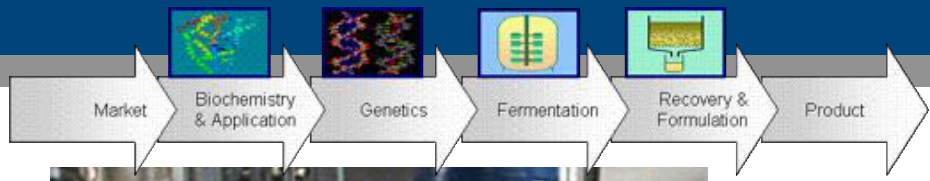
Annex 1

Cell Factories and Products



Fermenters



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10 years of genomics @ DSM A. niger genome project

Aspergillus niger secretes many enzyme in large amounts: Make use of this capacity

1999 : Start *A. niger* DNA sequencing project (CBS 513.88)

2002 : Finish sequence and annotation (assign gene functions): 14000 genes (7000 unkown..)

2003 : Affymetrix GeneChips for *A. niger*

2002-2008 : Functional Genomics

-Transcriptomics – Proteomics - Bio-informatics

2007: A. Niger sequence published by DSM in Nature BT (Pel et al 2007)

2009: Pel et al 2007 most cited paper in 2008 in field industrial biotechnology

Applied Genomics at DSM

- **Genomics is applied for**
  - ✓ **New Product Development (NPD):Mining the genome for new genes coding for new hydrolases or pathways (DNA sequence)**
  - ✓ **Strain and Process improvement (SPI): Studying the expression of genes under various conditions to find leads for SPI (RNA=transcriptomics; Proteins=proteomics)**

Accelerzyme, the cheese ripening accelerator

- Accelerzyme CPG speeds up flavor development in cheese
- Benefits for cheese manufacturers:
  - Reduced ripening time, higher cash flow
  - More cheeses can be produced in ripening warehouse
  - More tasteful cheese in same ripening time
  - Shortening bitter phase during ripening process
- Suitable for various cheese application
  - Only active in cheese, not in milk or whey
  - Inactivated during whey processing
  - Allergen-free

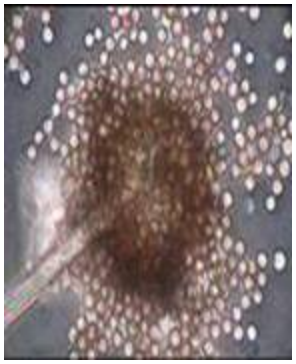
Accelerzyme® CPG

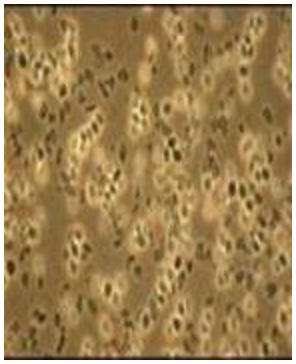
Unlimited. DSM

- Discovered via DNA sequence of A. niger

Unlimited. DSM

The workers and products
Importance of Genomics / Proteomics





Aspergillus niger	Enzymes, citric acid
Saccharomyces cerevisiae	Live cultures, flavors
Kluyveromyces	Enzymes
Lactic acid bacteria	Live cultures
Gluconobacter	Vitamin C
Propionibacterium	Vitamin B12
Bacillus	Enzymes, vitamin B2
Blakeslea trispora	Beta-carotene
Mortierella alpina	Arachidonic acid
Penicillium chrysogenum	Antibiotics
Escherichia coli	Enzymes, fine chemicals
PER.C6 cells	Pharmaceutical proteins

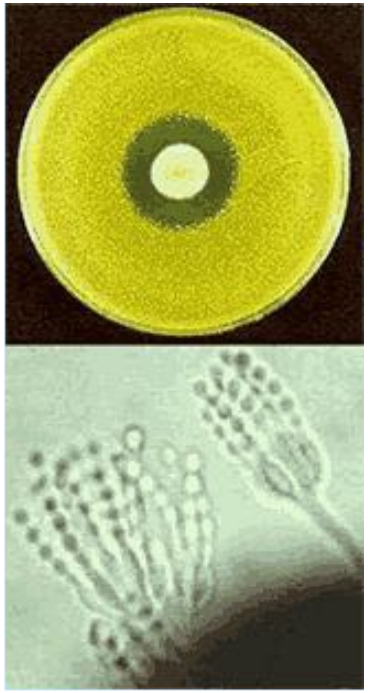
Strain & Process Improvement Existing Products / New products

Genome sequence available

Unlimited. DSM

Classical biotech and combined with automatic high intensity screening: Penicillin

Penicillium



A. Fleming

C
H
N
O
S

PenG
PenV

Filamentous fungal suitable source enzymes: Discrepancy between nature and industry…….

- FF natural habitat
  - Colonising solid substrate: cereals, bread, fruits, bathroom,wood
  - Substrates are various complex polymers
  - Slow release of monomers by extracellular hydrolase activity
  - Broad spectrum of enzymes, non-GMO
  - Low mixing

- FF in industry
  - Submerged fermentation
  - Substrates are defined chemicals
  - High concentration of media compounds
  - High production single enzymes (GMO)
  - High mixing

- Solid state for identification and production?

How to get the right enzymes

- Fungi colonise solid material by secreting many hydrolases
- Fungi secrete enzymes when needed (Induction)
  - Examine Existing Fungal enzyme products
  - Genome mining: Look in DNA databases FF for candidate genes

❑ Clone interesting genes in A. niger for testing

❑ If promising define strategy for production

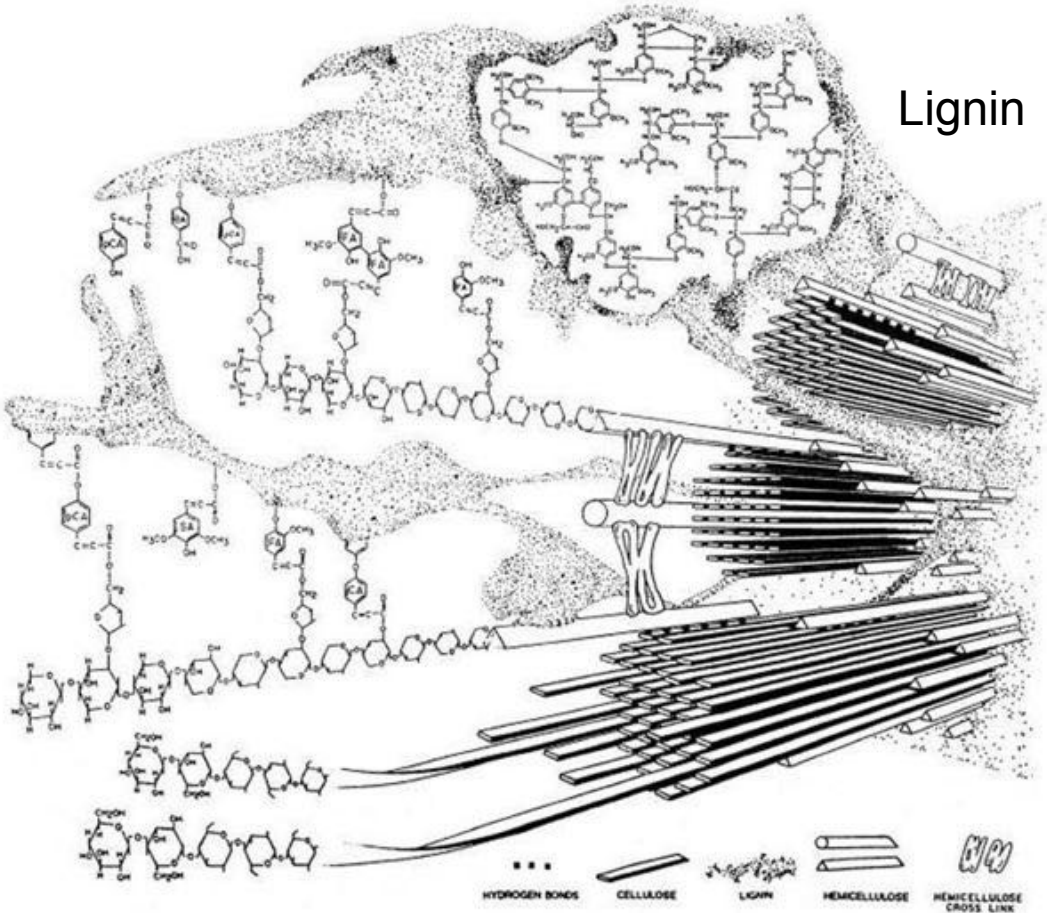
- Strains and processes

Plant cell wall composition

Lignin

Hemicellulose

Cellulose



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LC composition

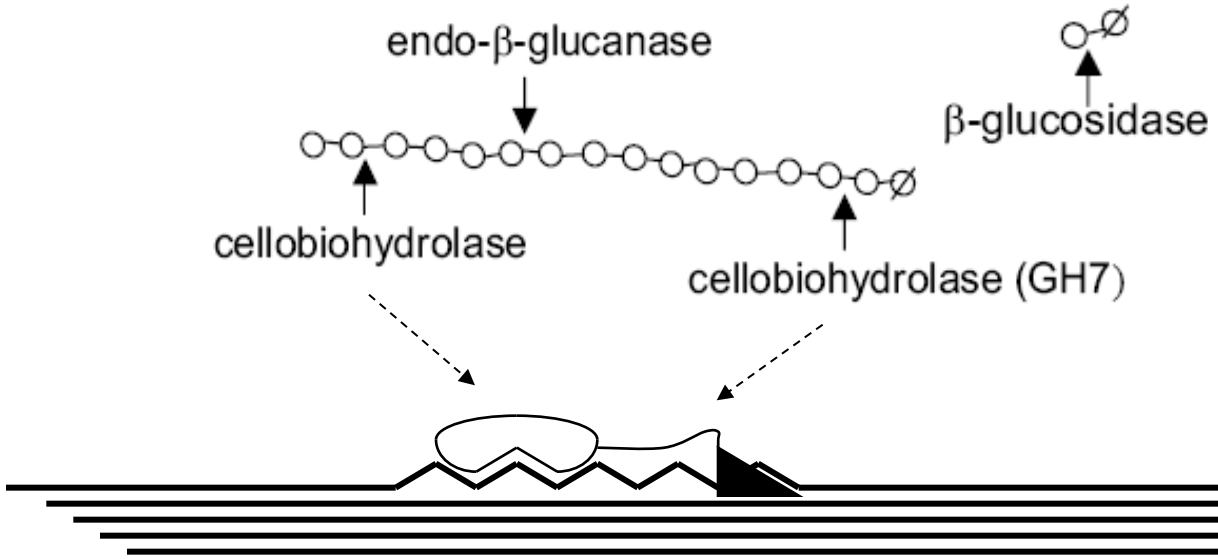
- Cellulose 45%
  - One monomer glucose (C-6), perfect substrate for yeast ethanol prd
- Hemicellulose 25%
  - Various monomers, mainly xylose, arabinose (C-5, can not be used by yeast>> engineering) galactose, mannose, ferulic acid)
- Lignin 20%
  - Heteropolymer of many cyclic monomers;
- Others 10%
  - Pectins: various monomers galacturonic acid (yeast eng), rhamnose

Enzymes needed for biogas

- Deconnect lignin from cellulose to make cellulose more accessible for enzymatic degradation without degrading lignin
- Auxilarly enzymes to start decomposing cellulose
- Cellulases (Cellulose degrading enzymes)

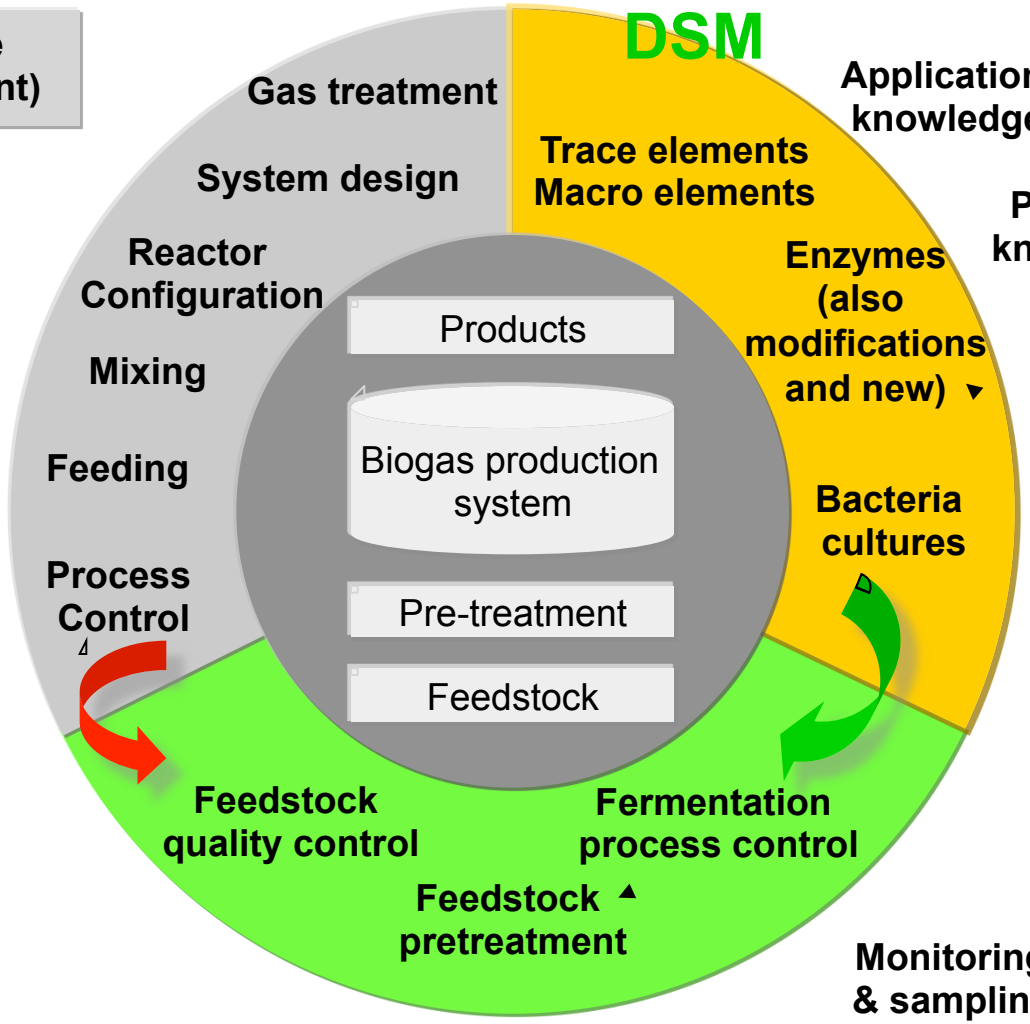
Enzymes – Cellulases / Glucanases

- Cellobiohydrolase, exoglucanase (EC 3.2.1.91)
- Endo-β-(1,4)-glucanase (EC 3.2.1.4)
- β-glucosidase (EC 3.2.1.21, EC 3.2.1.74)
- β-(1,3)(1,4)-glucanase (EC 3.2.1.73, EC 3.2.1.6, EC 3.2.1.58)
- Cellulase helpers, like swollenin, cip1, cip2



Products & services in and around biogas plant

DSM's proposition



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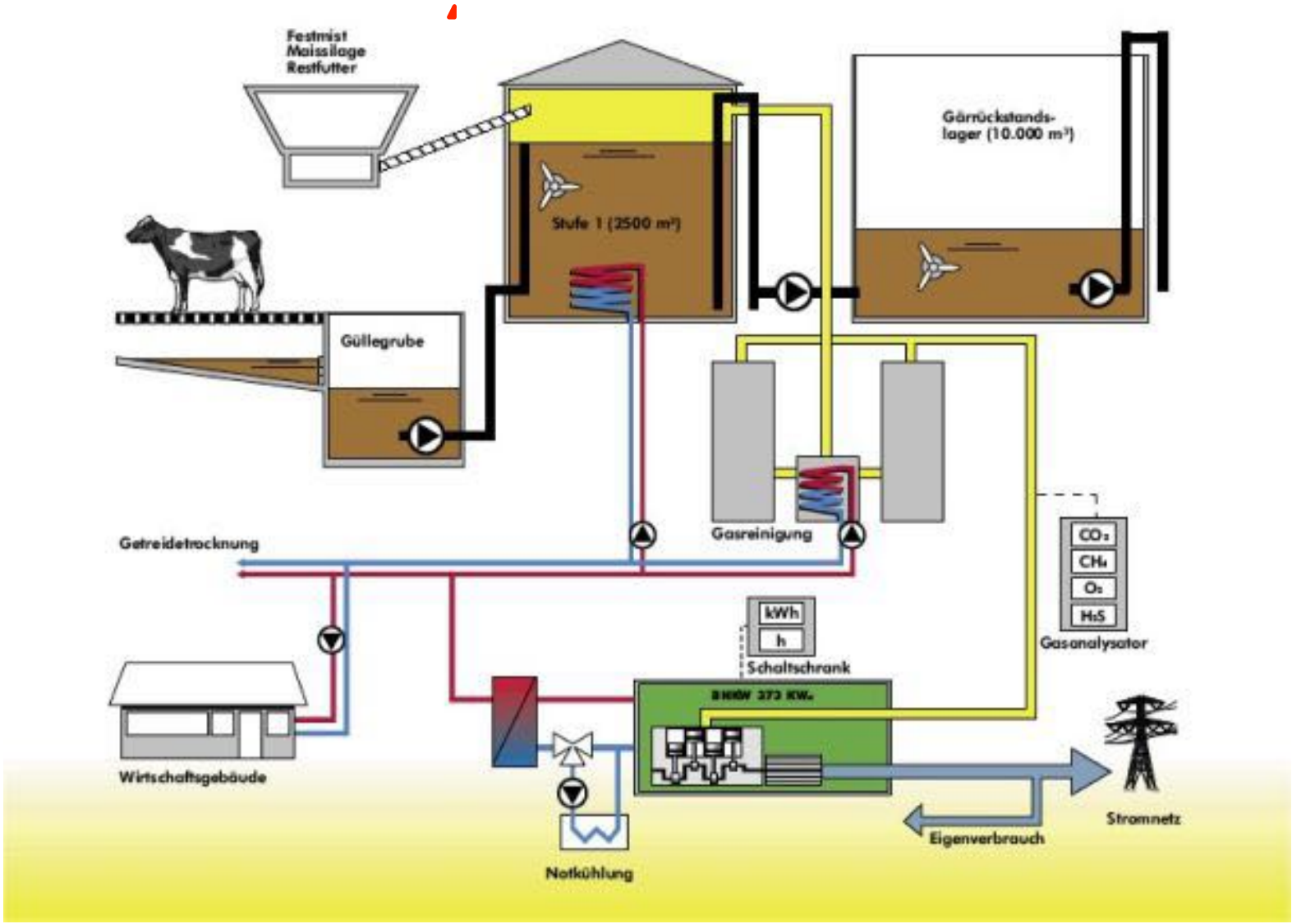
Basics of the Biogas Process

Flow chart of a typical biogas unit



DSM

Basics of the Biogas Process

Process steps

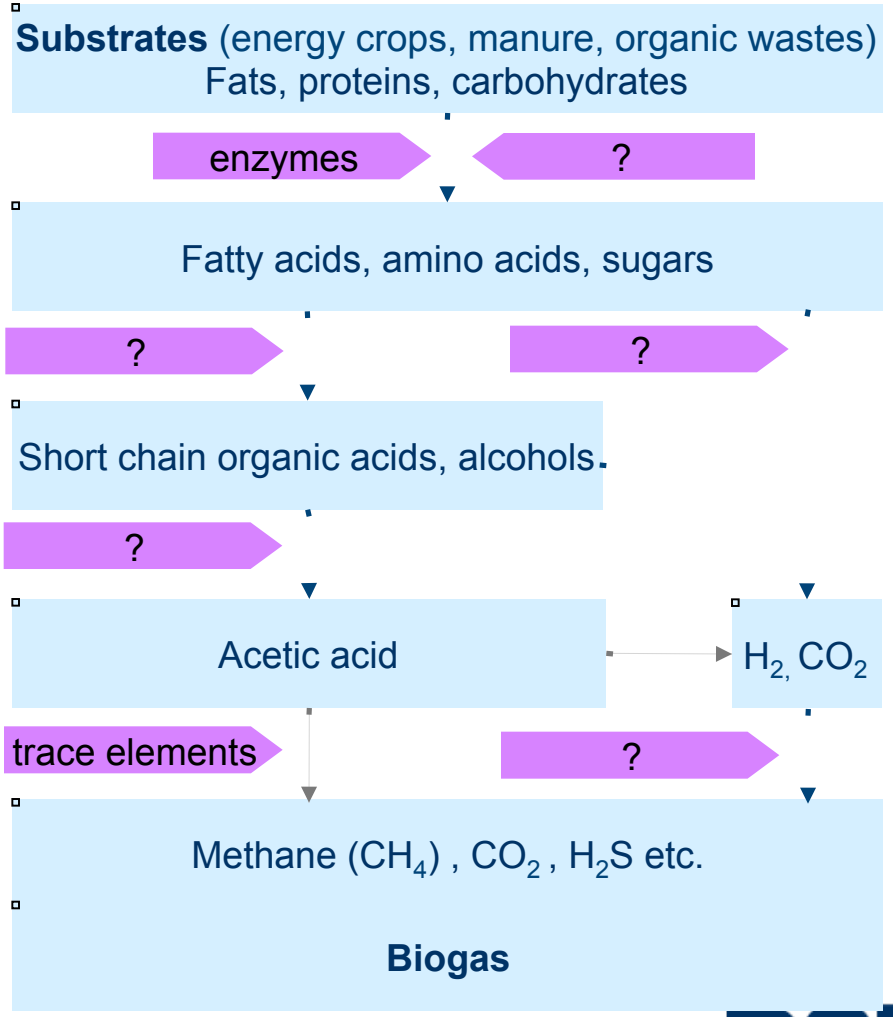
Phases

1st phase – ‘Enzymatic hydrolysis‘

2nd phase – ‘Acidification‘

3rd phase – ‘Acetic acid formation‘

4th phase – ‘Methane formation‘



Ø **Can additives push the actual rate limiting steps?**

Unlimited. DSM

BIOPRACT GmbH – Laboratory

Anaerobic cultivation systems

- Headspace
- HFT (100 ml)
- Eudiometer (500 ml)
- Fermenter (7 l)

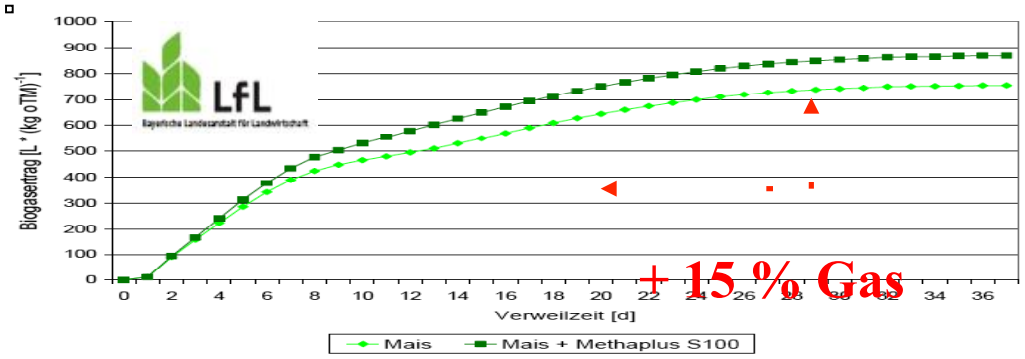
Analytical equipment

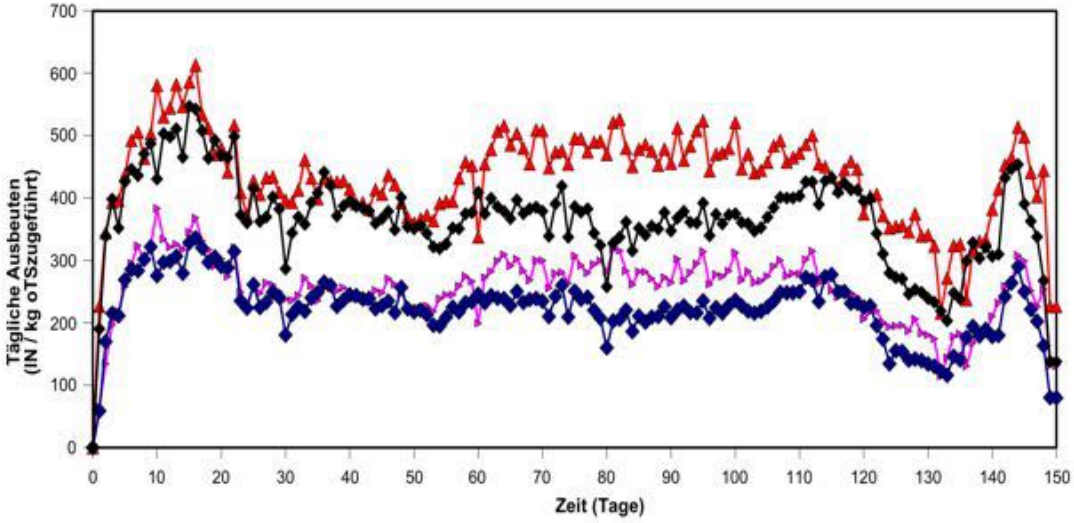
- GC (CH_4, H_2, CO_2, O_2, N_2)
- HPLC (Fatty acids, sugars, oligosaccharides, alcohols)
- Gas production (volumen, pressure)
- Automatic titration (FOS/TAC)
- Viscosity
- Microbiology (Microscopy, PCR, anaerobic cultivation)
- Enzyme activities

Unlimited. DSM

The effect of Methaplus on biogas yield

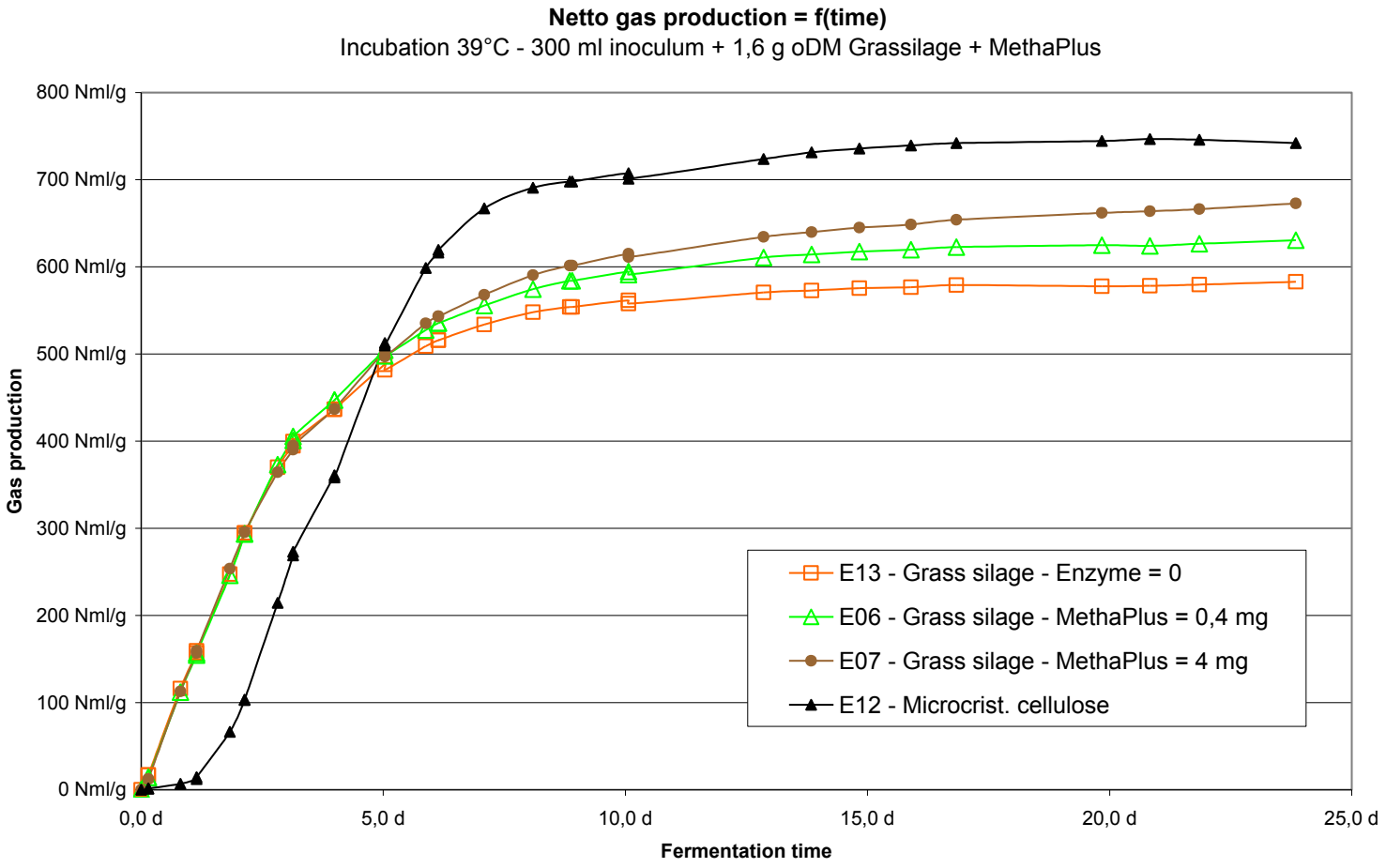
- *Enzyme additives that improve efficiency of fermentation process*
  - Increase efficiency (up to 20%)
  - Decrease viscosity of substrate in fermentor
  - Reduce residence time (ca 90 -> 60 days) and/ or increase throughput





Unlimited. DSM

Anaerobic fermentation in Eudiometers : grass silage as substrate

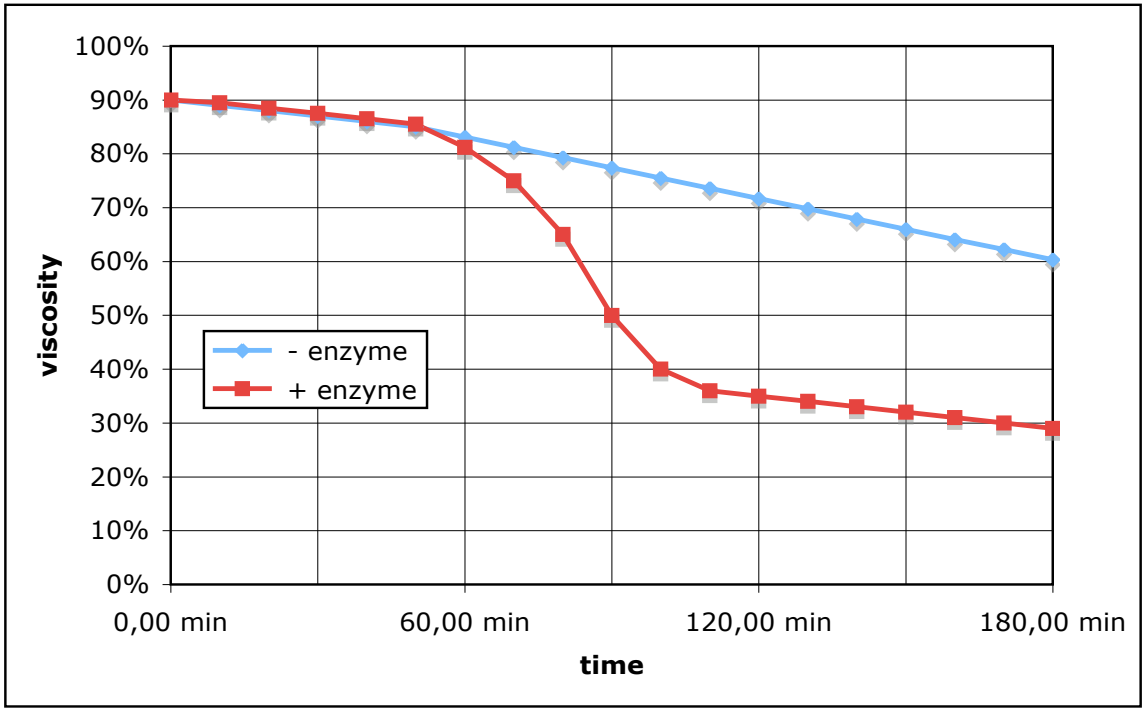


- Enzyme effects can be observed in batch fermentation but extrapolation is difficult (strong influence of inoculum)

Unlimited. DSM

Lower viscosity

- *Enzyme additives that improve efficiency of fermentation process*
  - Up to 50% decreased viscosity of substrate in fermentor
  - Reduce residence time with up to 30%
  - Increase throughput
- *Especially the reduction in residence time can have a significant impact on the footprint of new installations*

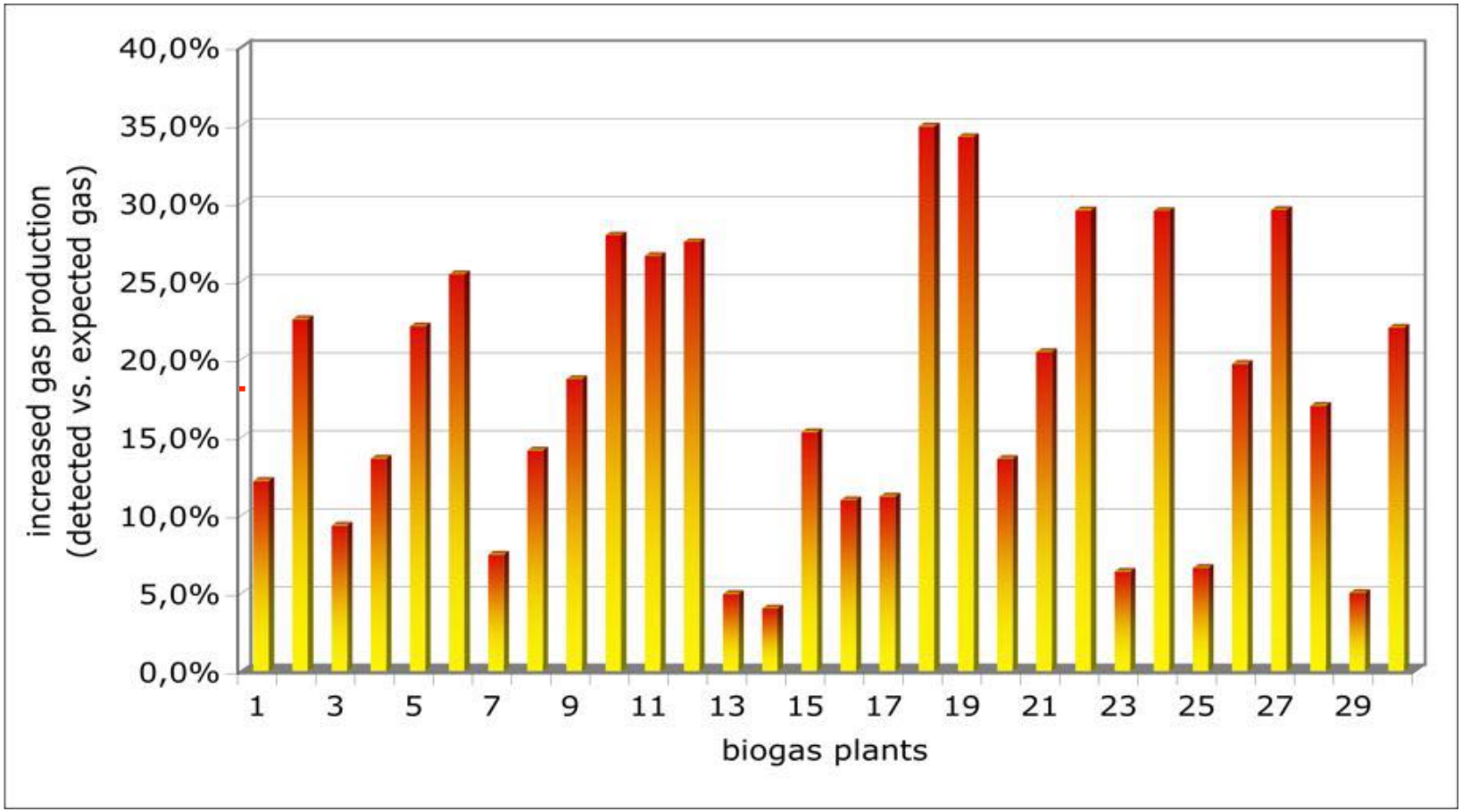


Unlimited. DSM

MethaPlus® in biogas production : Field trial

Results from a field study involving 30 individual biogas plants

Average increase of Methane production: 18 %



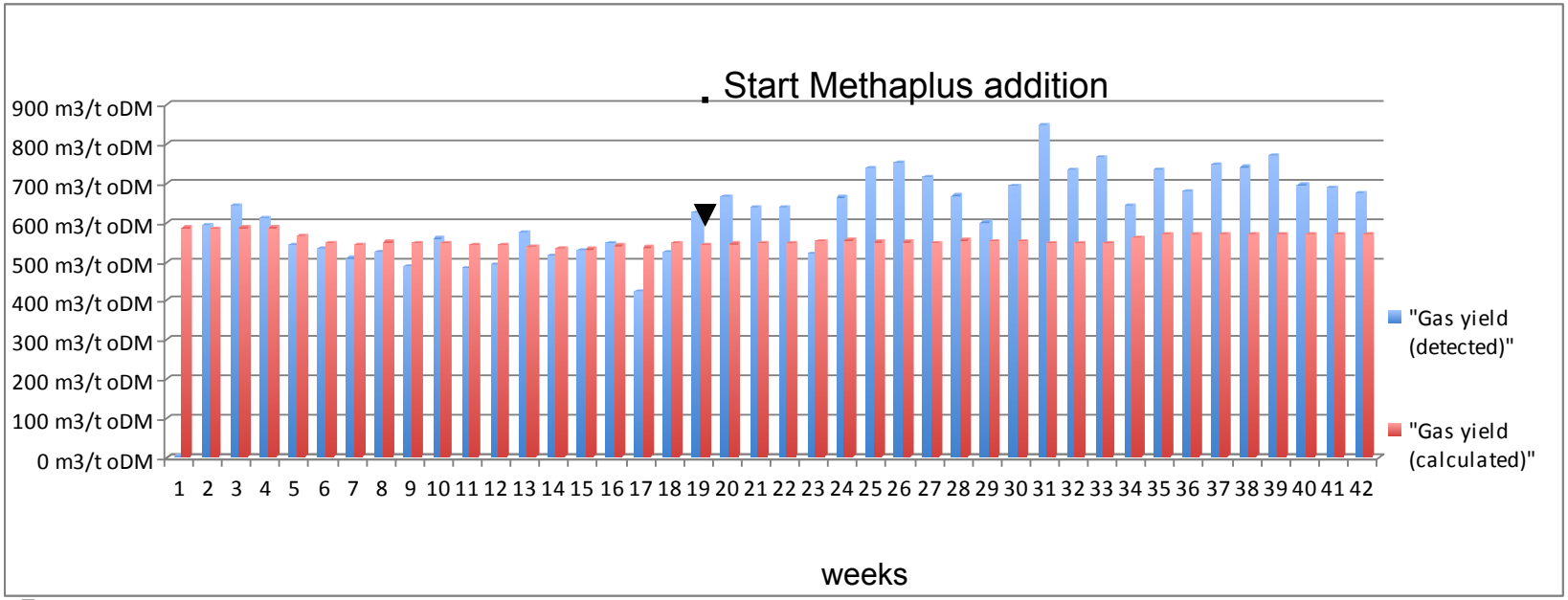
Unlimited. DSM

Case study: improvement by enzyme addition of a biogas plant in Germany

- Farm-based plant
- Substrate: cattle manure (21.7 %), maize silage (34.8 %), grass (26.1 %), wheat (17.4%) total 2.3 ton dry matter a day
- CHP 150 kW main capacity
  75 kW spare capacity
- Temperature conditions 43-48 °C
- pH 7.9 - 8.1
- Start : daily output 100-150 kW
- No registration of substrate input
- Unstable gas production
- Scum layers
- Test set up
  - Measure and register exact substrate input and make mass balance
  - Regular sampling and analyses of substrate and fermentor content
  - Stabilisation of substrate input in mix and amount

Results

Specific daily gas production



- Specific gas production increased with 29 %
- Daily substrate usages decreased with 32 %
- Spare CHP used 46 % more electricity produced
- Reduction of scum layers
- Stabile plant

Unlimited. DSM

Advantages of using additives in biogas plants

- Increased
  - Process stability
  - Gas yield
  - Higher loading of fermentor
  - Shorter residence time
  - Mixing
  - Size of plant can be smaller for same capacity for future plants

- Reduction
  - Scum layers
  - Viscosity

Additives increase the stability and economic performance of your plant

Main substrate ww freshly produced

Thank for your attention

Unlimited. DSM

Annex 2

Removal

of

Helminths

in

Anaerobic Digestate using Fecal Sludge

Facilitating the use of

Organic Fertilization

Meeting International WHO standards

Dr. Zahid Hayat Mahmud
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Environmental Microbiology Laboratory
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International Centre for Diarrhoeal Disease Research,
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February 2015

Table of Contents

Introduction

The helminths are very large and varied group of multicellular parasitic worms. Some infect humans, others animals or plants, while many may be free-living in the soil. All have differentiated organs, and their life cycles include the production of ova (eggs) or larvae. There are three major groups of helminths containing members that have man as their host, flukes (Trematoda), tapeworms (Cestoda), and roundworms (Nematoda). Helminth infections are spread through the ingestion or inhalation of their ova, some of which can survive outside the host for long periods of time, or via larvae penetrating skin exposed to infected soil/water. Once inside the body, helminth ova hatch and many undergo maturation in the tissues before re-entering the gut and lodging in the intestines. Here they grow and undergo sexual reproduction, resulting in the production of eggs or larvae which are passed out via the faeces to the environment.

Contamination of agricultural lands, environment, crops etc. with helminths can take place through direct faecal contamination with both human and animal excreta, or through the use of contaminated sludge or waste water for agricultural use. Since *Ascaris* ova are known to be most resistant to heat and other harsh environment compared to other helminth ova, these can

be used as marker of whether the fecal sludge is free of other viable helminth ova (Jimenez-Cisneros, 2007).

The Problem

The use of human waste in a dual digester to produce biogas through anaerobic digestion is a biological process in which organic matter is broken down to methane and other byproducts under anaerobic conditions (mesophilic and thermophilic processes of methane production). Disposal of untreated sewage in the land as fertilizer in developing countries can cause parasitic health risk. Biodigesters turn waste into a biofertilizer. There is also a major flaw in the sewage treatment systems of developed countries where enormous amounts of energy are used to aerate and treat sewage; Anaerobic Digestion treats sewage and also produces energy rather than consuming it. Wastewater treatment also produces solid residuals. Land application provides a sustainable, beneficial alternative for solids disposal, but it increases the threat of public exposure to disease. As such, regulatory agencies in many countries limit the number of pathogens allowable in residuals. One of the most common and resistant pathogens is the egg of the intestinal parasitic worm, *Ascaris* spp.

To date in Bangladesh, no standard method exists for measuring helminth ova inactivation temperature of waste made bio-fertilizer, wastewater sludge or faecal excreta. To obtain safe pathogen concentrations, the EPA has established a set of effective, pre-approved treatment options. Studies have shown that thermophilic conditions can reduce pathogens effectively while mesophilic conditions alone cannot.

Objectives

1. To recover *Ascaris lumbricoides* ova from faecal sludge using modified US-Environmental Protection Agency (US-EPA) protocol
2. To determine viability of *A. lumbricoides* ova in faecal sludge
3. To enumerate viable *A. lumbricoides* ova retrieved and detected from faecal sludge
4. To establish temperature and time required to inactivate *A. lumbricoides* ova

Methodology

Study sites

A total of 33 pit samples were collected from Bogra, Mirpur slum and Kamrangir Char during the study period. From each study area 10 pit samples were collected. Beside this 3 more samples were provided by BRAC which were collected from their study area in Bogra.

Collection and transport of fecal sludge samples

Approximately 200 to 250 grams of fecal sludge were collected from each pit latrine using a stool collection container. Samples were then kept in an insulated foam box using sufficient amount of ice to maintain temperature of 4-8°C and transported to the Environmental Microbiology Laboratory of icddr,b within 24 hours to avoid disintegration.

Step by step method to recover helminth ova

To concentrate the helminth ova from the fecal sludge, one gram of the collected sample was suspended into 5 ml sterile normal saline and homogenized using a vortex machine. The large particulates were removed by filtering the homogenized mixture through a 160 µm diameter sieved strainer. The filtrate was then centrifuged for 3.5 minutes at 1800 rpm. The supernatant was discarded leaving a small amount of fluid just above the sediment. 5 ml saturated $ZnSO_4$ solution (1.20 specific gravity) was added to suspend the sediment. The suspension was rehomogenized using vortex machine. Homogenized sample was centrifuged for 1.5 minutes at 1500 rpm. The flotation procedure yields a surface layer that contains *Ascaris* eggs. 1ml of surface layer was transferred into an ependorf tube containing a dye, methylene blue for determination of viability.

Test for viability and counting

The ependorf tube was kept 3-5 minutes at room temperature which was then homogenized using a vortex machine. Then it was examined microscopically to enumerate the ova. Both viable and nonviable ova were counted.

The amount of *Ascaris* ova retrieved was expressed in ova per gram of dry solids.

The percentage of total solids was determined by drying 10g of the remaining fecal sample in an oven until no change in weight was observed. The weight of the sample after drying was recorded. The percentage of total solids was calculated using the formula below:

% Total solids = W'/W x 100%

Where:
W'= weight of stool after drying in an oven
W = weight of stool before drying in an oven
After calculating the percentage of total solids, the amount of *Ascaris* ova per gram of dry solids was calculated using the equation below:

Ova/g dry wt= (NO)×(FV) / (TV)×(SP)×(TS)
Where:
NO= no. of ova
FV= final volume in ml
TV= tested volume in ml
SP= sample processed in ml or g
TS= % total solids

The approach followed to develop a standard inactivation temperature

An inactivation temperature of helminth ova was developed following a method similar to the one currently in use in several international laboratories. Environmental Protection Agency (EPA) method was adopted to enumerate helminth ova based on the fact that this technique demonstrated a greater recovery rate than the rest of the techniques.

Of the helminths, the one whose egg is the most difficult to inactivate in biosolids is that of the intestinal parasite *Ascaris lumbricoides*. Typical disinfection techniques fail to affect *Ascaris* egg viability and the eggs exhibit strong resistance to unfavorable environmental conditions (Krishnaswami and Post 1968). This characteristic made *Ascaris* the most common parasitic worm infection of humans with roughly 1 billion people infected worldwide (CDC 2002). The toughness of their highly impermeable eggshell has been deemed "one of the most resistant biological structures" (Wharton 1980). The shell allows the passage of essential respiratory gases while protecting the eggs from a wide array of chemicals and extreme pH environments (Barrett 1976).

This approach can help to determine viability of helminth ova, and to determine temperature and time to sterilize and inactivate *Ascaris*, the most resistant ova among helminthes, which can provide as marker of inactivation of helminth eggs and will provide approximate real situation of using faecal sludge as bio-fertilizer.

5 grams sample was taken in 4 oz bottles to determine the thermal inactivation point. Temperature increased at a rate of ≈5°C from 60°C to 80°C. At each temperature 3 bottles were kept. One bottle was removed and observed under light microscope after 15 mins, the next after 30 mins and the last one after 60 mins.

Result

None of the samples were found positive for helminth ova that were collected from Bogra and Mirpur slum. Five samples were found positive for helminth ova out of ten samples that were collected from a slum at Kamrangir Char, Dhaka. Every sample was tested twice to recover *Ascaris* ova. Among the five samples, two highly positive samples (L-5 and L-6) were selected for Time Temperature Inactivation Treatment (TTIT) study.

Sample L-5 contained 93.7% water and 6.3% total solid and Sample L-6 contained 94.6% water and 5.4% total solid.

Table 1: TTIT result as eggs per gram of sample L-5

Sample L-5 (Dry Weight) (*A.lumbricoides* EPG)				
	Temperature	**Time**	**Viable**	**Nonviable**
Initial count			4650	8460
	60°C	15	4222	12412
		30	3492	12698
		60	3174	11206
	65°C	15	3587	22428
		30	2539	19460
		60	2317	12698
	70°C	15	1476	3809
		30	841	4015
		60	523	1476
	75°C	15	0	0
		30	0	0
		60	0	0
	80°C	15	0	0
		30	0	0
		60	0	0

Table 1: TTIT result as eggs per gram of sample L-6

Sample L-6 (Dry Weight) (*A.lumbricoides* EPG)				
	Temperature	**Time**	**Viable**	**Nonviable**
Initial count			5925	19759
	60°C	15	5185	13092
		30	4444	14074
		60	3944	14314
	65°C	15	4925	16037
		30	3944	15055
		60	3703	22462
	70°C	15	1722	9870
		30	1240	12092
		60	740	3222
	75°C	15	0	0
		30	0	0
		60	0	0
	80°C	15	0	0
		30	0	0
		60	0	0

TTIT study graphs for sample L-5

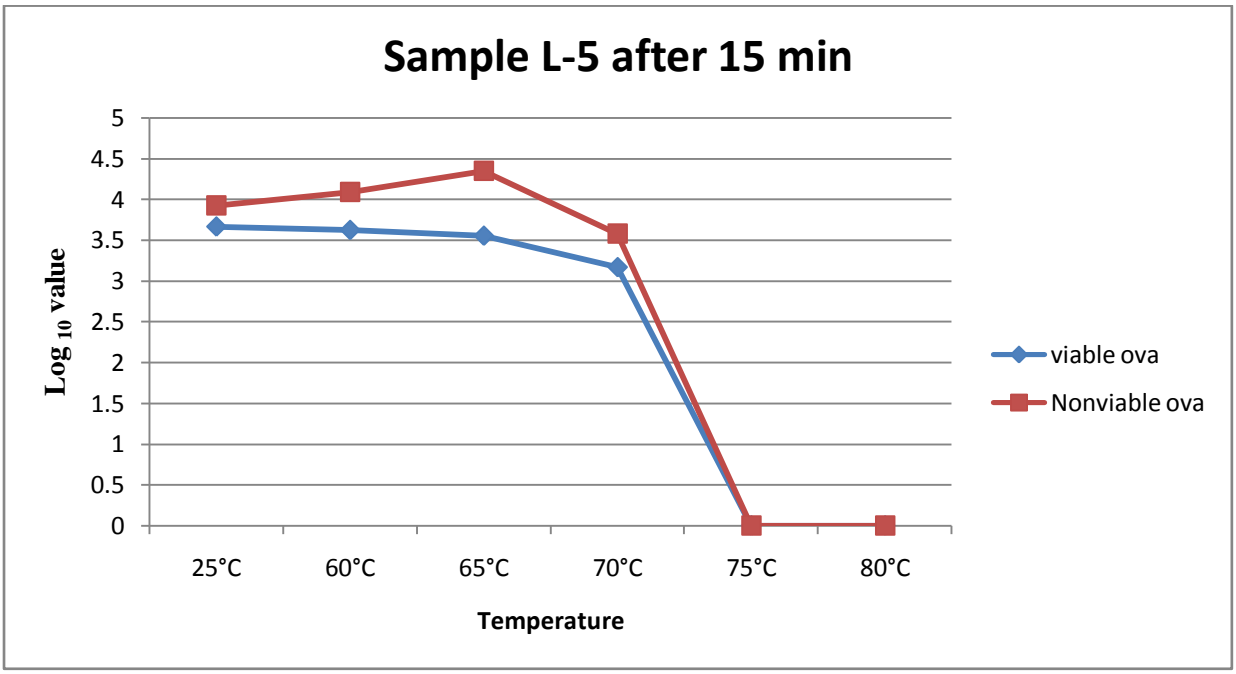

Figure 1: Inactivation of Helminth ova after 15 minutes at different temperatures

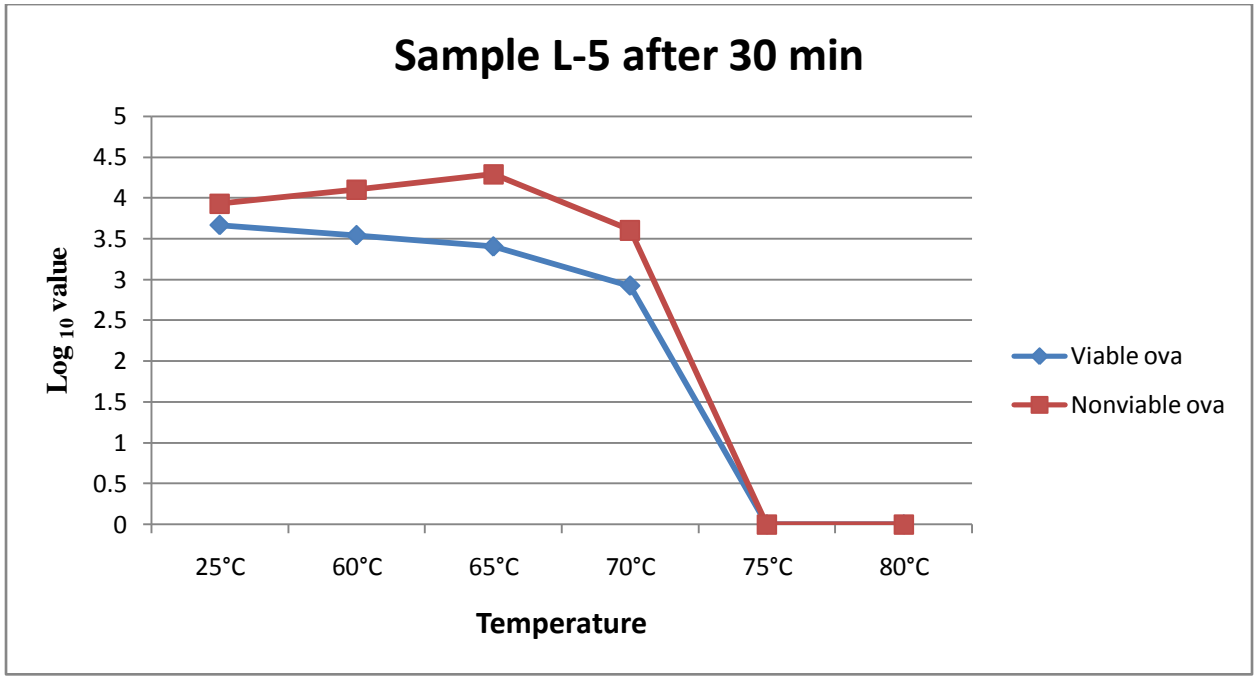

Figure 2: Inactivation of Helminth ova after 30 minutes at different temperatures

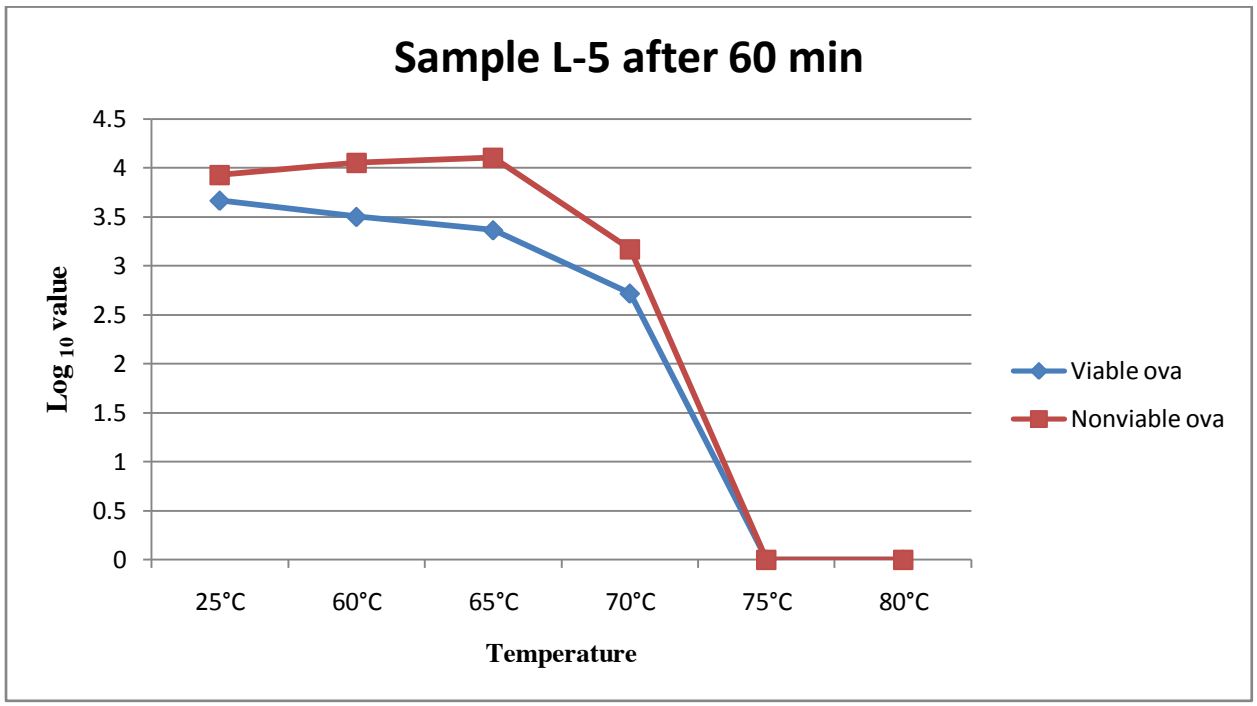

Figure 3: Inactivation of Helminth ova after 60 minutes at different temperatures

TTIT study graphs for sample L-6

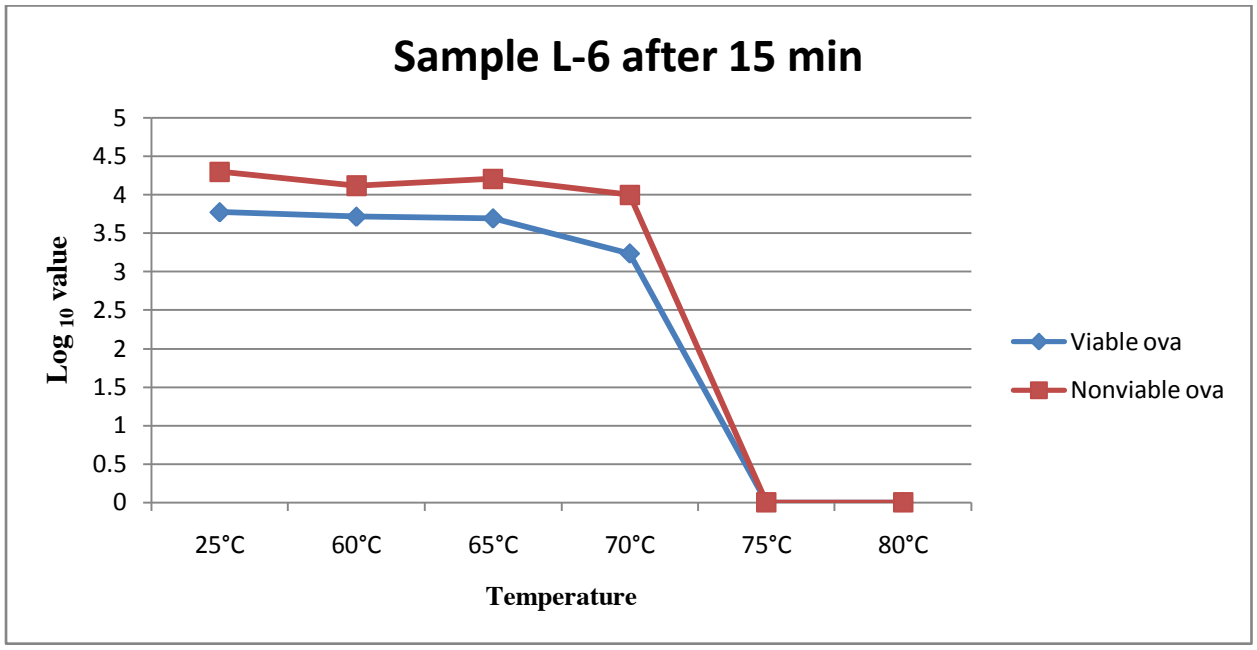

Figure 4: Inactivation of Helminth ova after 15 minutes at different temperatures

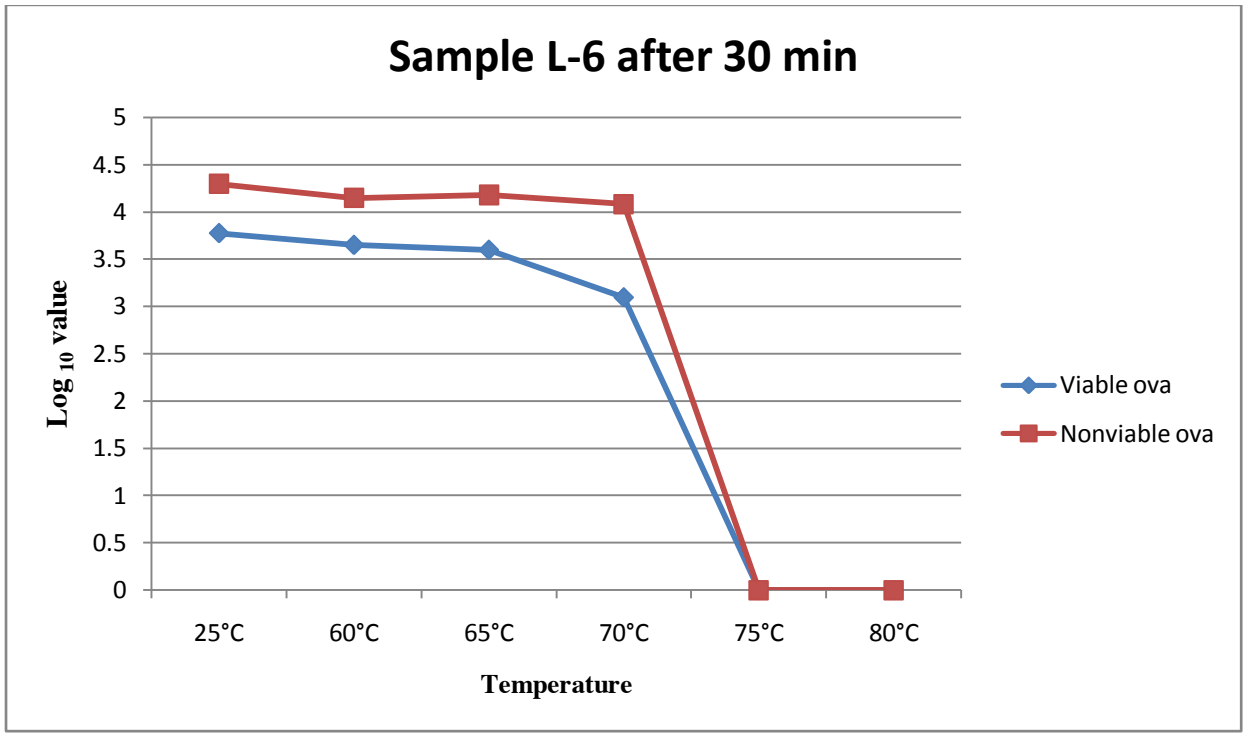

Figure 5: Inactivation of Helminth ova after 30 minutes at different temperatures

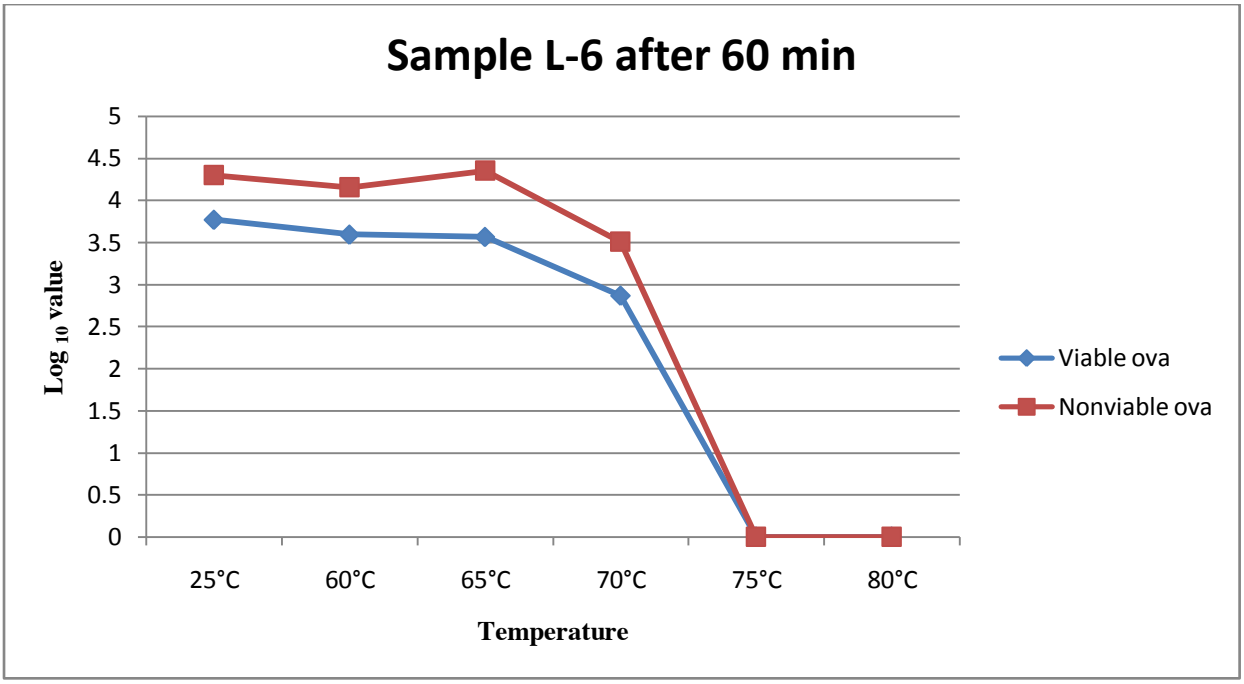

Figure 6: Inactivation of Helminth ova after 60 minutes at different temperatures

Conclusion:

It is observed that a temperature above 75°C with a minimal exposure time of 15 minutes can easily inactivate the activities of *Ascaris* ova. Hence, we can presume that any pathogens remaining in an object may also lose their propagative properties as an *Ascaris* ova with their highly thick shell membrane is known as a marker organism globally with an instance for the inactivation of any parasites.

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1) Barrett, J. 1976. "Studies on the induction of permeability in *Ascaris lumbricoides* eggs." Parasitology **73**: 109-121.

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5) Techniques for parasite assays and identification in faecal samples. www.fao.org/wairdocs/ilri/x5492e/x5492e05.htm

6) US Environmental Protection Agency. 2003. Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge. US-EPA, National Risk Management Research Laboratory, Cincinnati, Ohio.

7) Wharton, D. 1980. "Nematode egg-shells." Parasitology **81**: 447-463.

Annex 3

JRA
日本中央競馬会
特別振興資金助成事業

A Guide for Silage Making and Utilization in the Tropical Regions

March 2005

Japan Livestock Technology Association

FOREWORD

Japan Livestock Technology Association (JLTA) has, under supervision of Ministry of Agriculture, Forestry and Fisheries, been implementing a wide range of works to support Japanese livestock-related Official Development Assistance (ODA). Technical manual making is one of these supporting activities.

In the dry tropics having longer dry season, feed shortage in dry season is quite serious, and becomes a common and big constraint in cattle production.

To solve feed shortage, hay making is not always good solution due to the necessity of securing machines and difficulty of drying grasses in wet season.

On the other hand, silage making will be more feasible and effective because of its cheapness and easiness in preparation. In Thailand, silage making has become popular year after year and proved to be an easy solution to feed shortage in dry season in dairy cattle farming.

The aim of making this pamphlet is to provide Japanese overseas livestock technical experts working in developing countries or to be assigned in the future with technologies and knowledge of making good silage in terms of cost and quality.

In this pamphlet, the principle of making silage is included, which is based on Japanese technologies, and also overseas good examples observed and collected in developing countries through Japanese technical cooperation implementation activities.

I would be much happier, if this pamphlet is useful in your works.

Tokyo, March 2005

Yoshihiro Yamashita
President
Japan Livestock Technology Association

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A Guide for Silage Making and Utilization in the Tropical Regions

Contents

1. Shortage of livestock feed and importance of its storage in dry season in the tropical regions

(1) Feed resources in tropical regions

The feed resources for animals (cattle and other ruminants) in the tropical regions include mainly native plants, fodder trees, farm by-products (leaves and stems except for food use, straws, grains, brans, etc.), food processing by-products (cassava meal, soybean curd residue, brewery spent grains, molasses, etc.). On the contrary, the use of forage crops like pasture plants are limited to the advanced regions where mainly dairy farming is practiced. It is important to make good use of the feed resources which are produced in these regions and are inexpensively and easily available.

It is necessary to solve the production and utilization problems of forage crops, like pasture plants, by considering the land use, cost of production and feed needs in the dairy farming, etc. As to the use of farm and food processing by-products, the condition of the production (time, form, moisture content, amount, etc.), availability, prices, and methods for procurement like transportation should be examined. It is necessary to adjust the moisture content of the silage (TMR: total mixed ration) materials, accelerate fermentation and improve the nutritional value of the feed by adding these by-products to the materials of feed crops or native grasses at the time of silage making.

(2) Seasonal productivity of the feed resources and shortage of feed during the dry season

In many tropical regions, such as South East Asia, the climate conditions are characterized by the rainy season and the dry season (in continental regions, Thailand, Vietnam, etc., from October to April; in the coastal island regions like Indonesia, etc., from June to September).

In the rainy season, as the growth of herbage including native grasses and pasture plants is vigorous, sufficient feed becomes available and in most cases animals can be fed enough by cut-and-carry or grazing.

However, in the dry season, not enough feed tends to be secured and fed to animals, because herbage plants stops growing or dying due to the continued dry condition during the dry season. Thus animals suffer malnutrition, reduction of milk production, loss of body weight (see Figure 1 and Table 1), outbreak of diseases and reproduction disorders. These marked reduction in animal productivity causes mainly the stagnation of income growth in animal farming and becomes a limitation factor for increasing the animal keeping number.

In the advanced regions where dairy farming are practiced, pasture plants, etc. suitable for the tropical regions are introduced and selected and are widely spreading. Therefore it is vital to produce good quality roughage year-round by increasing the cropping area on the basis of those information and proven data.

Figure 1. Seasonal change of liveweight of grazing cattle in Northern Australia (Norman, 1966)

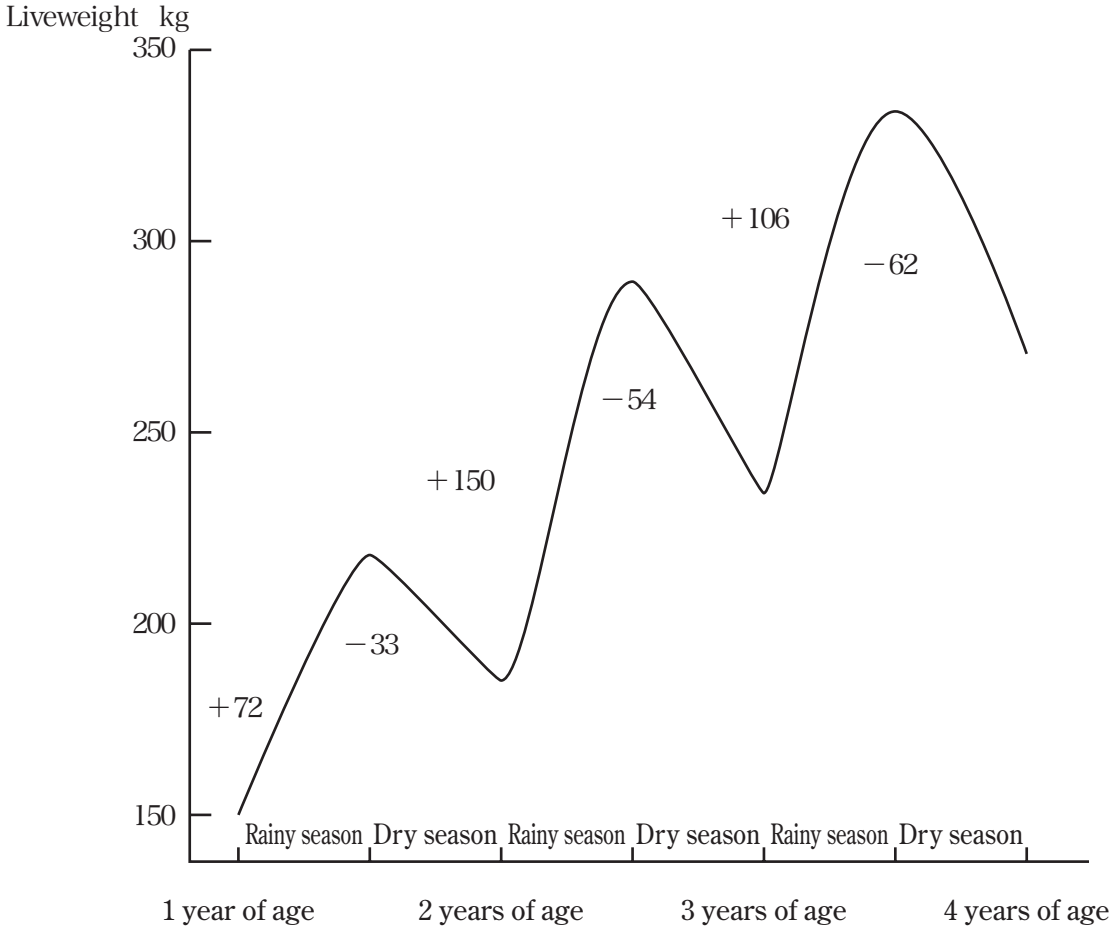


Table 1. Effect of introducing pasture legumes and applying fertilizers on beef productivity in native pastures

Native pastures	pasture legumes	Superphosphate	Reference
29	93	148	Shawand't Mannetje (1970)
30	56	76	Graham and Mayer (1972)
63	73	120	Winks (1973)
	279	474	Stobbs (1969)

(Note) Liveweight gain (kg/ha/year)

(3) Preparation and storage of silage for the dry season

As a measure against feed shortage of during the dry season, it is general that vigorously grown herbages in the rainy season (high temperature and heavy rain) are prepared, and stored as hay and silage and used in the dry season. However, it is difficult to make hay due to the climatic condition and cost, etc.

As a method for preparing and storing herbages under the climate condition of the rainy season, the silage making technology is the most reliable and low cost.

In the advanced regions in Thailand and Indonesia, silage making is spreading, and it is apparent that the technologies in the two countries can be used.

In silage making, the basic principles of silage making (manual) must be practiced as follows; ① harvesting and chopping the material herbages at the proper time, ② adjusting the moisture content, ③ giving sufficient treading, early complete sealing and application of heavy weights, ④ addition of molasses, or sugars and by-products (in case of delayed harvesting and poor condition for silage condition), ⑤ practicing complete silo management (measures against damages by birds, field mice, etc.), ⑥ short working time for adjustment at each silo. It is also important to introduce and use simple and inexpensive silos which can be easily procured or made in the region.

It is also vital to understand the nutritional characteristics that the most of the tropical herbages have a low content of sugars which are essential for silage making (lactic acid fermentation), and to utilize the local feed resources to the maximum, for example by mixing as TMR with other silage materials (farm by-products, food wastes, etc.).

(4) Measures for securing various feed resources and their spread

Rice straws are produced in large quantities in paddy field areas, but in reality most straws are not utilized as a feed resource due to the climatic conditions (because of the high air temperature and heavy rain, it is difficult to dry rice straws), the timing of the double and triple cropping, harvesting labor under the extreme heat condition, shortage of labor and storage facilities, etc.

There is a simple and low cost "urea treatment technology" as a method for collecting and storing these rice straws, and the straws can be stored in raw condition (with the moisture content at the cutting time) with improved digestibility, palatability and nutritional value. Therefore it can be expected that the use of rice straws for feed will increase.

The transitional time between the rainy season and the dry season often overlaps with the harvest time of agricultural products. By-products of the harvest are also produced in large quantities and can be used as stored feed after drying naturally. Furthermore herbage can be used (by grazing or cutting) as it is as standing hay or as storage feed after cutting and drying.

For extension of making and utilizing silage of herbages, it is necessary to demonstrate various disadvantages occurring with feed shortage during the dry season and advantages of feeding animals by securing the stored feed, and to make and distribute manuals (guides) for silage making technology, as well as to demonstrate the actual proof.

2. Principles of silage making

Silage, which is a succulent roughage, is made by keeping chopped silage materials air-tight in

a suitable container (silo) to undergo mainly lactic acid fermentation with the aim of storing feed. The principle of silage is the same as that in making pickles.

The fermentation process of silage is as follows:

(1) The first stage

① The packed raw materials are still respiring immediately after chopped and consumes oxygen.

② The temperature will rise to about 32°C around 4 days after packing.

(2) The second stage

① Acetic acid production begins by fermentation with acetic acid bacteria during the respiration in the first stage.

② The silage pH slowly changes from about 6.0 to about 4.0.

(3) The third stage

① Lactic acid fermentation begins by lactic acid bacteria about 3 days after packing chopped materials.

② Acetic acid fermentation by acetic acid bacteria decreases, and then acetic acid production declines.

(4) The fourth stage

① Lactic acid production continues for about 2 weeks.

② The temperature goes down slowly to about the normal atmospheric temperature.

③ The pH decreases to about 4.0, and the activity of the various bacteria ceases.

(5) The fifth stage

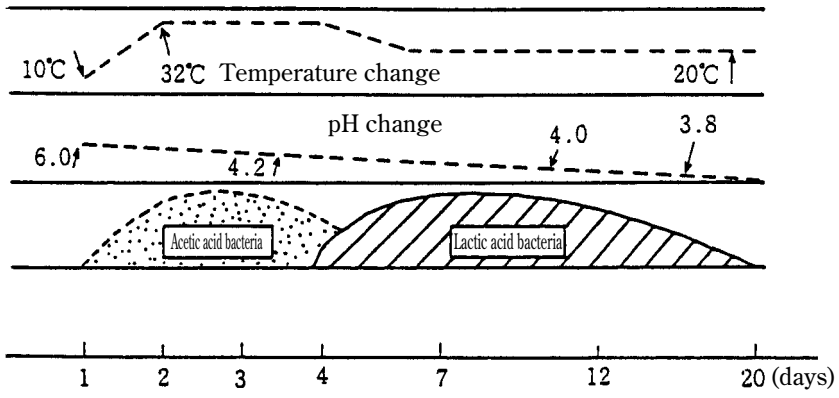
① If the reaction proceeds smoothly up to the fourth stage, it enters a stable phase with a low pH condition, and high quality silage is made.

② The lactic acid fermentation completes in about 20 days, and the silage product is finished.

③ If the lactic acid production is insufficient, butyric acid fermentation begins and quality deterioration occurs.

The fermentation process of silage is shown in Figure 2.

Figure 2. Diagram showing the fermentation process of silage



(Note) cited from “All about Feed Crops” made by DAIRYMAN Co.

3. Major raw forage materials for silage making

(1) Pasture grasses: Elephantgrass (Napiergrass), Guineagrass, Rhodesgrass, Sudangrass, Setaria, Ruzigrass, Atratum, Kinggrass, etc.

(2) Pasture legumes: Desmentus, Stylo, etc.

(3) Corn: Corn for feed

(4) Sorghum: Sorghum for feed

(5) Fodder tree: Leucaena, etc.

(6) Straws: rice straw, wheat straw, soybean chaff, peanut hulls, etc.

(7) Farm by-products: stover of sweet corn, stover of sweet sorghum, pineapple stover, sugar cane top, rice bran, wheat bran, etc.
Cassava meal, soybean curd residue, brewery spent grain, juice pomace, molasses, etc.

4. Kinds of silos (for small-scale operation having about 10 animals)

(1) Stack silo

① Silage can be made easily with a simplest silo.

② A plastic sheet (about 0.1 mm thick) is spread over the ground, and similarly chopped silage materials on the sheet are entirely covered with a plastic sheet. Proper tread pressure has to be applied, and complete sealing is required.

③ The size can be determined according to the number of raising animals.

④ It is necessary to make steps to prevent damages on the plastic sheet by field mice or birds.

Figure 3. Stack silo

(Note) cited from “Zen-Noh Grass”

(2) Bunker silo

Figure 4 shows a bunker silo, half of which is below the ground level.

① A bunker silo is generally built on the ground (Figure 4), but there are other building

methods to build a silo using the configuration of the ground (slope) or a semi underground type, which is half below from the ground level.

② Side walls made of wood and concrete are needed, and the interior is preferably sealed by plastic sheets. Proper tread pressure has to be applied, and complete sealing is required.

③ Supports are needed so that the side walls do not fall toward the outside.

④ The width of the front should be such that the total amount of silage per day can be taken out with a thickness of 20-30 cm to prevent aerobic deterioration.

Figure 4. Bunker silo

(3) Trench silo

① A trench silo can be built by simply digging the ground, but it is better to place plastic sheets inside to prevent loss.

Proper tread pressure also has to be applied, and complete sealing is required.

② A trench silo whose interior is coated with concrete can be used for a long time (Figure 5).

③ The width of the front should be such that the total amount of silage per day can be taken out with a thickness of 20-30 cm to prevent aerobic deterioration.

Figure 5. Trench silo

(4) Plastic bag silo

Figure 6 shows plastic bag silos.

① This is a plastic bag with the thickness of about 0.1 mm and silage materials are packed inside.

② Commercial plastic bags are used if available.

③ Plastic bags for fertilizer and feed may be reused for cost-cutting. Bags must be packed with chopped raw materials, compressed as much as possible to remove the internal air and then sealed completely.

④ The number of bags is determined freely in accordance with the operation size.

⑤ It is necessary to watch out for damage on the plastic bag by field mice, birds and dogs.

Figure 6. Plastic bag silos

(5) Fenced silo (framed silo)

① The frame is made of bamboo, wooden, iron materials, etc., which are easily available locally.

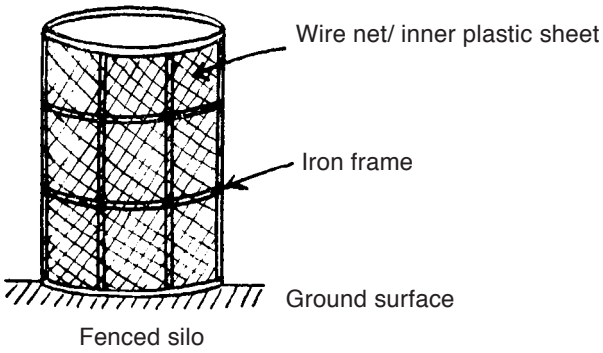
② The shape of cross section may be circular or rectangular.

③ The inside is sealed with plastic sheets. The silos are packed with compact and chopped raw materials and must be compressed as much as possible to remove the internal air and sealed completely.

④ As the silo cannot be made in a large size, the number of silos is determined by the size of operation.

⑤ This is a convenient silo because it can be easily made.

Figure 7. Fenced silo (framed silo)



(Source) "Kinds and Characteristics of Silos (by Nobuo Takano)"

5. The size of a silo

The silo size is determined by a herd size, the amount of daily feed, the number of feeding days and packed density of the raw materials. An example of calculation in case of 10 dairy cows is as follows:

① Ten dairy cows (a herd size) × 20 kg (daily ration) × 180 days (number of feeding days) = 36 tons (see Table 2)

② The capacity of the silo is: 36,000 kg ÷ 700 kg/m^3 (see table 5) = 51.4 m^3

③ 10% is added to account for packing loss in the silo: 51.4 m^3 ÷ (1 – 0.1) = 57.1 m^3

④ 20% is added to account for loss during storage. The resulting calculated silo capacity is: 57.1 m^3 ÷ (1 – 0.2) = 71.4 m^3

⑤ See Table 3 and 4 for the type of a silo.

Table 2. The needed amount of silage corresponding to a herd size

(Unit: ton)

Feeding category / Number of cows	Feeding for 180 days			Feeding for 300 days			Feeding for 365 days		
	Daily feed quantity			Daily feed quantity			Daily feed quantity		
	20kg	30kg	40kg	20kg	30kg	40kg	20kg	30kg	40kg
1 head	3.6	5.4	7.2	6.0	9.0	12.0	7.3	11.0	14.6
2	7.2	10.8	14.4	12.0	18.0	24.0	14.6	21.9	29.2
3	10.8	16.2	21.6	18.0	27.0	36.0	21.9	32.9	43.8
4	14.4	21.6	28.8	24.0	36.0	48.0	29.2	43.8	58.4
5	18.0	27.0	36.0	30.0	45.0	60.0	36.5	54.8	73.0
6	21.6	32.4	43.2	36.0	54.0	72.0	43.8	66.0	87.6
7	25.2	37.8	50.4	42.0	63.0	84.0	51.1	77.0	102.2
8	28.8	43.2	57.6	48.0	72.0	96.0	58.4	88.0	116.8
9	32.4	48.6	64.8	54.0	81.0	108.0	65.7	99.0	131.4
10	36.0	54.0	72.0	60.0	90.0	120.0	73.0	110.0	146.0

Table 3. Volume calculation chart for rectangular silos (stack, trench and bunker types)

(Unit: m^3)

Length m / Width × height (m)	4	5	6	7	8	9	10	11	12
2×1	8	10	12	14	16				
3×1	12	15	18	21	24	27			
4×1	16	20	24	28	32	36	40		
5×1	20	25	30	35	40	45	50	55	
2×2	16	20	24	28	32	36	40	44	48
3×2	24	30	36	42	48	54	60	66	72
4×2	32	40	48	56	64	72	80	88	96
5×2	40	50	60	70	80	90	100	110	120
3×3	36	45	54	63	72	81	90	99	108
4×3	48	60	72	84	96	108	120	132	144
5×3	60	75	90	105	120	135	150	165	180
6×2	72	90	108	126	144	162	180	198	216

Table 4. Volume calculation chart for cylindrical silos

(Unit: m^3)

Height(m) / Diameter(m)	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1.0	2.36	2.75	3.14	3.53	3.93	4.32	4.71
1.5	5.29	6.17	7.06	7.94	8.82	9.70	10.58
2.0	9.42	10.99	12.56	14.13	15.70	17.27	18.84
2.5	14.72	17.16	19.62	22.07	24.52	26.97	29.42
3.0	21.20	24.73	28.26	31.79	35.33	38.88	42.39
3.5	28.85	33.66	38.47	43.26	48.07	52.88	57.68
4.0	37.68	43.96	50.24	56.52	62.80	69.08	75.36
4.5	47.69	55.64	63.59	71.53	79.48	87.42	95.36
5.0	58.88	68.69	78.50	88.31	98.13	107.94	117.75

(Source) "Consultant Handbook" made by Japan Agricultural Structural Improvement Association

6. The place and method for building a silo

(1) Place to build a silo

① A place with good drainage and no staying of rain water (especially close attention is required when building a semi-underground silo or a trench silo).

② A place which is not exposed under direct sunlight, as far as possible, because quality deterioration of silage often results from the direct sunlight in tropical regions.

③ When building a stack silo, the preparation should be done by raising the ground level in advance, if there is no place with good drainage to be found.

④ A place near the place (feed trough) for feeding animal where the carrying work is easy at feeding.

⑤ If the distance for transportation between the production field and the silo is shorter, the work efficiency is better.

(2) Method for building a silo

① There are actual examples in the tropical regions which simple roofs made of leaves of palm or banana trees are built to avoid direct sunlight or torrential rains. It is also effective to lower the rise of the inside temperature of a silo that if covering the entire top surface of the sealed plastic sheets is done with soil to avoid the direct sunlight

② An ideal trench silo has concrete side walls, but in case the silo does not have walls, it is necessary to seal the silo by covering the side parts with plastic sheets instead.

③ The floor of a stack silo, bunker silo, trench silo, etc. should have a slope of 3-5% toward

the entrance to make the flow of liquid discharge easy.

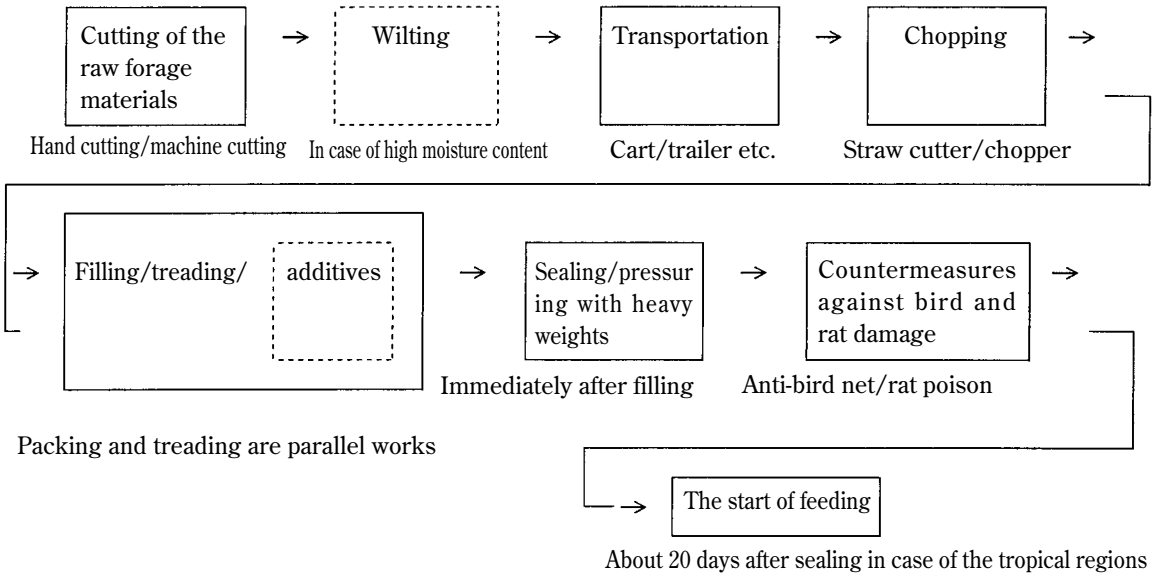
④ Rat poison should be scattered around the places where many field mouse inhabit.

7. Silage making technology

(1) The procedures for silage making

The procedures for silage making are as follows.

① Because it is preferable to be able to finish the work of packing materials into one silo (stack, bunker, trench, etc.) within a short time (1 or 2 days), the silo size, working machineries and working system (labor) should be examined.



③ Cutting and transportation of raw forage materials

a. Cutting work for raw forage materials is carried out by hand cutting using sickles, bush cutter etc., or by machinery like hand mowers etc. which are locally popular and available.

b. For cutting work in a large area, the introduction and use of mowers, harvesters etc. are efficient. However, their cost and after-service etc. should be considered.

c. For the transportation work, the means such as man-power (carrying poles with baskets), carts, wagons, which are locally popular and available, should be utilized.

④ The following points should be closely watched in silage making:

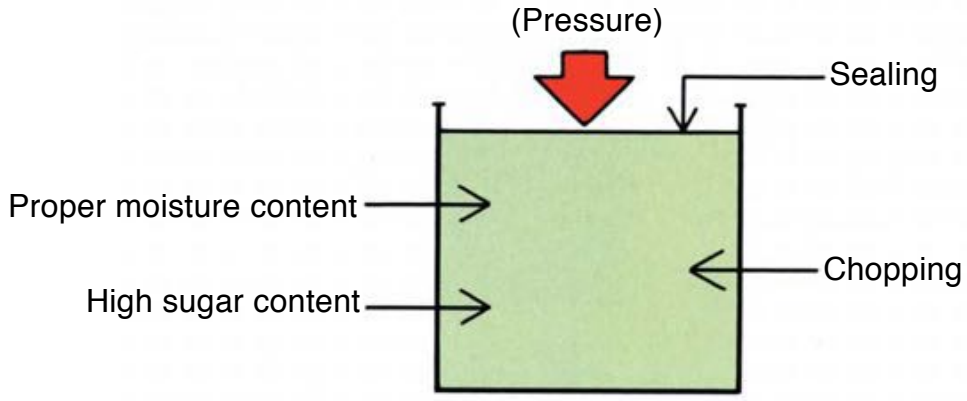
a. Harvesting of the raw forage materials at proper time

b. Chopping, treading, early sealing and pressurizing with heavy weights

c. Control of the moisture content of raw forage materials

d. Additives (used when the raw forage materials are not of good quality and the conditions for making silage are poor).

Figure 8. Important points for silage making



The Forage Q&A (made by All Japan Agricultural Cooperative Federation)

(2) Harvesting of raw forage materials, etc. at proper time and mixing of them

① Pasture grasses (including native grasses)

From early heading to heading stage: this period can acquire the highest nutritional yield per unit area and high quality silage. Delayed cutting tends to cause the decline in the silage quality (palatability) and regrowth vigor of grasses.

② Pasture legumes (including native legumes)

From budding to early flowering stage: this period can acquire the highest nutritional yield per unit area and high quality silage. Mixing with pasture grasses makes fermentation better and silage making easier.

③ Corn

Yellow ripening stage:

- When the grain moisture content becomes 40-45%.
- When the grain milk line of the grain passes the central part.
- When the moisture content of the whole plant, including stems, leaves and grains is about 65-73%.

cited from "Zen-Noh Tane 1995 Spring seeding"

[Judgment of the yellow ripening stage]

The milk line is utilized for judging the yellow ripening stage.

The milk line is a line between the yellow part and the white part of kernels that can be seen clearly when one breaks an ear of corn by hand and observes the outer part. The proper harvesting time is when this milk line passes the center point of the grain.

(4) Sorghum

Dough stage: ・ When the hardness of the grain becomes like that of dough.

・ The time when the dry matter yield is maximum and the moisture content, including stems and leaves, is 65-70%.

⑤ Agricultural and food processing by-products such as stovers and by-products

a. Since stovers (fresh forage), raw by-products are easy to decompose if left without any treatment, they are mixed with other materials (forage) and made into silage.

b. If they are dry and preservable, they are stored and utilized as moisture content regulators for raw materials with high moisture content.

c. The forage plants in the tropical regions are quite often low in the sugar content that is essential for lactic acid fermentation.

For this reason, it is important to improve the quality of silage by adding locally available and cheap by-products (especially high-sugar-content by-products).

(3) Moisture content in raw materials

① In case of the tropical regions, the moisture content of raw materials should be adjusted at 65-75% in silage making, which is a little higher than in the temperate regions, because the chance of failure becomes much less from the viewpoint of preventing aerobic deterioration(60-70% is the optimum moisture content for butyric acid fermentation.).

If the moisture content of the raw materials is too high (80% or more), it may cause poor fermentation and the loss of liquid discharge and they need to be adjusted by mixing by-products and straws with low moisture content.

② The sign of the optimum moisture content is that water seeps out of chopped raw materials by hand squeezing.

(4) Chopping of raw materials

① The raw materials are chopped to about 1-3 cm long so that the packing density is kept higher, lactic acid fermentation takes place in good condition and the work of packing and taking out are carried out easily.

② The raw materials harvested by directly cutting with a chopper (frail mower type) contains stems and leaves that are 20-30 cm long, but the silage quality is not affected.

(5) Packing and treading

① The chopped raw materials are packed with occasional flattening so that they will pile up evenly.

② The treading is applied by human feet or tractors in parallel with the packing, and especially the peripheral area should be given priority for treading.

③ The signs of the finishing of treading are that there is almost no sinking of the shoes when human labor is used, and that the sinking of the tractor tires is less when a tractor is used. The density at that finishing time is shown on Table 5.

Table 5. Packing density of silage

(Unit: kg)

Raw materials	Weight per 1 m^3
Wilted pasture plants	600～700
Pasture plants with high moisture content	700～800
Corn	600～700
Sorghum	600～700

(Source) "Consultant Handbook" (Japan Agricultural Structural Improvement Association)

④ Ideally the packing should be finished in a short time within the day. If the packing work has to be continued to the next day, the packed raw materials should be covered with plastic sheets at the end of the work in the first day so that the packed raw materials are not exposed directly to the air.

(6) Additives

When the raw materials are fresh and of high quality (high sugar content), there is especially no need for additives to be used (this leads to low cost). If the quality of the raw materials is deteriorated, due to delayed cutting and rainfall so on, additives should be used

to improve the quality.

Usually molasses and brans are easy to obtain in the tropical regions, so these are utilized. The method for adding is as follows:

① Addition of molasses

a. Molasses solution is diluted by 2 times with hot water and is sprayed on the raw materials with a watering pot or the like at the level of about 2-3% of the material weight.

b. If the moisture content of the raw material is high, molasses addition may have no effect. In that case, the raw materials are dried up to about 65-75% of moisture content.

② Addition of bran

a. When the moisture content of the raw materials is 80% or higher, brans are evenly sprayed at about 10% of the silage materials with manual. When the moisture content is 70-80%, 5% is sprayed.

b. Addition of brans also leads to the moisture adjustment of raw materials having higher water content.

c. Bran additives are expensive just for only improving the fermentation, but they bring about the effect of nutritional improvement.

(7) Early complete sealing

① The sealing by plastic sheets and so on should be done to put the silage into air tight condition immediately after the packing and treading works are completed.

② Especially the peripheral area should be given a priority for sealing to prevent deterioration.

③ In case of transparent plastic sheets, inside raw materials are visible from outside and have a tendency to receive damage from birds. Therefore it is better to use colored sheets.

(8) Pressurizing with weight after sealing

① In stack silo, bunker silo, trench silo etc., the sealed plastic sheets is covered completely by soil with about 20 cm thickness.

This covering is also effective to suppress the temperature rise in the silo caused by direct sunlight.

② The used tires or fertilizer bags filled with earth and sand etc. can be used as weights. The heavier the weight is the better.

(9) Countermeasures against damages by rats, birds and dogs

① To prevent damages by birds, anti-bird nets can be put up, fish lines or plastic tapes, etc. may be put up criss-cross.

② If there is a possibility of damages by rats, rat poison should be scattered around.

If weeds grow around the silo, they should be cut whenever necessary.

③ After the silage sealing, the plastic sheets should be inspected for breakage from time to time, and if breakage is found, it should be repaired to maintain the airtight condition.

(10) Termination of silage fermentation

Since lactic acid fermentation ends about 20 days after sealing, with the pH dropped around 4 and the quality of the silage stabilized. From this time, the silage can be fed.

8. Method of feeding silage and a point to note

(1) Since the nutritional ingredients of silage varies greatly with the kind, mixing ratio, and moisture content of the raw materials, it is important to analyze feed, and carry out appropriate feeding to cattle.

(2) Pasture plant silage should be fed together with other roughage such as hay, although it can be fed alone.

(3) In general, whole crop silage is not fed by itself. It is because this silage contains high nutrients (TDN), if it is fed too much females will become fat and tend to be infertile.

(4) If the number of animals suffering from diarrhea increases, as it might be possible that the silage has deteriorated in quality, and feeding should be stopped. After discarding the deteriorated parts, feeding may be restarted.

(5) When keeping on feeding a large quantity of silage having a high concentration of nitrate nitrogen (2,000 ppm or higher in DM), it is needed to pay close attention because females might develop infertility, abortion, sudden death, etc.

Silage with a high concentration of nitrate nitrogen is sometimes found when pasture plants, corns, etc., to which too much manure was applied, is harvested (especially early cutting) and processed.

If there is a possibility that the silage might contain high concentration of nitrate nitrogen, it is preferable to check the concentration beforehand (it can be simple to do with an indicator drug). Depending on the result of the check, the silage may be discarded, or given with a reduced ration by combining it with other roughage (straws, etc. having low nitrate nitrogen concentration).

9. Judging the quality of silage

The quality of silage can be judged by its color, smell, taste and touch.

(1) Color: In general, pale yellow indicates good quality. If the color is from dark brown to dark green, the silage underwent bad fermentation and is of bad quality.

(2) Smell: Acidic or a sweet-sour pleasant smell indicates good quality. On the other hand, if there is a manure smell or putrid smell and it is so repugnant that one cannot put the silage near one's nose, the quality is poor.

(3) Taste: If the silage tastes sour and there is no problem in putting it in one's mouth, the quality is good. On the other hand, if the silage tastes bitter and one cannot put it in one's mouth, the quality is poor.

(4) Touch: When squeezing the silage tightly in a hand and then opening the hand, if the silage breaks slowly into two, that silage is of good quality. If the silage breaks into

small pieces separately, the silage is deficient in moisture content. If water is dripping, the moisture content of the silage is too high.

Table 6. Judgment of the quality of silage in the field

Category		Grade	Color	Smell	Observation when touching silage with hands	Flieg score	pH	Feeding
Safety		A	Pale yellow, olive color	Pleasant light sweet-sour	Silage is judged so clean that it is considered not necessary to wash hands	80 points or higher	3.6～3.8	Can be fed in large quantities
		B	Brownish yellow	Sweet-sour smell with slightly stimulative smell	Smell on hands is gone after washing with water	60 points or higher	3.9～4.2	Be careful in feeding cows in milking
Danger	Attention needed	C	Dark brown	Strong pungent smell	It needs wash hands with hot water	40 points or higher	4.2～4.5	For feeding to growing feifers
	Unsuitable	D	Dark brown and dark green	Ammonia smell, putrid smell	The smell on hands is gone only after washing with hot water and soap	39 points or lower	4.6 or higher	Stop feeding to cows in milking Also be careful in feeding growing heifers

(Source) “Silage Bible” (Rakuno Gakuen Shuppan)

10. Prevention of the aerobic deterioration

Secondary fermentation occurs easily in such conditions that the air temperature is high, the packing density is low, the moisture content of raw materials is low or the take-out amount per day is small.

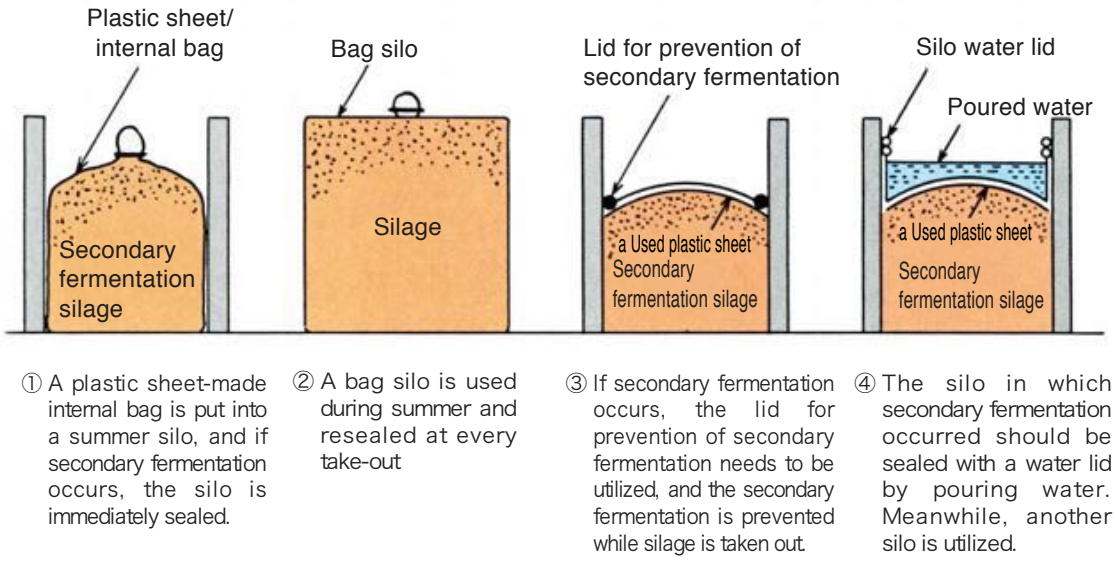
Especially in tropical regions, it is assumed that often the air temperature is high, the packing density is low and the amount taken out per day is small. Therefore it is important to pay attention to the type and size of the silo as well as to follow the basics of silage making.

(1) The packing density of silage should be increased to about 700 kg per 1 m3.

(2) The moisture content of raw materials should be adjusted to about 65-75%.

(3) The size (width) of a silo should be adjusted so that the thickness of silage taken out per day is 20 cm or thicker.

Figure 9. A concrete method for preventing secondary fermentation



(Source) "The Forage Q&A" (Zen-Noh information)

11. Prevention of accidents in silo works

(1) It may happen occasionally that poison gas is produced in underground silos, causing oxygen deficiency.

When a worker enters into a silo to restart packing more silage materials after silage making works were temporarily discontinued and it passed more than half a day, and when the work for silage take-out is carried out in the lower part of a silo, a burning candle (fixed on a stick) should be brought near the lower part of a silo to check whether fire is extinguished. If fire is extinguished immediately, there is a possibility that oxygen may be deficient. Since this is a very dangerous situation, air in the lower part of the silo should be ventilated before starting work by exhausting with a vacuum cleaner or sending air with a blower, etc.

(2) A ladder should be used to go up and down to prevent people from falling. When an underground silo becomes empty, a fence should be built around the silo.

12. Actual examples of silage making and utilization in the tropical regions

(1) Indonesia

① Examples in the JICA's "The Strengthening Project of Artificial Insemination Center in Indonesia" (Singosari)

Hand cutting of raw materials (Elephant grass). Grass height is 2-3m.

Hand cutting of raw materials (Guinea grass). Heading stage

Cultivation of indigenous corn in Indonesia

Cultivation without application of cattle manure

Increased production by cultivation using cattle manure

Chopping of raw materials (Elephant grass) by a small-sized cutter with an engine

Treading work in a plastic bag silo

Completion of sealing work

Packing a trench silo dug into the ground with chopped materials (Plastic sheets are laid inside the silo.)

Concrete-made trench silo (packing, leveling and treading)

Covering work of plastic sheets (A roof is put up using coconut leaves to shut off the direct sunlight.)

② Actual examples of JICA's Dairy Technology Improvement Project in the Republic of Indonesia" (Bandung)

A concrete-made bunker silo (The frontage is made narrow to prevent secondary fermentation.)

Quick sealing is needed after packing work. The container is reusable.

After sealing, the plastic sheets covering the silo are further covered with colored sheets to prevent pinhole formation on the plastic sheets, damages by birds, etc.

A drum can silo (Drum cans can be obtained easily and placed in a convenient place.)

Feeding cows with a simple wooden feed trough

(2) Thailand

Actual examples in Thailand

A chopper shredding corn stover left after harvesting ears

Silage making by packing chopped pasture plants into small plastic bags (for garbage disposal) (nationwide use)

Silage making in a small plastic bag which is the re-use of a fertilizer bag (Central region)

Silage making by re-using a discarded plastic container (Central region)

A carton container utilized for silage making, which is a discarded container for tomato paste and a thin plastic bag is placed inside.

Silage making by packing chopped pasture plants in a larger plastic bag (in the center and right side) (Central region)

Silage making using concrete cylinders on a farm (Central region)

Silage making by packing chopped pasture plants in a concrete-made bunker silo (also note two large plastic bag silos next to the bunker silo, which have preventive measures against dogs) (Central region)

Silage making by packing chopped pasture plants in a bunker silo built with concrete blocks (Central region)

A plastic stack silo placed on a concrete floor (The top is covered by rice straws to protect the silage from direct sunlight.)

Silage making in a bunker silo dug in the ground with utilizing a depression

A silo on a concrete floor with a raised ground as side walls

An ammonia treatment trough for rice straws

(3) Chile

Examples of JICA's " Improvement of Productivity for the Small Scale Farmers Project in the Republic of Chile" (Valdivia)

A stack silo (Pasture grasses are perennial ryegrass. No plastic sheet is laid down, and the moisture content is controlled by the liquid discharge seeping into the ground. From the floor about 10-20 cm thick of silage may be damaged, but the overall quality is good.)

Take-out of silage (Cut off by a tool with an ax-like edge. The cutting edge is kept hard, preventing secondary fermentation.)

Feeding silage with wooden feed troughs (The area around feed troughs becomes muddy condition due to rainfall. Some countermeasures are needed.)

Feeding silage in the pastures (With some loss caused)

A large bunker silo in the Agricultural Experiment Station (If air tightness is maintained, storage for more than 1 year is possible.)

A large stack silo in a dairy farm (Since moisture content is high, at about 80%, secondary fermentation does not occur.)

13. Examples of advanced silage making and utilization technologies

(1) Silage making technologies generally widely used

In countries with advanced livestock industries, such as Europe, America and Japan, widely used silage making is carried out in vertical silos which are cylinder- or square-shaped concrete tower silos (built underground or semi underground type) or in horizontal silos like bunker silos, trench silos or stack silos.

The technologies for silage making consists of the work of harvesting raw materials for silage, like pasture plants, corn plants, etc., by tractor-pulled or self-propelled harvesters, the work of transporting the harvested raw materials by vehicles (forage wagons, trucks, etc.) to the silos, the work of packing the transported raw materials into the silos and treading, and finally the work of sealing the silos.

As an example of generally practiced silage making by a bunker silo

An example of silage making by bunker silos

Harvesting corn plants and loading chopped plants to a transporting car

Harvesting pasture plants by a self-propelled harvester and loading chopped plants to a transporting car

Treading by a wheel loader in a bunker silo

Sealing and storing in the bunker silo with a roof (the weights are old tires)

(2) Roll bale silage making technology

The roll bale silage making technology has been spread rapidly in farms in Japan since late

1975. After harvesting pasture plants, etc. and reducing the moisture content of these materials to about 60%, the materials are packed into cylinder-shaped bales (called roll bales) and wrapped around rapidly with a film to seal it air tight.

This film wrapping forms about 4-6 layers, and the machine used for wrapping is called a bale wrapper. The size of the bales is about 1 m in diameter, and the weight is about 350 kg, although it varies depending on the moisture content of the raw materials. Silage is made in about 2 months, and if the degree of sealing is good, it may be preserved in good quality condition for more than 6 months.

Originally, the roll bale silage is a technology for making pasture plants silage. But recently the machinery for chopping, making roll bales and wrapping, and technology have been developed to utilize large-sized crops like corn plants as raw materials, and they are attracting attention as an energy-saving technology for making and utilizing corn silage. Also relatively small machinery has been developed for utilizing pasture plants, rice for feed, rice straw, etc. cultivated in relatively small fields to make roll bale silage.

Examples of roll bale silage making with pasture plants are shown as follows.

An example of making roll bale silage with pasture plants

Pasture plants gathered in a windrow before being rolled into bales by a roll baler

A pasture plant roll bale made by a roll baler

Wrapping work of a roll bale

Wrapped roll bales (completed)

Addendum Urea treatment of rice straws, etc.

In the tropical regions there is a shortage of roughage, but rice straws and wheat straws are often seen discarded without being utilized. Therefore, as it is expected that the shortage of roughage may be improved by utilizing these unused resources as feed, and the preparation method is explained below.

Because rice straws and wheat straws are high in fiber content and hard, their digestibility and palatability are low. They have the feed characteristic that they are low in protein and fat content in nutritional value. By treating these straws with urea (ammonia treatment), they can be stored for a long period of time as raw straws, their digestibility and palatability are increased, and the nutritional value is also improved (increase in nitrogen content). Furthermore, it is said that urea treatment is effective against fungal growth, has an insecticidal effect and may is a preventive measure against hepatic facioliasis.

The quality improvement of rice straws through urea treatment

Unit: % of materials

Ingredients / Tested feed	Organic matter	Crude protein	Total fiber	Highly-digestible fiber component	pH	Lactic acid
Untreated straws	82.4	3.1	57.6	5.2		
Treated with 2.3% urea	80.3	10.8	60.0	13.6	7.87	0.49
Pasture plants silage	78.1	3.9	63.6	6.5	4.38	1.04

(Source) Mr. Tsuneo Kondo at National Agricultural Research Center for Tohoku Region

(1) Basic principles of the treatment

① Raw materials to be treated: fresh rice straws or wheat straws produced in the year are used.

② Moisture content after the treatment: the moisture content is adjusted to 40-60% after the addition of urea solution.

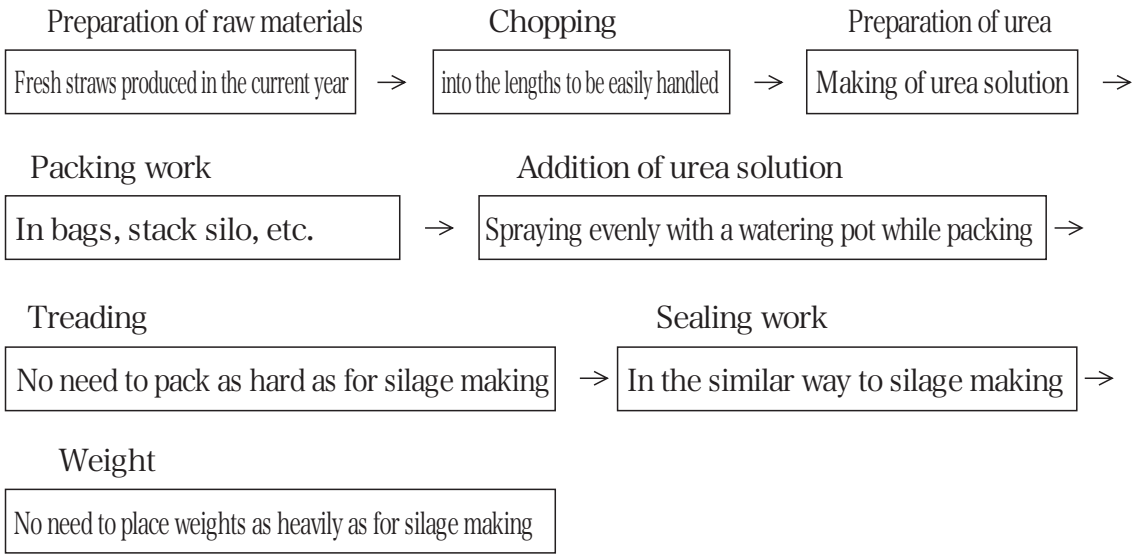
③ Amount of urea added: 2-3% of the weight of the silage materials.

④ Method for storage: a plastic bag or a stack silo, etc.

⑤ Sealing duration for treatment: about 20 days.

⑥ Confirmation of urea degradation: with ammonia smell and the material changed to yellow color.

(2) Treatment procedures



(3) Treatment technology

① The fresh materials produced in the current year are used.

② The materials are cut into appropriate size for easy handling when feeding.

③ Adjustment of urea solution

a. In the case that one ton of rice straws with moisture content of 30% is used.

b. About 20 kg of urea is needed (2-3% of materials).

c. Adjusting water is needed (for making the moisture content of materials to 50 %)

- 1,000kg (rice straws) × 70/100 (moisture content of rice straws)＝700kg (DM content of rice straws)
- 700kg of water is needed to change 700kg dry matter materials into air dry matter materials having 50% moisture content.
- As 1,000 kg of rice straws contains 300 kg of water, insufficient 400 kg (700 kg – 300 kg) of water is required.

d. Take a proper quantity of water from the prepared 400 kg of water for dissolving 20 kg of urea is heated to 20-30°C (due to insolubility of urea in cold water).

e. 20 kg of urea is dissolved in the above-mentioned hot water.

f. Then, this urea water is returned to the original water to complete the urea-added solution of about 400 kg.

④ The raw materials are packed into a silo while being sprayed the urea solution evenly over with a water pot or the like.

In case that the moisture content of raw materials such as rice straws is high (40-50%), the concentration of the urea-added solution should be increased, and the adding volume be reduced and sprayed evenly by using a sprayer, etc.

⑤ There is no need for a heavy weight, different from silage making, but it is recommended

for the tropical regions to cover the top surface with soil to shut off direct sunlight.

⑥ Concerning the rest of the technology, that of the silage making is applied..

Storage situation of "ammonia-treated rice straws" with a plastic bag

(4) Feeding

① In the tropical regions, silo can be opened in about 20 days after sealing and then urea-treated rice straws can be used.

② Since urea-treated rice straws have an ammonia smell immediately after being taken out of the silo, the needed amount should be taken out and left outside for 1-2 days to reduce the smell, and then be fed to cattle.

③ It is preferable to feed urea-treated rice straws together with hay or silage rather than feeding itself alone.

Annex 4

Story Board

Pilot Testing of Pit Latrine Emptying by Plastic Bucket

Location: Shariakandi, Gabtoli and Durgapur in Bogra.

August - September 2014

Report Submitted on
30 October 2014

I. Introduction

This is the second Study Board Report dealing with the Pilot Testing of Pit Latrine Emptying by Plastic Bucket. This report on the Logistics Test Action Research presents the pit latrine emptying hardware devices' installation and removal assessment and findings including observations and conclusions. The assessment included all three types of pit latrines, that is, single pit, double pit and offset pit types.

II. Background

BioSol Energy is implementing the back-to-back feasibility study on Technical Feasibility and Commercial Viability of the Processing of Pit Latrines Contents in Bangladesh, in short, Safe Processing of Pit Latrine Content. The study will rollout pilot testing plan for the installation and operation of the Biogas plant in Bogra based on cornstovers, chicken manure and fecal sludge in the 6:3:1 mixing ratio. The plant will use 10,000 of feedstock annually.

The Logistics Test Action Research (LTAR) data provides confirmation of the assumptions within the financial parameters of the feasibility study design. The purpose is also to come up with alternative solutions, where applicable.

The outcome of LTAR provides the foundation for setting up of biogas plant pilot plant in Bogra that will use annually 1000 metric tons of fecal sludge from pit latrines installed and used by rural households in the Bogra district in Bangladesh; together with 3,000 metric tons of chicken manure, and 6,000 metric tons of cornstovers or similar adequate cellulose material to produce more than 3000 MWh electricity (net), 2,800 MWh of heat and about 1500 tons of high quality bio-fertilizer.

Logistics Tests have been carried out in different Upazilas in Bogra in the months of August to November 2014. The Logistics Test outcomes are documented in the following pages including pictures with the narrative. The LTAR simulates the actual collection and operation of bucket based pit latrine emptying process.

BioSol Energy has contracted GKSS, a Bogra based organization that owns and runs an organic fertilizer enterprise in Sariakandi for implementation of the LTAR for pit latrine emptying by plastic bucket.

III. Findings and Observations

The first step to bucket based pit latrine emptying has been to find out the bucket placement arrangement in the existing pit latrine. To this end, the LTAR, in systematic sequence, employed three methods: (a) a bucket with metal clamps from the pit latrine slab - hanging from the slab, (b) a steel frame on the ring – lying on the top ring, and (c) a steel truss to hold the bucket – sitting on the floor of pit latrine. Field testing findings of the three methods reveal the following:

1.1 **Plastic buckets via Steel Hanger:** A steel clamp-supported hanging bucket, the original idea for a pit latrine emptying method was originally perceived to be the most convenient and cost-effective and was field-tested in Shariakandi upazila in Bogra. Field test findings of steel clamp supported hanging buckets reveal the following:

1. 2 Slab strength (being made from slim wire-mesh) does not support the steel fastener (hook, clip, buckle, etc) hanging bucket, which will gradually reach a 20 kg weight. Pit latrine masons and waste keeper workers observed that the method carries high risk, as it would cave in and fall to the pit.

1. 3 The method would require doctoring on the slab; fixing the steel hinge into the slab and the subsequent hanging bucket together with the fecal sludge will weaken the slab strength making it unable to hold it for long. The problem will be compounded with repeated removing of the bucket. Lifting filled-in bucket (20 kg weight) would cause the already weak slab to collapse as the pit latrine masons observed.

2.1 **Plastic buckets via Flat Steel Frame:** WASH Committee members suggested an alternative to the hanging type, which was tested in Sharakandi, Bogra. The following sketch illustrates the steel frame to hold the bucket and placement of the steel frame on the top ring of the pit latrine.

2. 2 The steel frame was fabricated from steel bar, weighing 2.89 kg in a local micro enterprise in Bogra, and cost Tk. 250/- each (Euro 2.5).

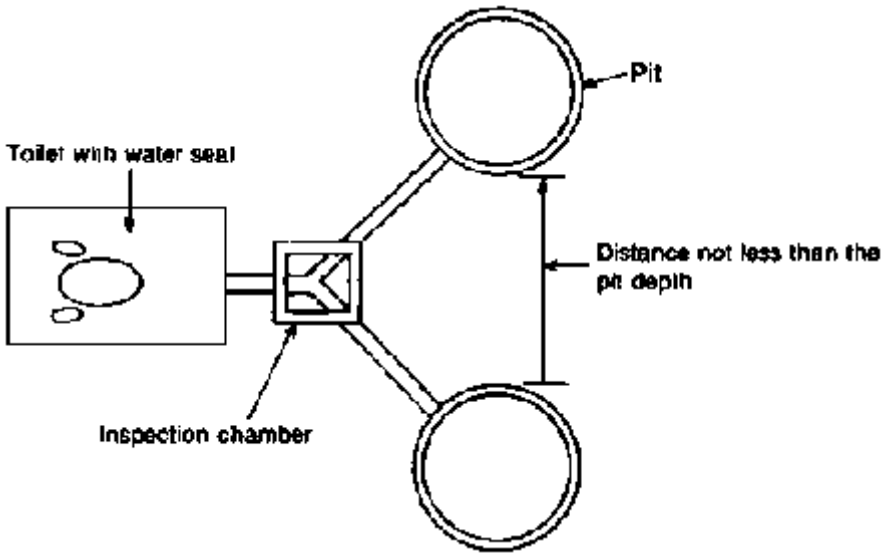
2. 3 This method requires a series of steps – installation of steel frame on the ring would need first the removal of the top ring and the slab; in the second step the ring and the buckets are installed, in the third step a new ring has to be placed on the steel frame. While executing these steps the latrine house made of bamboo and bamboo thatch need to be removed and replaced with a new structure. Consultations with pit latrine owners' suggest a preference for corrugated iron sheets on the side and the top to replace the old bamboo structure. Next with the frequency of emptying the

filled bucket and reinstalling an empty one is most likely to cause the need for the replacement of the slab after some time.

2. 4 Taking note of all the technical requirements and clients expectations, a costing of the process for 100 units of pit latrine has been worked out (Annex A). The costing found that for an installation of 100 units it would require BDT 599,000 or BDT 5,990, which is to say BDT 6,000 or Euro 6 per pit latrine (exchange rate Tk 100 = Euro 1). The bio gas plant needs to make this investment for collecting fecal sludge from households.

2. 5 The social aspect is also a major factor aside from the economic factors. Sanitation experts find a low rationale for going back to old days of bucket based fecal sludge emptying especially keeping in mind the behavioural change practices resulting from an earlier mass campaign.

3.1 **Plastic buckets via Steel Standing Truss:** The idea for this device evolved in the field when the research team visited an Offset pit latrine, which is a new type of pit latrine as schematized in the figure below. Emptying the pit latrine by bucket in this type of latrine is possible to achieve because the pits are outside the latrine and accessible to the waste cleaning workers. Because of its convenience of emptying, it has been gaining popularity very fast. However, so far only 500,000 offset pit latrines are found all over Bangladesh.



Of the two pits, one is not yet put into use. In other words it is empty (not being used). The installing bucket for collection and emptying operation in the pit is not being used now.

3. 2 A pit floor supported vertical steel truss provides sufficient strength to support a bucket filled to 20 kg or more. The chances are high that eventually the household laborer can handle it with an appropriately designed metal clamp lifter and by moving it with a garden trolley but the chances are also that the feet (one or all) of the steel frame may gradually sink into the pit floor. Field workers estimate it could sink 4 inches under the pit floor earth. Therefore the installation of and removal of a filled bucket by a lifting/closing slab although ergonomically highly convenient and highly feasible may require brick support under the 4 legs. Pollution wit this method is

controlled and socially acceptable and the Installation of. and removal of filled bucket by a lifting/closing slab is ergonomically highly convenient and highly feasible but would require ring-and-steel frame .

3.3 However, the outreach is extremely limited as only 800,000 offset pit latrines have been installed all over Bangladesh. Therefore, servicing pit latrine emptying with wider rural scope is not achievable.

IV. Conclusion

4.1 The original idea for pit latrine emptying method by using bucket – perceived to be the most convenient and cost-effective is not a technically feasible method to emptying pit latrines. Two reasons dissuade the bucket-based operation. First, from an investment perspective it is not feasible as it requires massive investment in reengineering the pit latrines and second, socially the rationale is weak as the method reverts back to very old practice not compatible after massive the behaviour change campaign investment over a long period to time.

4.2 The method therefore, needs to be replaced by a more technically doable option. Suction pump led Vacutug method of emptying pit latrine content needs further logistics test investigation.

Story Board in Pictures

Typical rural latrine 3-sides covered by bamboo-thach and front with sheet from synthetic bag (pillow-pack type).

Space in the latrine and removing top ring for bucket and steel frame installation and empltying (with new replacement) require removing/ replacing the thached three sides every time.

Actual state of fecal sludge would only be known till slab is removed and state of fecal sludge in the pit is observed.

Selection of pit for the logistics test would, therefore, require opening it first.

Bucket Hanging from Slab








Ring-steelframe-Bucket Arrangment

For RFBA pilot testing, a new slab has been procured.

Steel frame and bucket is placed on the ring with 6 slots to firmly hold the steel frame in postion.

The new slab is placed on top of the bucket and ring.

Slab placed on the top ring.

Earth filled in the buckt, to simulate sludge collection in the bucket.

Weighing of the earth – 28.24 kg.

Carrying the earth filled bucket.

Placing the bucket, then a ring on the bucket and steel frame, finally slab on the ring.

Complete arrangment – two rings then steel frame, bucket, the top ring and slab on the top ring.

Close view of the vertical alignment long pan and bucket arrangment – feasibility of collection. Important to note here that perfect vertical alighnment is required for effecctive collection of fecal sludge.

Abandoned pit latrine after years of use.

Standard garden trolley is not suitable for carrying bucket filled with fecal sludge; Combined Engineering Works (cell 01717 221033), Railway Market, Bogra has demonstrated its capacity to fabricate a custom made one so that risk of spillage during transportation can be substantially reduced.

Costing Sheet of 100 Pit Latrines with Steel Frame and Bucket Arrangment

গ্রামীণ কৃষক সহায়ক সংস্থা (জিকেএসএস)
GRAMEEN KRISHOK SOHAYAK SANGSTHA (GKSS)

Quotation 13 September 2014

Dr.Antonie de Wilde
Biosol Europe BV
Bornebroekse Weg 17468 RM
The Netherlands

100 Pit Latrine Preparation						
SL No.	Preparation	Quantity		Unit Cost	Total Amount	Total Amount of 100 Piece
A	Pit Latrine Preparatory Work	Unit	Unit Description			
1	Pit Latrine Super Structure:					
	Ci Sheet 6×6	6	Piece	120	720	72000
	Ci Sheet 1×10	1	Piece	250	250	25000
	Bamboo pillar	4	Piece	75	300	30000
	Frame Wood	50	Feet	7	350	35000
	Labour	1	Person	300	300	30000
	Fitting & Fixing	1	Person	150	150	15000
	Total of A	**0**	0	**902**	2070	**207,000**
2	Ring	1	Piece	150	150	15000
	Slab	1	Piece	350	350	35000
	Steel Frame for Bucket	1	Piece	300	300	30000
				800	**800**	**80,000**
3	Bucket	**1**	Piece	**800**	**800**	**80,000**
4	Transportation For pit latrine Structure	**1**	Van	200	200	**20,000**
5	Labour cost for new latrine	**1**	Person	300	300	**30,000**
6	Waste keeper	**2**	Person	300	600	**60,000**
	Sub Total				**4770**	**477,000**
B	Collection & Dumping:					
1	Old Bucket Replace	4	2 Person	250	1000	25,000
	Old Bucket Transportation	4	1 Van	125	500	12,500
	Dumping Place Rent	20	20 Decimal	2000	40000	40,000
	Dumping Place Earth filling & cutting	20	Labour	300	6000	6,000
	Unloading Van	4	1 Van	250	1000	25,000
	Trolley	4	Piece	3500	14000	14,000
	Sub-Total				**62500**	**122,500**
	Total				**67270**	**599,500**

Md.Mirza Salah Uddin
Chairperson
GKSS

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Double Pit Offset Latrine









Annex 5

Story Board

Logistics Test Action Research (LTAR):
Pit Latrine Emptying with Vacutug

Location: Bogra.

November - December 2014

Table of Contents

I. Introduction

The Story Board Report deals with the Logistics Test Action Research (LTAR) of pit latrine emptying of fecal sludge by Vacutug Pit Latrine Emptying Device, (VPED) in Bogra from 18 November to 20 December 2014. The report presents the fee-based demand assessment, VPED operation and fecal sludge disposal in the special facility created in the GKSS Organic Fertilizer premises in Sariakandi in Bogra. The Logistics Test outcomes are documented in the following pages including pictures with narratives. The report presents findings including observations and conclusions.

MAWTS, Bangladesh produces few models of Vacutug Pit Latrine Emptying Devices. The LTAR employed one particular model because of its ease of access through rural roads. The model Vacutug MK IV had a 700 liter tank (storage capacity) mounted on a 3 wheeler country-made vehicle known as Nashimon that runs by a 16 HP diesel engine with a 30 km per hours moving speed. In alternate mode, the diesel engine drives a centrifugal suction pump for emptying pit latrines or moves the vehicle to cover short distance at low speed.

II. Background

BioSol Energy is implementing the back-to-back study on the Technical Feasibility and Commercial Viability of the Processing of Pit Latrines Contents in Bangladesh, in short, Safe Processing of Pit Latrine Content. The study will rollout pilot testing of the installation and operation of a Biogas plant in Bogra based on cornstovers, chicken manure and fecal sludge in the 6:3:1 mixing ratio respectively; the annual combined feedstock requirement is 10,000 metric tons.

The Logistics Test Action Research (LTAR) data indicates the suitability of VPED for emptying pit latrines in rural Bangladesh. The outcome of LTAR provides the foundation for collecting annually 1000 metric tons of fecal sludge biogas feed stock from pit latrines installed and used by rural households in the Bogra district in Bangladesh.

For LTAR implementation in Bogra, BioSol Energy has contracted GKSS, a Bogra based private organization that owns and runs an organic fertilizer enterprise in Sariakandi, Bogra.

The LTAR targeted empting 150 pit latrines. In terms of activities, the LTAR carried out first a demand assessment through focus group discussion, followed by the listing of the pit latrines, VPED operation and disposal.

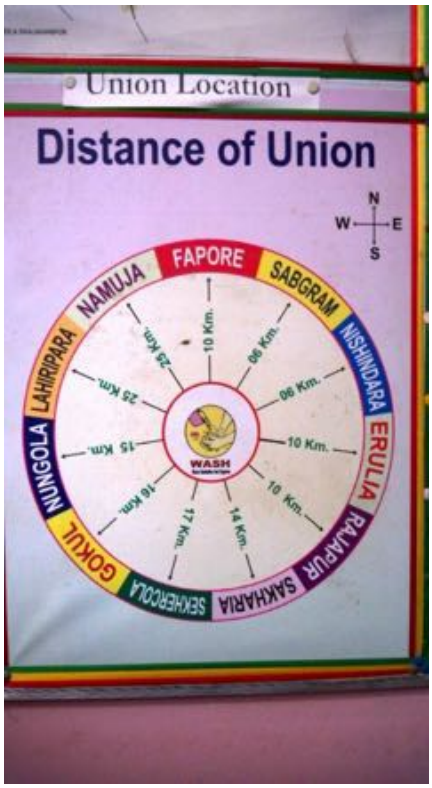
III. Field Findings

3.1 Logistics Test Action Research

On 19 November 2014, pit latrine emptying with VPED was launched from the BRAC branch in Gabtoli, Bogra. The group discussed sustainable pit latrine emptying by changing the fee and communication approach and the strategy with the group.

Summary statistics of Pit Latrine situation in Bograis presented below.

Total number of latrines in Bogra sadar	**60,474**
Number of latrines under BRAC	*7310*
One-pit latrines	3334
Double/super latrine	3976
Total number of latrines in Gabtoli	**91,432**
Number of latrines under BRAC	*7463*
One-pit latrines	2068
Double-pit latrines	4697
Super offset latrines	698
Total number of latrines in Sariakandi	**37,681**
Number of latrines under BRAC	*6802*
One-pit latrines	3780
Double-pit latrines	1898
Super offset latrines	1124



3.2 Pit Latrine Emptying Services: Demand Assessment

The action research team held focus group discussions (FGD) from 19- Nov-14 to 03-Dec-14. In all the team held 10 FGDs; details are presented below.

FGD No 1: Held at Kuptola Adarsha Para (19-Nov-14, 9.45 am)

FGD No. 1 commenced with the individuals in Kuptola Adorshopara who were given the pit latrines by BRAC. "The communication message delivered was the individuals were told that if the pit latrines could be cleaned hygienically then the chances of diseases such as diarrhea will be reduced. Also, the Vacutag fecal sludge emptying vehicle will visit and properly clean their pit latrines. The individuals were then asked how they clean their pit latrines". Some household participants replied that they dig a hole beside the latrine and dump the waste from the latrines to the hole using a bucket. Finally, they cover up the hole with dirt. The wealthier ones said that they hire sweepers to clean their latrines at the rate of BDT 50/- per RCC ring. One individual also said that he had to pay up to BDT 1000/- for cleaning services of waste. After the meeting, finished at 10.40 am, some individuals said that being very poor they cannot pay the sweepers for cleaning. The participants finally agreed to pay BDT 200/- for every latrine up to a total of 5 RCC rings. If there are more RCC rings then the price will be negotiated.

For actual listing of pit latrines a second visit was paid on the 22-Nov-14. All 7 of them expressed great interest in cleaning their pit latrines. However, they said that they were very poor and could not give any fees whatsoever. But yet some members were ready to pay up to BDT 200/-. The latrines are at various distances from the road; some have their latrines about 200-300 ft. away from the roads.

FGD No 2: Held at Ramchandrapur (19-Nov-14, 11.55 am)

FGD No. 2 commenced with 12 individuals assigned by BRAC in Ramchandrapur. After the communication message delivery the response was mixed. Some of them expressed concern because their latrines were already full and had to be cleaned immediately. Finally they were willing to pay BDT 200/-.

FGD No 3: Held at Taraf Meru (19-Nov-14, 1.15 pm)

FGD No.3 commenced in Torofmeromno Dokkinpara Gabtoli with some individuals assigned by BRAC. They said that they only paid BDT 500/- to clean 3 to 4RCC rings, however they were not willing to spend BDT 200/- for cleaning a latrine, These individuals included only a handful. It was understood that people in this area are very underprivileged and could not afford to spare BDT 200/- for cleaning services. An indicator of this would be the fact that the water cell of their latrines has been broken and they cannot yet fix it due to a shortage of cash. On the other hand, those who are well-off compared to the others are willing to pay BDT 200/- for cleaning services.

FGD No 4: Held at Shabgram Kursha Para (20-Nov-14, 10.00 am)

FGD No. 4 commenced in Shab-Gram Kurshapara. They said that the latrines of 7 individuals were full and needed to be cleaned immediately. After that the discussion continued regarding the Vacutug. At first the individuals were quite reluctant to pay BDT 200/-, but later changed their minds. They proposed a payment system by pieces of rings finally agreed to BDT 200/- for a maximum of 5 RCC rings.

For actual listing the action research team paid a second visit. There were 10 individuals and all of them expressed great interest in cleaning their pit latrines by paying a fee of BDT 200/-. Some of them were even ready to have their latrines cleaned at that moment. A lot of the members not under BRAC WASH have their latrines approximately 200 ft. away from the roads. Compared to the high road level many homes are at much lower level. If the Vacutug fecal sludge emptying vehicle is moved there it cannot be driven back up with tank loaded with sludge. However, they are very serious about having their latrines cleaned.

FGD No 5: Held at Durgahata Bulgari (23-Nov-14)

The pits revealed the same kind of situation, i.e. the pits were from 200 to 300 ft. away from the road. The bridges in Durgahata were about 3 feet high. However, Dr. Mostofa in Bhulgari was been able to clean his pit latrines in just a few days; so he spoke with some others and was given consent to clean their pits.

Afterwards the action research team went to Gabtoli Unchurki Dokkhinpara and met with BRAC WASH women members. They were very poor and did not have the financial capabilities to pay

for cleaning services. Their pits are approximately 200 ft. away from the road. Apart from a few the team concluded that it will be very difficult to clean because the Vacutug has a 50 feet hose pipe.

FGD No 6: Held at Hat Fulbari Poschimpara (03-Dec-14)

In Haat Fulbari Poshcimpara the situation was very different. The team discussed the topic of fecal sludge cleaning and Vacutug operations with 11 women. They were convinced but could not comply with the BDT 200/- fee because of their poor financial condition. However, despite their low financial capacity the women agreed to pay BDT 100/- for cleaning the pits. Finally including new comers the team listed 14 individuals as cleaning service clients.

Having committed to the service The Head Master of Haat Fulbari Poshchimpara Government Primary School, Mr. Ataur Rahman, request the cleaning of their pit latrines and agreed to pay BDT 300/-.

The team along with BRAC field employees went to Haat Fulbari Dohkhin para. Most of the individuals in this area have shown an interest in cleaning their pit latrines in Vacutug. The BRAC and outside BRAC agreed to pay BDT 100/- and BDT 200/- respectively. They all showed keen interest when asked who wanted their pit latrines cleaned and quickly registered their names.

The pits in Sariakandi are approximately 200 feet away from the main roads, however, the team decided that few closer pits can be cleaned. The team discussed with the Head Master of Sariakandi Government Model Primary School, Mrs. Afroja Begum, about cleaning the pit latrines. She said that she will clean the pits however, will not be able to pay the fees because there is no fund available to her. Later, they discussed about the Vacutug fecal sludge emptying vehicle and she welcomed the approach. She then talked with the clerk (about fees) and confirmed that the pits can be cleaned. Some individuals wanted to clean the waste right at that moment.

The 9 members of the BRAC WASH committee in Haatfulbari West para expressed interest in using the pit emptying service. However, being very poor they offered only BDT 100, which the Action Research team has agreed to take. On 06-Dec-14, Vacutug pit latrine emptying service was delivered to Mr. Md. Taherul's residence. Annexure 1 c provides the data.

All the 7 FGD participants were Haatfulbari West para non-BRAC members outside of BRAC's candidates. All expressed great interest in cleanings their pit latrines by paying a fee of BDT 200. Some of them were even ready to have their latrines cleaned at that moment.

All the 3 members of BRAC WASH Haatfulbari Dorigon para expressed great interest in pit latrine cleaning services by paying a fee of BDT 200. Some of them were even ready to have their latrines cleaned at that moment. Some latrines are about approximately 250 ft away from the roads. The members were eager to avail themselves of the pit latrine services immediately by paying on-the-spot the fee of BDT 200.

FGD No 7: Held at Hat Fulbari Dokhin para

All of the 7 FGD participants have expressed great interest in cleaning their pit latrines by paying a fee of BDT 200/-. Some of them were even ready to have their latrines cleaned on-the-spot. Many households not with BRAC WASH have their latrines about 250 feet away from the road.

FGD No 8: Held at Narsy Union

All the 5 participants of BRAC WASH showed a keen interest in availing themselves of the Vacutug cleaning service However, they will not be able to pay more than BDT 100/-. But, some of them have agreed to a fee of BDT 150/-.

Altogether 4 participants who are non-BRAC members had expressed great interest in cleaning their pit latrines by paying a fee of BDT 200/-. Some of them were even ready to have their latrines cleaned at that moment. Some of the non-BRAC members have their latrines about 200-300 ft. away from the roads and were eager to have their latrines cleaned then and there by paying the fee .

FGD No 9: Sharikandi Municipality

There were 2 participants and both their pit latrines were provided by BRACWASH. They showed great interest to having them cleaned. However, they will not be able to pay more than BDT 100/-.

All of the 4 participants not under BRAC expressed great interest in cleaning their pit latrines by paying a fee of BDT 200-250/-. Some of them were even ready to have their latrines cleaned at that moment. A lot of the members not under BRAC have their latrines about 200-300 ft. away from the roads. Some members far from the road were even ready to pay BDT 300/-.

FDG No 10: Unchurki Dokhin Para

They have all expressed great interest in cleaning their pit latrines. However, they said that they were very poor and could not give any fees whatsoever.

3.3 Final list of pit latrines emptying service clients.

List of BRAC&Non-BRAC Vacutug Sludge Emptying pit-owners name

BRAC

Location	ID No	Name	Group
Kuptola Adarshapara	01	Md. Kuddus	Household
Shabgram Kurshapara	02	Md. Solaman	Household
Hat-Fullbari West para	03	Md. Taherul	Household
Hat-Fullbari Westpara	04	Md.Shamsul Alam	Household

Non-BRAC

Location	No	Name	Group
Hasnapara Gabtoli	05	Md. Asraful	Household
Hasnapara Gabtoli	06	Md. Ratan Mia	Household
Tarafmeru Gabtoli	07	Md. Shimul Ahmed	Household
Naruli , Bogra	08	Md. Shamim Ahmed	Household
Naruli , Bogra	09	Md. Shahidul Islam Shabu	Household
Naruli , Bogra	10	Md. Ziller Rahman	Household
Hasnapara Gabtli	11	Md. Abu Harez	Household
Hatfulbari Southpara	12	Md. Babu	Household
Hat-Fullbari Southpara	13	Md. Hamidul	Household
Sariakandi	14	Md. Anwar	Central Mosque
Sariakandi	15	Md. Masud	Orphanage
Sariakandi	16	Abdur Rashid	Household
Sariakandi	17	Lookman Hakim	Household

3.4 Pit Latrine Emptying Service Delivery

3.4.1 Sourcing of Vacutug

The sourcing of Vacutug initially faced a few challenges as getting the device was difficult, largely due to institutional and project ownership. Finally, Jhenidah Municipality, through the intervention of the Mayor, agreed to rent the Vacutug on the condition that the LTAR must also take the operator along with the device, which was quite logical and the team agreed to the proposal.

GKSS brought the Vacutug and travelled approximately 200 kilometers on a 10 ton truck to the Gabtoli Municipality . Loading and unloading of the Vacutug was another challenge as it required a kind of access ramp to lift it on the truck and to bring it down from the truck.

The Vacutug pit emptying device (VPED) used in the Action Research has three units; the Vacutug tank of 700 liter capacity, a 16 horse power diesel oil run engine to drive both the trailer called *Nashimon* and the centrifugal pump. Vacutug is supplied by the manufacturer with 50 feet of hose pipe with a diameter of 4 inches.

3.4.2 Vacutag Operation

3.4.2.1 Emptying suction and operation:

In general, the physical condition of fecal sludges in the pit latrine was semi-solid; so before the emptying operation with VPED most had been loosened by agitation with a bamboo pole (4 to 5 feet length) and water. By suction pump the sludge was transferred into the tank. However, fecal sludge at the bottom of the pit was hardened and so could not be softened by the bamboo stick. An attempt was made to soften the bottom sludge with 2 feet of sharp barbed wire; thereby some more fecal sludge could be softened and emptied from bottom.

The water content is generally judged by the colour of the fecal sludge. New and currently used tanks have a green/yellow colour implying a high water content; and longtime used pit latrines have darkened fecal sludge implying a low water content. The volume of sludge was higher in the latter case.

In almost all cases the water to sludge ratio was from 70:30 to 75:25. In cases with darkened sludge the sludge to water ratio was 55:45 percent. The Vacutug suction system took an average of 6 minutes to extract 700 liters of sludge from the 7 RCC rings pits.

The volume of sludge in one pit latrine was estimated on the basis of the number of RCC rings emptied to fill up one full load of 700 liters of tank capacity. Therefore the volume of fecal sludge in one RCC rings is 117 (rounded).

Depending on the water content and thickness of the fecal sludge, the LTAR noted 5 to 6 minutes to emptying 700 liters from the pit latrines into the Vacutug while unloading of the sludge into the disposal tank took 2.30 minutes.

3.4.2.2 Transportation of Fecal Sludge in Vacutug

A fully loaded Vacutug faced many challenges during travel from the pit latrine to the disposal site, mostly due to the low power of the 16 HP engine. First, it could not travel on uneven rural roads and second it can only climb comfortably one feet height (elevation). However, the height of most of the roads from the plain rural land is more than a feet.

The Vacutug, being driven by belt and pulley, faced another challenge. While carrying a full load on an uneven and rough rural road, especially on sandy soil, the belt often breaks and requires immediate replacement. This is an additional cost of operation. The Vacutug consumed 45.50 liters of diesel to run the suction pump (to lift fecal sludge into the tank) and traveled an estimated 330 kilometers during the entire operation from servicing pit latrines to the fecal sludge disposal site in Sariakandi. The logistics test has taken this as the basis for computation, as the Vacutug vehicle did not have any device whatever either for measuring consumption or for measuring the distance travelled. Therefore, for each kilometer traveled, Vacutug suction and the lifting operation consumed 0.62

liters of diesel oil for lifting of one full tank load of 700 liters of fecal sludge. Water to solid ratio was 75:25.

The outreach of the Vacutug is a 50 feet suction pipe. However, most pit latrines in LITAR area are from 100 to 200 feet from the road. Therefore, the Vacutug operation could only service a limited number of pit latrines.

3.4.2.3 Vacutug Operation Labor Issues:

On 21-Nov-14 the Vacutug car was brought from Jhenidah Municipality office to Gabtoli Municipality in the Gabtoli South Para but the operation could not be conducted due to the obstacles created by the Municipal waste workers, as they found the operation a direct threat to their employment with, and their livelihood from, pit latrine and safety tank emptying work. They even got hold of the Vacutug and threatened the driver. They complained to the Mayor whose intervention together with GKSS's clarification were finally able to overcome the problem.

Getting labor was very difficult due to the stressful and unhygienic nature of work. The workers only agreed to work from 10 am to 2 pm on the logical ground that they require shower before taking lunch at home.

The Vacutug operator charged BDT 1,000/- per day; and the helper BDT 500/- per day. The general labor charge was BDT 300/- per day. However, if the team was sourced from Bogra a team of one driver and two laborers would cost BDT. 1,500 per day.

3.4.2.4 Cost of Empty pit latrines

During the total operation of emptying 12,200 liters of fecal sludge from 17 pit latrine and travel of a total distance of 330 km the Vacutug consumed 45.50 liters of diesel oil.

3.5 Pit Latrine Emptying Services: Disposal

The LTAR service provider, GKSS, constructed a disposal facility modeled on the one in the Khustia Municipality in Barundi, Khustia. The disposal tank size is length 20 ft., width 10 ft., height 3 ft. In between the 20 ft. length, a divider has been built and holes have been made so that if one side is full, the water can easily go to the other side. And on the roof a tin shed has placed. 3 pits have been built on each side of the disposal tank. Inside each, 10 “wheels” have been placed. Afterwards, the pits have been raised and a slab placed to cover it up. 12 pits and 1 safety trunk have been emptied and the fecal sludge extracted and poured into the disposal tank. After pouring it could be seen that fecal sludge amounting to 1 inch was stored.

The distance between the pit latrine emptying operation area to the fecal sludge disposal facility in Sariakandi was varied, the nearest being 3 kilometers and the furthest on is 18 kilometers away from the site.

IV. Conclusions:

1. Access to rural households with the Vacutug was viewed as an effective means to rural household pit latrine emptying; however, the logistics test action research found that the Vacutug could not do the pit latrine emptying job effectively. This is largely due to the Vacutug's not-so-efficient operating mechanism and modality. Most important of the operational impediments was the Vacutug's limited (700 liter) capacity, high water content in the currently used pit latrines, the not-so-powerful haulage mechanism to travel a long distance and through partly bumpy/rough rural roads, the frequent breakdown of the V belt, the small (50 feet) length of suction pipes; and finally the distance of the fecal sludge dumping/ disposal sites. All these factors contributed to the inefficient pit latrine empting service delivery.

2. FGD participants expressed the great need for emptying of pit latrines; however, the payment they could make would not break-even with the costs of the pit emptying service.

3. The logistics test action research, therefore, recommends a two-tier approach to dealing with the access to rural roads, transportation and disposal of fecal sludge to the Bio Gas plant. First, the emptying operation needs to create 'satellite' type large tanks close to villages where rural households can dispose of fecal sludge conveniently. This part can be carried out by improving and altering the design of the Vacutug depending on the need of the households to be served. This can be a commercial operation, a kind of small to micro enterprise having access to lease financing of equipment. Routine empting of satellite fecal sludge tanks can be carried out by a "Honey Sucker" type of truck, mounted with a large tanker, capable of transportation and delivery to the Bio gas plant.

Household Contacted

List of BRAC&Non-BRAC Vacutug Sludge Emptying pit owners name

BRAC

Location	No	Name	Group
Hat-Fullbari Westpara	01	Mrs. Dolna	Household
	02	Md. Taherul	Household
	03	Mrs. Laily	Household
	04	Mrs. Akena	Household
	05	Md. Rafiqul	Household
	06	Md. Zahidul	Household
	07	Mrs. Golapi begum	Household
	08	Mrs. Rubi	Household
	09	Md. Tandu	Household
Hat-Fullbari South Para	10	Md. Hamidul	Household
	11	Md. Mukul	Household
	12	Md. Hobibor	Household
Sariakandi Municipility	12	Mr. Sutka Howlader	Household
	13	Md. Anawar	Household
Kuptola Adarshapara	14	Md. Ziaur Rahman	Household
	15	Md. Kuddus	Household
	16	Mrs. Julakha Begum	Household
	17	Md, Rafiqul	Household
	18	Mrs. Kalpona	Household
	19	Mrs. Kana Begum	Household
	20	Mrs. Suboni	Household
Shabgram Kurshapara	21	Md. Millon	Household
	22	Mrs. Rahima	Household

	23	Mrs. Helana	Household
	24	Mrs. Merina	Household
	25	Mrs Lipi	Household
	26	Mrs. Sultana	Household
	27	Md. Dulal	Household
	28	Md. Farajul	Household
	29	Md. Solaman	Household
	30	Mrs. Jornna	Household

Non-BRAC

Location	No	Name	Group
Hat-Fullbari West para	01	Government Primary school	School
	02	Mrs. Tuli Begum	Household
	03	Md. Badal	Household
	04	Mrs. Shokina Begum	Household
	05	Md. Mostak Ahmed	Household
	06	Mrs. Poribibi	Household
Hat-Fullbari South Para	07	Md. Babu	Household
	08	Md. Mojid	Household
	09	Md. Abdul Kader	Household
	10	Md. Abdul Akkach	Central Mosque
	11	Md. Jamir	Orphanage
	12	Md. Akter	Household
Sariakandi Municipility	12	Sarikandi Model High School	School
	13	Sariakandi Govt. Primary School	School
	14	Md. Shabijar	Household
	15	Md. Shakoat	Household

Naruli	16	Md. Shamim Ahmed	
	17	Md. Shahidul	
	18	Md. Shamsul	
	19	Md. Akbar	

V. ANNEX-1

Data of all the owners of the pit latrines that were cleaned: In light of the data sheet

a. Data of vacutag operation: Data sheet -1

Sl.	A	B	C	D
1		Md. Abdul Kuddus		01718-945202
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	Yes
4	2	Date of Emptying	Date	22.11.14
5	3	Service Buyer: Location	Village	Kuptola Sahapara
6	4	Service Buyer: Family Size	Number	5
7	5	Income Earning Members	Number	2
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Farmer
10	8	Service Income/Month	Month	10,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	4
14	12	What Last Emptying Done	Month/Year	2 months
15	13	Who did Last Emptying	Self/WashWorker	Self
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	B
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	10
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	6
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	22.11.14
23	21	Vacutug Operation	Time	12.09
24	22	Pit Latrine ID	ID No.	01
25	23	Pit Distance from Vacutug	Feet	40
26	24	Pit to Nex Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	40
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Bricks/Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Minutes	48.5
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	½
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	3
33	31	Fuel Consumed by Nashimom	Liters	1
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.62
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	Minutes	48.5 minutes
38	36	Start Loading	Time	12.09
39	37	End Loading	Time	12.14
40	38	Loading Hours	Minutes	05 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	2
42	40	Start UnLoading Sludge Tank Sariakandi	Time	12.55
43	41	End UnLoading Sludge Tank Sariakandi	Time	12.57.30
44	42	UnLoading From Vacutug Hours	Minutes	2.30 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometers	6
46	44	Sludge Emptying	Liters	700
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

b. Date of vacutag operation: Data sheet -2

Sl.	A	B	C	D
1		Md. Solaman		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	Yes
4	2	Date of Emptying	Date	27.11.14
5	3	Service Buyer: Location	Village	Shabgram Kurtshapara
6	4	Service Buyer: Family Size	Number	07
7	5	Income Earning Members	Number	2
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Retd. BDR
10	8	Service Income/Month	Month	20,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	2
14	12	What Last Emptying Done	Month/Year	N/A
15	13	Who did Last Emptying	Self/WashWorker	N/A
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	10
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	6
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	27.11.14
23	21	Vacutug Operation	Time	10.59
24	22	Pit Latrine ID	ID No.	02
25	23	Pit Distance from Vacutug	Feet	25
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	15
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth yard
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	03 hours 06.30 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	16
33	31	Fuel Consumed by Nashimom	Liters	2.67
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.62
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	Hours/Minutes	03.06.30
38	36	Start Loading	Time	10.59
39	37	End Loading	Time	11.07
40	38	Loading Hours	Minutes	08 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	2
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	02.03
43	41	End UnLoading Sludge Tank Sariakandi	Clock	02.05
44	42	UnLoading From Vacutug Hours	Minutes	2.30 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	32
46	44	Sludge Emptying	Liters	700
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

c. Date of vacutag operation: Data sheet -3

Sl.	A	B	C	D
1		Md. Taherul		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	Yes
4	2	Date of Emptying	Date	06.12.14
5	3	Service Buyer: Location	Village	Hat Fullbari West para
6	4	Service Buyer: Family Size	Number	02
7	5	Income Earning Members	Number	01
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Tailor
10	8	Service Income/Month	Month	5,000
11	9	Service Fee Paid	Taka	100
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	4
14	12	What Last Emptying Done	Month/Year	N/A
15	13	Who did Last Emptying	Self/WashWorker	N/A
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	NR
19	17	Pit Depth in Rings	Number	5
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	2
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	H
22	20	Vacutug Operation	Date	06.12.14
23	21	Vacutug Operation	Time	11.58
24	22	Pit Latrine ID	ID No.	03
25	23	Pit Distance from Vacutug	Feet	15
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	40
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	
31	29	Pit To Pit Nashimon Distance Covered	Feet	50
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	3
33	31	Fuel Consumed by Nashimom	Liters	
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.21
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	
38	36	Start Loading	Time	11.58
39	37	End Loading	Time	12.01
40	38	Loading Hours	Minutes	0.3 inutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	2
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	01.20
43	41	End UnLoading Sludge Tank Sariakandi	Clock	01.22
44	42	UnLoading From Vacutug Hours	Minutes	
45	43	Distance Travelled upto GKSS Tank	Kilometer	
46	44	Sludge Emptying	Liters	300
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

d. Date of vacutag operation: Data sheet -4

Sl.	A	B	C	D
1		Md. Shamsull Alam		01722-231337
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	Yes
4	2	Date of Emptying	Date	06.12.14
5	3	Service Buyer: Location	Village	Hat Fullbari Wpara
6	4	Service Buyer: Family Size	Number	04
7	5	Income Earning Members	Number	01
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Service
10	8	Service Income/Month	Month	6,000
11	9	Service Fee Paid	Taka	100
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	15
14	12	What Last Emptying Done	Month/Year	01 month
15	13	Who did Last Emptying	Self/WashWorker	Wash worker
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	B
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	10
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	2
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	06.12.14
23	21	Vacutug Operation	Time	12.15
24	22	Pit Latrine ID	ID No.	04
25	23	Pit Distance from Vacutug	Feet	40
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	42
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Part-filled
30	28	Vacutug Operator Hours Worked	Hours/Minutes	01 hours 07 minutes
31	29	Pit To Pit Nashimon Distance Covered	Feet	50
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	3
33	31	Fuel Consumed by Nashimom	Liters	1
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.21
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	Hours	01 hours 07 minutes
38	36	Start Loading	Time	12.15
39	37	End Loading	Time	12.18
40	38	Loading Hours	Minutes	03 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	2
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	01.20
43	41	End UnLoading Sludge Tank Sariakandi	Clock	01.22
44	42	UnLoading From Vacutug Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	6
46	44	Sludge Emptying	Liters	350
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

e. Date of vacutag operation: Data sheet 5

Sl.	A	B	C	D
1		Md. Asraf Ali		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	20.11.14
5	3	Service Buyer: Location	Village	Hasnapara, Gabtoli
6	4	Service Buyer: Family Size	Number	09
7	5	Income Earning Members	Number	02
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Farmer
10	8	Service Income/Month	Month	16,000
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	15
14	12	What Last Emptying Done	Month/Year	6 months
15	13	Who did Last Emptying	Self/WashWorker	Wash worker
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	B
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	5
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	3
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	20.11.14
23	21	Vacutug Operation	Time	3.00
24	22	Pit Latrine ID	ID No.	05
25	23	Pit Distance from Vacutug	Feet	25
26	24	Pit to Next Pit Distance	Feet	60
27	25	Road to Home Distance	Feet	10
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	
31	29	Pit To Pit Nashimon Distance Covered	Feet	10
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	9
33	31	Fuel Consumed by Nashimon	Liters	
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.31
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	Hours/Minutes	
38	36	Start Loading	Time	3.00
39	37	End Loading	Time	3.04
40	38	Loading Hours	Minutes	04 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	2
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	04.06
43	41	End UnLoading Sludge Tank Sariakandi	Clock	04.08
44	42	UnLoading From Vacutur Hours	Minutes	
45	43	Distance Travelled upto GKSS Tank	Kilometer	
46	44	Sludge Emptying	Liters	300
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

f. Date of vacutag operation: Data sheet -6

Sl.	A	B	C	D
1		Md. Ratan Mia		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	20.11.14
5	3	Service Buyer: Location	Village	Hasnapara, Gabtoli
6	4	Service Buyer: Family Size	Number	10
7	5	Income Earning Members	Number	01
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Farmer
10	8	Service Income/Month	Month	9,000
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	4
14	12	What Last Emptying Done	Month/Year	6 months
15	13	Who did Last Emptying	Self/WashWorker	Wash worker
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	8
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	3
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	20.11.14
23	21	Vacutug Operation	Time	3.15
24	22	Pit Latrine ID	ID No.	06
25	23	Pit Distance from Vacutug	Feet	25
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	25
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth yard
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Part filled
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 8.30 minutes
31	29	Pit To Pit Nashimon Distance Covered	Feet	10
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	9
33	31	Fuel Consumed by Nashimom	Liters	1.50
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.31
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	Hours/Minutes	01 hours 8.30 minutes
38	36	Start Loading	Time	3.15
39	37	End Loading	Time	3.18
40	38	Loading Hours	Minutes	03 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	3
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	04.06
43	41	End UnLoading Sludge Tank Sariakandi	Clock	04.08.30
44	42	UnLoading From Vacutur Hours	Minutes	2.30 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	9
46	44	Sludge Emptying	Liters	400
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

g. Date of vacutag operation: Data sheet -7

Sl.	A	B	C	D
1		Md. Shimul Ahmed		01714-463511
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	21.11.14
5	3	Service Buyer: Location	Village	Tarafmeru, Gabtoli
6	4	Service Buyer: Family Size	Number	04
7	5	Income Earning Members	Number	02
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Service
10	8	Service Income/Month	Month	10,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	03
14	12	What Last Emptying Done	Month/Year	N/A
15	13	Who did Last Emptying	Self/WashWorker	N/A
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	8
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	5
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	21.11.14
23	21	Vacutug Operation	Time	11.52
24	22	Pit Latrine ID	ID No.	07
25	23	Pit Distance from Vacutug	Feet	50
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	50
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Bricks-Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hour 36.30 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer/Feet	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	11
33	31	Fuel Consumed by Nashimom	Liters	1.83
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.52
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	Hours/Minutes	01 hours 36.30 minutes
38	36	Start Loading	Time	11.52
39	37	End Loading	Time	11.58
40	38	Loading Hours	Minutes	06 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	3
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	01.42
43	41	End UnLoading Sludge Tank Sariakandi	Clock	01.44.30
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	11
46	44	Sludge Emptying	Liters	700
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

h. Date of vacutag operation: Data sheet -8

Sl.	A	B	C	D
1		Md. Shamim Ahmed		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	29.11.14
5	3	Service Buyer: Location	Village	Naruli, Bogra
6	4	Service Buyer: Family Size	Number	05
7	5	Income Earning Members	Number	02
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Service
10	8	Service Income/Month	Month	20,000
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	20
14	12	What Last Emptying Done	Month/Year	3 months
15	13	Who did Last Emptying	Self/WashWorker	Washwokers
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	8
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	4
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	29.11.14
23	21	Vacutug Operation	Time	10.40
24	22	Pit Latrine ID	ID No.	08
25	23	Pit Distance from Vacutug	Feet	Railway 20
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	20
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Railway Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 02 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer/Feet	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	18
33	31	Fuel Consumed by Nashimom	Liters	3
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.42
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01 hours 02 minutes
38	36	Start Loading	Time	10.40
39	37	End Loading	Time	10.43
40	38	Loading Hours	Minutes	03 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	11.40
43	41	End UnLoading Sludge Tank Sariakandi	Clock	11.42
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	36
46	44	Sludge Emptying	Liters	600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

i. Date of vacutag operation: Data sheet -9

Sl.	A	B	C	D
1		Md. Shahidul Islam Shabu		01732-063542
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	29.11.14
5	3	Service Buyer: Location	Village	Naruli, Bogra
6	4	Service Buyer: Family Size	Number	04
7	5	Income Earning Members	Number	02
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Business
10	8	Service Income/Month	Month	10,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	15
14	12	What Last Emptying Done	Month/Year	7 months
15	13	Who did Last Emptying	Self/WashWorker	Washwokers
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	15
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	03
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	29.11.14
23	21	Vacutug Operation	Time	01.40
24	22	Pit Latrine ID	ID No.	09
25	23	Pit Distance from Vacutug	Feet	40
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	30
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Railway Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	
31	29	Pit To Pit Nashimon Distance Covered	Kilometer/Feet	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	
33	31	Fuel Consumed by Nashimom	Liters	
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.31
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	
38	36	Start Loading	Time	01.40
39	37	End Loading	Time	01.43
40	38	Loading Hours	Minutes	03 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	03.10
43	41	End UnLoading Sludge Tank Sariakandi	Clock	03.12
44	42	UnLoading From Vacutur Hours	Minutes	
45	43	Distance Travelled upto GKSS Tank	Kilometer	
46	44	Sludge Emptying	Liters	300
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

x

V. ANNEX-1

j. Date of vacutag operation: Data sheet -10

Sl.	A	B	C	D
1		Md. Ziller Rahman		01717-141747
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	29.11.14
5	3	Service Buyer: Location	Village	Naruli, Bogra
6	4	Service Buyer: Family Size	Number	06
7	5	Income Earning Members	Number	01
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Service
10	8	Service Income/Month	Month	12,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	3
14	12	What Last Emptying Done	Month/Year	1 months
15	13	Who did Last Emptying	Self/WashWorker	Washwokers
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	06
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	03
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	Soft
22	20	Vacutug Operation	Date	29.11.14
23	21	Vacutug Operation	Time	1.55
24	22	Pit Latrine ID	ID No.	10
25	23	Pit Distance from Vacutug	Feet	50
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	50
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Railway Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Part filled
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 32.30 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	18
33	31	Fuel Consumed by Nashimom	Liters	3
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.31
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01 hours 32.30 minutes
38	36	Start Loading	Time	1.55
39	37	End Loading	Time	1.59
40	38	Loading Hours	Minutes	04 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	3.10
43	41	End UnLoading Sludge Tank Sariakandi	Clock	3.12
44	42	UnLoading From Vacutur Hours	Minutes	02.30 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	36
46	44	Sludge Emptying	Liters	400
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

x

V. ANNEX-1

k. Date of vacutag operation: Data sheet- 11

Sl.	A	B	C	D
1		Md. Abu Harez		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	30.11.14
5	3	Service Buyer: Location	Village	Hasnapara, Gabtoli
6	4	Service Buyer: Family Size	Number	05
7	5	Income Earning Members	Number	01
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Business
10	8	Service Income/Month	Month	10,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	10
14	12	What Last Emptying Done	Month/Year	6 months
15	13	Who did Last Emptying	Self/WashWorker	Self
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	Slab Casting
19	17	Pit Depth in Rings	Number	10x6x3
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	Safety tank
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	Soft
22	20	Vacutug Operation	Date	30.11.14 to 01.12.14
23	21	Vacutug Operation	Time	10.10, 12.14, 2.20, 11.20
24	22	Pit Latrine ID	ID No.	11
25	23	Pit Distance from Vacutug	Feet	5
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	10
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Maid road Side
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	6 hours 39 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	9 x 4 trips
33	31	Fuel Consumed by Nashimom	Liters	6
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	2.5
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	06 hours 39 minutes
38	36	Start Loading	Time	10.10, 12.14, 2.50, 12.15
39	37	End Loading	Time	10.15, 12.20.30, 2.57.30, 12.21
40	38	Loading Hours	Minutes	25 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	10
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	10.55, 1.10, 2.50, 12.15
43	41	End UnLoading Sludge Tank Sariakandi	Clock	10.57, 1.12.30,3.52.30,12.17
44	42	UnLoading From Vacutur Hours	Minutes	09 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	72
46	44	Sludge Emptying	Liters	2600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

I. Date of vacutag operation: Data sheet Non-BRAC -12

Sl.	A	B	C	D
1		Md. Babu		01751-442449
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	05.12.14
5	3	Service Buyer: Location	Village	Hat Fullbari South para
6	4	Service Buyer: Family Size	Number	05
7	5	Income Earning Members	Number	02
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Farmer
10	8	Service Income/Month	Month	10,000-12,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	14
14	12	What Last Emptying Done	Month/Year	7 months
15	13	Who did Last Emptying	Self/WashWorker	Washworker
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	NR
19	17	Pit Depth in Rings	Number	7
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	5
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	05.12.14
23	21	Vacutug Operation	Time	10.31
24	22	Pit Latrine ID	ID No.	12
25	23	Pit Distance from Vacutug	Feet	30
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	30
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth field
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 11 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	3
33	31	Fuel Consumed by Nashimom	Liters	0.5
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.52
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01 hours 11 minutes
38	36	Start Loading	Time	10.31
39	37	End Loading	Time	10.35
40	38	Loading Hours	Minutes	04 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	11.40
43	41	End UnLoading Sludge Tank Sariakandi	Clock	10.42
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	6
46	44	Sludge Emptying	Liters	650
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

m. Date of vacutag operation: Data sheet Non-BRAC 13

Sl.	A	B	C	D
1		Md. Hamidul		01745-468878
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	05.12.14
5	3	Service Buyer: Location	Village	HatFullbari South para
6	4	Service Buyer: Family Size	Number	05
7	5	Income Earning Members	Number	01
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Business
10	8	Service Income/Month	Month	6,000-7,000
11	9	Service Fee Paid	Taka	200
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	10
14	12	What Last Emptying Done	Month/Year	4 months
15	13	Who did Last Emptying	Self/WashWorker	Washworker
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	B
17	15	Supper Structure Conditon	VG. **G.** B	B
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	NR
19	17	Pit Depth in Rings	Number	10
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	5
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	05.12.14
23	21	Vacutug Operation	Time	1.20
24	22	Pit Latrine ID	ID No.	13
25	23	Pit Distance from Vacutug	Feet	45
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	25
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 04 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	3
33	31	Fuel Consumed by Nashimom	Liters	0.5
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.52
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01 hours 04 minutes
38	36	Start Loading	Time	1.20
39	37	End Loading	Time	1.24
40	38	Loading Hours	Minutes	04 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	02.12
43	41	End UnLoading Sludge Tank Sariakandi	Clock	02.14
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	6
46	44	Sludge Emptying	Liters	600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

n. Date of vacutag operation: Data sheet Non-BRAC 14

Sl.	A	B	C	D
1		Md. Anwar		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	16.12.14
5	3	Service Buyer: Location	Village	Sariakandi Central Mosque
6	4	Service Buyer: Family Size	Number	Approxmately daily prayer 400
7	5	Income Earning Members	Number	
8	6	Service Buyer Gender	Male/Female	
9	7	Service Buyer Occupation	Occupation	
10	8	Service Income/Month	Month	
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	
13	11	Pit Age	Years	20
14	12	What Last Emptying Done	Month/Year	1 year
15	13	Who did Last Emptying	Self/WashWorker	Self
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	10
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	6
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	SS
22	20	Vacutug Operation	Date	16.12.14
23	21	Vacutug Operation	Time	10.40
24	22	Pit Latrine ID	ID No.	14
25	23	Pit Distance from Vacutug	Feet	20
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	20
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 11 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	5
33	31	Fuel Consumed by Nashimom	Liters	0.83
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	1.25
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01 hours 04+ minutes
38	36	Start Loading	Time	10.40
39	37	End Loading	Time	10.46
40	38	Loading Hours	Minutes	06 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	11.49
43	41	End UnLoading Sludge Tank Sariakandi	Clock	11.51
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	10
46	44	Sludge Emptying	Litres	600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

o. Date of vacutag operation: Data sheet Non-BRAC 15

Sl.	A	B	C	D
1		Md. Masud		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	16.12.14
5	3	Service Buyer: Location	Village	Sariakandi orphanage
6	4	Service Buyer: Family Size	Number	Approxmately daily prayer 75
7	5	Income Earning Members	Number	
8	6	Service Buyer Gender	Male/Female	
9	7	Service Buyer Occupation	Occupation	
10	8	Service Income/Month	Month	
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	10
14	12	What Last Emptying Done	Month/Year	2 year
15	13	Who did Last Emptying	Self/WashWorker	Self
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	12
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	5
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	Soft
22	20	Vacutug Operation	Date	16.12.14
23	21	Vacutug Operation	Time	1.35
24	22	Pit Latrine ID	ID No.	15
25	23	Pit Distance from Vacutug	Feet	30
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	30
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 11 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	5
33	31	Fuel Consumed by Nashimom	Liters	0.83
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	0.52
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01 hours 04+ minutes
38	36	Start Loading	Time	1.35
39	37	End Loading	Time	1.
40	38	Loading Hours	Minutes	05 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	02
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	11.49
43	41	End UnLoading Sludge Tank Sariakandi	Clock	11.51
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	10
46	44	Sludge Emptying	Litres	600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

p. Date of vacutag operation: Data sheet Non-BRAC 15

Sl.	A	B	C	D
1		Md. Rashid		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	17.12.14
5	3	Service Buyer: Location	Village	Shariakandi
6	4	Service Buyer: Family Size	Number	7
7	5	Income Earning Members	Number	1
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Farmer
10	8	Service Income/Month	Month	7000
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	10
14	12	What Last Emptying Done	Month/Year	2 year
15	13	Who did Last Emptying	Self/WashWorker	Self
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	12
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	5
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	Soft
22	20	Vacutug Operation	Date	17.12.14
23	21	Vacutug Operation	Time	10.05
24	22	Pit Latrine ID	ID No.	16
25	23	Pit Distance from Vacutug	Feet	25
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	25
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1Hours 17 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	5
33	31	Fuel Consumed by Nashimom	Liters	0.52
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	1
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	1Hours 17 minutes
38	36	Start Loading	Time	10.05
39	37	End Loading	Time	10.11
40	38	Loading Hours	Minutes	06minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	03
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	11.20
43	41	End UnLoading Sludge Tank Sariakandi	Clock	11.22
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	10
46	44	Sludge Emptying	Litres	600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

V. ANNEX-1

q. Date of vacutag operation: Data sheet Non-BRAC 16

Sl.	A	B	C	D
1		Md.Lookman Hakim		
2		Information	Unit Definition	Field Data
3	1	Enlistment with BRAC	Yes/No	No
4	2	Date of Emptying	Date	17.12.14
5	3	Service Buyer: Location	Village	Shariakandi
6	4	Service Buyer: Family Size	Number	7
7	5	Income Earning Members	Number	1
8	6	Service Buyer Gender	Male/Female	Male
9	7	Service Buyer Occupation	Occupation	Farmer
10	8	Service Income/Month	Month	7000
11	9	Service Fee Paid	Taka	
12	10	Latrine Type-Double or Single Pit	DP/SP	SP
13	11	Pit Age	Years	10
14	12	What Last Emptying Done	Month/Year	2 year
15	13	Who did Last Emptying	Self/WashWorker	Self
16	14	Slab Condition-V Good. Good. Bad	VG. G. B	G
17	15	Supper Structure Conditon	VG. **G.** B	G
18	16	Roof Type, Tin. Thatched. No Roof	T. Th. NR	T
19	17	Pit Depth in Rings	Number	12
20	18	Fecal Sludge in the Pit Empty from Top Ring	Number	5
21	19	Sludge Condition; Hard/Semi Soft/Soft	H,SS,H	Soft
22	20	Vacutug Operation	Date	17.12.14
23	21	Vacutug Operation	Time	1.10
24	22	Pit Latrine ID	ID No.	16
25	23	Pit Distance from Vacutug	Feet	25
26	24	Pit to Next Pit Distance	N/A	N/A
27	25	Road to Home Distance	Feet	25
28	26	Main Road to HH-Road Type Earth/Metalled	Earth/Metalled	Earth
29	27	Vacutug Tank Contents at Time of Operation	Empty/Part Filled	Empty
30	28	Vacutug Operator Hours Worked	Hours/Minutes	1 hours 42 minutes
31	29	Pit To Pit Nashimon Distance Covered	Kilometer	N/A
32	30	Pit to Sludge Tank in Sariakandi	Kilometer	5
33	31	Fuel Consumed by Nashimom	Liters	0.52
34	32	Fuel Consumed by Sunchtion Pump Moter	Liters	1
35	33	Others Lube oil		
36	34	Labours Worked Vacutug Helper	Number	01
37	35	Labour Hours Worked	House/Minutes	01hours 42 minutes
38	36	Start Loading	Time	1.10
39	37	End Loading	Time	10.15
40	38	Loading Hours	Minutes	05 minutes
41	39	Unloading Labour- Sludge Tank in Sariakandi	Persons	03
42	40	Start UnLoading Sludge Tank Sariakandi	Clock	2.50
43	41	End UnLoading Sludge Tank Sariakandi	Clock	2.52
44	42	UnLoading From Vacutur Hours	Minutes	02 minutes
45	43	Distance Travelled upto GKSS Tank	Kilometer	10
46	44	Sludge Emptying	Litres	600
47	45	Pit Owners Satisfied/Unsatisfied	Satisfied/Unsatisfied	Satisfied

VI. ANNEX-II

Logistic Test Focus Group Discussion on Service Payment
Exit Interview Check list
[Individual Service Consumer Interview]

1. Upazila Name :*Bogra Sadar*
2. Union Name : *Shabgram*
3. Village Name :*Naruli*
4. Pit Latrine Type SP/DP/OffP : *Single Pit*
5. Name of Family/Type of Institution : *Md. Zillar Rahman 01717-141747*
6. Pit Use Time in the Year : *03 (Three Years)*
   Dry months of the Year : *Normal; all year round*
   Wet months of the Year :*N/A*
7. No of Users : *06 (Six Persons)*
8. In the past, how easy or difficult was to get the service:
   In the past it was very difficult because the sweepers did not clean the pit latrines hygienically. They would always create a big hassle. The sweepers would charge BDT 400-500/- for cleaning one pit latrine.
9. In this exercise what we did for your pit latrine, how easy or difficult was to get the service:
   It was very easy for me to get this service because as soon as I was informed of the service of the Vacutug car, I immediately wanted it to clean my latrines. The next day the Vacutug car came and cleaned it.
10. Did you ask for the service and got that: *I got the service immediately after 24 hours of asking for it.*
11. How much did you pay for the service: *BDT 200/- (Two Hundred only)*
12. If not satisfied then why: *N/A*
13. Would you be using the service again:
    Yes, I would use the service again because I was very satisfied the first time.
14. After how many months would you use the service again:
    After 2-months. Also, I have two more latrines that need to be cleaned immediately and I would like to avail the services of the Vacutug again.

VI. ANNEX-II

15. What are your suggestions for service delivery improvement?
    If the Vacutug service is available all the time in the village, it will help the locals and also save money. Also, it will be much more useful if we are informed 1-2 days before and the time when the Vacutug car arrives.
16. Date of interview: *20 January, 2015; Time: 13.40*

VI. ANNEX-II

Logistic Test Focus Group Discussion on Service Payment
Exit Interview Check list
[Individual Service Consumer Interview]

1. Upazila Name :*Gabtoli*
2. Union Name : *Gabtoli Municipility 7no ward*
3. Village Name :*Tarafmeru*
4. Pit Latrine Type SP/DP/OffP : *Single Pit*
5. Name of Family/Type of Institution: *Md. Shamim Ahmed*
6. Pit Use Time in the Year : *03 (Three Years*)
   Dry months of the Year : *Dry; all year round*
   Wet months of the Year :*N/A*
7. No of Users : *04 (Four Persons)*
8. In the past, how easy or difficult was to get the service?
   In the past it was difficult because the sweepers do not clean the pit latrines hygienically and also during the cleaning process a lot of bad smell is created. The sweepers would charge BDT 500-600/- for cleaning one pit latrines.
9. In this exercise what we did for your pit latrine, how easy or difficult was to get the service:
   It was very easy for me to get this service because as soon as I was informed of the service of the Vacutug car, I immediately wanted it to clean my latrines. The next day the Vacutug car came and cleaned it.
10. Did you ask for the service and got that:
    I got the service immediately after asking for it.
11. How much did you pay for the service: *BDT 200/- (Two Hundred only)*
12. If not satisfied then why: *N/A*
13. Would you be using the service again: *Yes, I would use the service again*
14. After how many months would you use the service again: *After 3-months*
15. What are your suggestions for service delivery improvement?

VI. ANNEX-II

It will be much more useful if the Vacutug car came to clean the pit latrines in a more routine manner.

16. Date of interview: *20 January, 2015; Time: 11.15*

Annex 6

Story Board

Sourcing of Vacutug: Experiences from Fecal Sludge Management Programmes

Location: Faridpur and Kushtia.

October 2014

Report Submitted on
09 November 2014

I. Introduction & Background

The original idea of pit latrine emptying with plastic bucket and garden trolley has been found not feasible in the Logistics Test Action Research (See story board report). However, an effective popular alternative has been used by few Fecal sludge management (FSM) programmes implemented in different municipalities in Bangladesh. Most of the FSM programmes have been using Vacutug – a device produced by the MAWTS, located in the Mirpur/Pallabi area in Dhaka, Bangladesh. The Vacutug is a combined diesel engine powered suction pump (similar to the type used by shallow tube well/low lift pump for irrigation) and storage tank (capacity types are 600 litres and 2,000 litres) facility to suction out the fecal sludge from the pit latrines by hose pipes. The device lifts off fecal sludge from pit latrines/ safety tanks, tugged with either Power Tiller or a local rural transport vehicle named *Nashimon.* MAWTS has been researching Vacutug's practical application and use continuously and modified versions are produced and supplied. The latest one is lorry/truck and tanker type, similar to petrol/water carriers.

The pit latrine emptying Logistics Test Action Research visited several Fecal Sludge Management Programmes to get hold of Vacutug. Purpose of the LTAR is to find out logistical date to establish the number of pit latrine emptying practically possible in a day and its cost for financial modeling of the technical, commercial and financial feasibility study of a biogas plant. Appendix A provides list of Fecal Sludge Management service providers. The important ones agreed in principle are Population Services and Training Center (PSTC), Practical Action and Urban Poor Poverty Reduction (UPPR) project of the UNDP; however, both could not workout a way to rent Vacutug within the project mandate and also being limited to Municipal areas while the scope of the LTAR is rural pit latrines. With the active cooperation of and effort by the GKSS, the Bogra based LTAR service provider a Vacutug has been arranged.

Experiences of Practical Action and the Municipality based programme of Kustia Municipality is presented below.

II. Findings

Practical Action

Practical Action, based on its Faridpur-based field experiences of Vacutug operation for fecal sludge management program developed proposal for funding by the Bill and Melinda Foundation. Scope of Vacutug suction pump based latrine emptying covers municipal geographical boundary. Fecal sludge management has three parts – collection from pit latrines/ safety tanks, transportation and treatment.

Faridpur Municipality, based on its limited scale pilot experience, will create a treatment plant on 3 acres of land, which will treat, among others, fecal sludge from pit latrines and safety tanks in the Municipality. The treatment plant will initially (pilot phase) process 14 cubic meter of fecal sludge a day (in 3 years it will reach 35 cubic meters); Practical Action field test found that one Vacutug Mark II model having 600 liters capacity could empty 7 to 8 pit latrines per day and collect 14 cubic meter of fecal sludge. The project will transport fecal sludge by *Nashimon* to the treatment plant from pit latrines spatially distributed – the closet one is 2 kilometers and the furthest one is 8 kilometers.

Faridpur Municipality will supply on lease term two sets of vacutug and Nashimon to two Waste Worker pit latrine emptying cooperatives. Each cooperative has 26 recent Muslims and 41 traditional workers.

Kustia Municipality Program

Visit Date	11 October 2014
Place	Kustia Municipality Mr. Ekramul Haque, Conservancy Inspector
	Jhenidah Municipality
Vacutug Program UGF	
Number of Vacutugs	Kustia Municipality – 3 units Tractor type 1 and truck type 2 Jhenidah Municipality – 2 units; Nashimon type 2 units.
Vacutug Operation Information	
Vacutug type	Nashimon pulled, capacity 2,000 kg Fixed pipe 90 feet; additional 120 feet and 150 feet
	Truck mounted, capacity 5,000 kg Fixed pipe 90 feet; additional 120 feet and 150 feet
Days of Operation	22 days
Hours of Operation	8 am to 5 pm
Service Unit	(a) 2 to 3 safety tanks (b) 3 pit latrines
	Nashimon pulled, capacity 2,000 kg 6 tons per day of 8 hours
	Truck mounted, capacity 5,000 kg 10 tons per day of 8 hours
Service Price	Safety Tank: Within Municipality – Tk. 800/- Safety Tank: Outside Municipality – Tk. 2,000/- Pit Latrine: Within Municipality – Tk. 300/- Pit Latrine: Outside Municipality – Tk. 600/-
Average Distance	From Project to Client Latrine - 5 kilometers; from client latrine to dumping (5 kilometer) and finally back to Project station 10 kilometers
Service Interval	6 months to 12 months
Operation Consumables	(a) Nashimon/ Tractor Model (Shallow Pump Engine 10 HP) 4 to 5 liters of diesel (b) Truck Model 5 liters of diesel (c) Mobil oil for Nashimon – 3 litres per 7 days (d) Mobil oil for Truck (2000 cc) – 5 litres diesel per 7 days
Operation Labour	Driver – One @ Tk. 500/- per day Operator – One @ Tk. 500/- per day Waste Keeper – 4 @ Tk. 380/- to 400/- per day
Use of Fecal Sludge	Organic compost fertilizer
Demand as on 11 October 2014	13 requests in one day
Service Requisition types	On line Phone call Walk in
Maximum Safety Tank sludge volume	8 to 10 tons
Pit Emptying loading per pit	One hour
Vacutug Emptying per pit	One hour

III. Conclusion:

1. One Vacutug having 600 liter capacity could empty 7 to 8 pit latrines per day – average 7.5 Therefore, Total number of Vacutug required for emptying 150 pit latrine daily is 20 Vacutug and Nashimon.

2. Management of this fleet of Vacutug operation is extensive; which can only be achieved gradually over a time-period with the concrete lessons learned.

Appendix A

Service Provider		Address
Dushtha Shasthya Kendra (DSK)	Dr.A.B.M. Abdullah (President) Dr. Dibalok Singha MD (Executive Director)	House-741, Road-9, Baitul Aman Housing Society Dhaka – 1207, Bangladesh Phone: 880-2-9128520, 880-2-8122861, 880-2-8120965, 880-2-8159656 Fax:880-2-8115764 Ext 123 Email : info@dskbangladesh.org
Population Services and Training Centre (PSTC)	Milon Bikash Paul Executive Director POPULATION SERVICES AND TRAINING CENTER (PSTC)	30, Shahid Sangbadik Selina Parveen Sarok (Old-103, New Circular Road) Dhaka-1217, Phone: 8322459, 8322569 Fax: 8322568 E-mail: pstcpaul@bangla.net , pstc@bangla.net www.pstc-training.info
Faridpur Municipality Office	শখে মাহ্ তাব আলী মখে্ু	Mujib Road, Faridpur - 7800 Phone: (+88) 0631-65300 Email: mayorfaridpur@yahoo.com/ admin@faridpurmunicipality.gov.bd www.faridpurmunicipality.gov.bd
Cox's Bazar Munipality Office	Samachuddina Md., Secretary (Information Officer)	Cox's Bazar Municipality http://www.coxsbazar.gov.bd/node/690289 জনাব মোঃ সামছুদ্দনি সচবি কক্সবাজার পৌরসভা কক্সবাজার। মোবাইল নং ০১৮২৩১৪৪২৯৪
	Mohammad Ahsan Kabir মোঃ আহসান কবীর (District Information Officer)	Mobile No: 0171610608 (০১৭১৬১০৬২০৮) Phone: ০৩৪১ ৬৩২৬৬
Jessore Municipal Office		প্রধান নর্িবাহি কর্মকর্তা জলো পরষিদ ভবন বডি হল ফোনঃ অফসি ০৪২১ ৬২২৯৫বাসা ০৪২১ ৬২২৯৬

Jhenaidah Municipal Office	Sayedul Karim (Mayor) সাইদুল করমি	Mobile: 01733547810 (০১৭৩৩৫৪৭৮১০) jhenaidahmuni@gmail.com
Kushtia Municipal Office		Information Center Mobile: 01733-729696 Phone: 071-71674 Fax: 071-71348 Email: callcentrekp@gmail.com Website: www.kushtiamunicipality.org

Vacutug, Diesel Run Suction Pump (STW/LLP) with Power Tiller

Truck Mounted Vacutug (inset Emptying Safety Tank)

Annex 7

Story Board

Logistics Test Action Research (LTAR): Chicken manure collection

Location: Bogra.

November - December 2014

Table of Contents

I. Introduction

The Story Board Report deals with the Logistics Test Action Research (LTAR) on collecting chicken manure in Bogra using 2.5 ton truck from 8th November to 10th November. The report presents information about broiler/layer chickens in the area, purchasing chicken manure, transporting and discarding it to the GKSS organic fertilizer enterprise in Sariakandi, Bogra. The Logistics Test outcomes are documented in the following pages including pictures with narratives. The report presents findings including observations and conclusions.

II. Background

BioSol Energy is implementing the back-to-back study on Technical Feasibility and Commercial Viability of the processing of chicken manure in Bangladesh. The study will rollout pilot testing of the installation and operation of a Biogas plant in Bogra based on corn-stovers, chicken manure and fecal sludge in the 6:3:1 mixing ratio respectively; the annual combined feedstock requirement is 10,000 metric tons.

The Logistics Test Action Research (LTAR) data indicates the suitability of collecting chicken manure via trucks in the rural Bangladesh. The outcome of LTAR provides data for collection of 30 tons of chicken manure in 3 days.

For LTAR implementation in Bogra, BioSol Energy has contracted GKSS, a Bogra based private organization that owns and runs an organic fertilizer enterprise in Sariakandi, Bogra.

The LTAR targeted poultries for collecting chicken manure based on dialogue with retailers and other poultry owners. In terms of activities, the LTAR with the help of GKSS, carried out interviews with poultry farm owners and the results are presented in ANNEX-1. Afterwards, GKSS began the actual collection of chicken manure from different poultries, followed by transporting and discarding it in the GKSS premises.

III. Field Findings

3.1 Chicken manure collection: Actual purchases

The action research team held discussions with respective poultry owners and purchased chicken manure from 8th November to 10th November. In total the team visited 6 farms and the details are presented below.

Poultry Farm No. 1: Shabgram, Bogra Sadar (08-Nov-14)

Firstly, Mr. Saroj and Mr. Salauddin visited the poultry farm owned by Md. Shahidul Islam, located in Shabgram. The respondent said that if we were to purchase chicken manure from poultry owners, we would have to inform the respective owners beforehand (at least a week before). The reason for this is that most of the poultry owners clean out the chicken manure as quickly as possible and some even sell it off within the first 5 days of the month. It takes 60-70 days for a sonali layer and 30-45 days for a broiler to collect chicken manure.

Poultry Farm No. 2: Koilashgura, Gabtoli (08-Nov-14)

Next the LTAR team visited a poultry farm located in Koilashgura, Gabtoli owned by Md. Belal Hossain. The team came to an agreement with Mr. Hossain about purchasing the chicken manure at the rate of BDT 50/- per sack. The LTAR team bought 90 bags of chicken manure weighing 4.5 tons from him. Detailed information was collected from Mr. Hossain's employees. They said that all the chicken manure is sold off and the rest is used as feed for the fish.

Poultry Farm No. 3: Shabgram, Bogra Sadar (09-Nov-14)

Meetings took place with Manik Thakur, situated in Shabgram who is a broker. However, the chicken manure from Manik Thakur's poultry had to be purchased at BDT 60/- per bag. It should be noted here that this rate is inclusive of the labor loading costs. Afterwards, 85 bags weighing 4.25 tons were purchased from there. Mr. Thakur sells it to farmers in areas such as Joypurhat, Rangpur, Dinajpur, Lalmonirhat, Gazipur, Tangail and Mymensingh. Those who purchase it, use it as fertilizer on their sugarcane plantations, potato plantations and even as feed for fish. Some also produce organic fertilizers from these.

Poultry Farm No. 4: Shabgram, Bogra Sadar (09-Nov-14)

Next in line was a visit to Shafla poultry farm in Shabgram. The owner was not present thus the conversation took place with the employees. They asked for BDT 150/- per bag of chicken manure and were reluctant to reduce the price. Thus no bags were purchased from them. Upon questioning them about why the price was so high, they said that they mix good quality grain of bran with the chicken manure resulting in it being quite expensive.

Poultry Farm No. 5: Choukibari, Ramchondropur, Shariakandi (10-Nov-14)

The LTAR team travelled by van to poultries situated in Choukibari, Ramchondropur, Shariakandi owned by Md. Mahbubur Rahman and saw that there was some chicken manure. Upon conversation with him it was revealed that he uses the chicken manure as fertilizer for his own land and also in a biogas plant which he owns. After using the chicken manure in the biogas plant for 6 months he sells the rest of it for BDT 2.50-3.00. Mr. Rahman sells each bag poultry manure for BDT 35-40/-

Poultry Farm No. 6: (10-Nov-14)

Afterwards, they went to the poultry farm of one Mohidul Islam. He said that he uses the chicken manure for his own land and the sells the remaining amount. Mr. Mohidul sells each bag poultry manure for BDT 40-45/-

3.2 Chicken manure collection: Information from poultry farms

TOTAL NUMBER OF POULTRY FARMS IN THE BOGRA SADAR UPAZILLA:

Types of poultry farms	**Number of poultry farms**
Layer farms	2000
Broiler farms	1500
Sonali meat farms	2500
Total	**6000**

Size of poultry farms	**Total capacity of chickens**	**Capacity of chicken manure produced per week (in KG)**
Larger farm	40,000 chickens	3000 KG
Medium Farm	20,000 chickens	2000 KG
Small Farm	20,000 chickens	1000 KG
Total	**80,000 chickens**	**6000 KG**

TOTAL NUMBER OF HATCHERIES:

Size of hatcheries	**Number of hatcheries**
Large type of hatchery	21
Small type of hatchery	40
Total	**61**

EXCLUDING BOGRA SADAR UPAZILLA, TOTAL NUMBER OF POULTRY FARMS IN THE 11 OTHER UPAZILLAS:

Size of poultry farms	**Number of poultry farms**
Small farms	6000
Medium Farms	2000
Large farms	4000
Total	**12,000**

Types of chickens	**Number of chickens**
Layer	3000
Broiler	3000
Sonali meat	6000
Total	**12,000**

3.3 Chicken manure collection: Information on different types of chickens

a. Sonali broiler chickens, it takes about 60-70 days to fill 145-150 sacks (50 kg per sack) with manure.
b. The manure from the broiler chickens are collected after 30-45 days. The reason being that broiler chickens eat more and thus excrete more.
c. One chicken eats 110g of food and excretes 50g of manure every day. It does this 40-50 times every day.
d. The usual heights of the chickens are in between 8”-12”. In 1 month a chicken grows to 10”. The layer and broiler chickens are of the same height.
e. No ammonia gas can be produced from the manure of broiler chickens because there is slit rice paddy mixed with it. However, the manure from the broilers which is left from the raised platform is more useful. If the bio-gas plant is to be built, using the manure of the layer chickens is more useful.

3.4 Chicken manure collection: Detailed information on actual collection & discarding

- Both the pickup trucks travelled 348 KM in total to collect and discard 30 tons worth of chicken manure from 6 farms in 3 days.

- Total amount of fuel required for the operation was 23.8 liters.

- For each of the 2.5 ton pickups there were two labors for loading-unloading. The total expense incurred per ton for transporting, loading and unloading was BDT 720/-.

3.4.1 Transportation & loading-unloading services

For transportation the LTAR team used two trucks of 2.5 ton capacity each. Each truck made two trips per day. In each trip the trucks carried 2.5 tons (2 sacks) of chicken manure. Each truck had two labor who loaded and unloaded the sacks. The loading time necessary is 40-55 minutes, and mainly depends on the number of sacks and distance of the farm from the pickup truck. Expenses for such a trip are detailed in the section 3.4.5.

According to the LTAR teams' observation, it would be difficult for a 5 ton truck to travel some places, however a small pickup which can carry 2.5 ton, can go almost everywhere. But, in some locations even the 2.5 ton truck could not enter and thus the chicken manure was transported to the main road via noshimon. After carrying it to the main roads, the sacks were conveyed to GKSS via the 2.5 ton truck. In doing so the van and labor costs increased from BDT 1800 to BDT 2000.

3.4.2 Chicken manure discarding in GKSS

Both the trucks carried 2.5 tons of chicken manure from the poultries to GKSS office in Sariakandi. The sacks were then unloaded and placed in two warehouses inside the GKSS organic fertilizer enterprise. One warehouse measured 22.30 sq. meters and the other one measured at 16.72 sq. meters. The unloading time took 25-30 minutes.

3.4.3 Chicken manure processing in GKSS

After the chicken manure is unloaded onto the warehouse floors it is processed by mixing with various chemical powders, water and cow dung to create organic fertilizer.

3.4.4 Poultry owners' opinion

a. Most of chicken manure is bought by the brokers.
b. The chicken manure that is left after selling are used by the owners their lands, lipiyar grass, bamboo bush and fish farms.
c. Sometimes, according to the needs, the chicken manure has to be disposed without any cost. At that time it has no value.
d. The rate increases during November to March because the land is used more.
e. During the rainy season the price decreases 20% because the land is used less.
f. The farm is open all year round
g. Most of it is outside the towns and thus the chicken manure does not cause any problems, i.e. bad smell, to the locals. Before any such problems arise, it is put into bags and the buyers lay it out on the main roads.
h. Buyers come from the surrounding areas of Bogra to purchase the chicken manure.

3.4.5 Expenses

- For a 2.5 ton pickup from GKSS to Shabgram and if 50 sacks, i.e. 2.5 ton chicken manure is loaded-unloaded, the expenses are:
  a. Car rental: BDT 1000-1500/- (including fuel)
  b. Labor expenses: BDT 250-300/- (2 labors including loading and unloading at BDT 5-6/- per bag)
  c. Fuel expenses: BDT 140-175/-, i.e. 2.5 liters (If we do not bear the fuel costs then the car rental expense decreases by BDT 140-175/-)

- For a 5 ton pickup from GKSS to Shabgram and if 100 sacks, i.e. 5 ton chicken manure is loaded-unloaded, the expenses are:
  a. Car rental: BDT 2400-2500/- (including fuel)
  b. Labor expenses: BDT 500-600/- (2 labors including loading and unloading at BDT 5-6/- per bag)
  c. Fuel expenses: BDT 490-500, i.e. 7 liters (If we do not bear the fuel costs then the car rental expense decreases by BDT 490-500/-)

- Thus, total expenses for transporting 30 tons of chicken manure to GKSS organic fertilizer enterprise is:

a. Car Rental:	*30 ton x BDT 600/ton*	= BDT 18,000/-
b. Labor	: *600 bag x BDT 6/bag*	= BDT 3,600/-
Total		= BDT 21,600/-

IV. Conclusion

In light of the logistics test carried out and the resources used (such as two 2.5 ton trucks), it is possible to collect 10 tons of chicken manure every day. However, it could be more because during the logistics test a lot of time was spent looking for poultry farm owners who had sacks of chicken manure available and were also willing to sell them.

V. ANNEX-1

Information Table

(Chicken manure)

1

1. *Provider's name & address:* Md. Belal Hossain; Khoilashgura, Gabtoli, Phone # 0171484691
2. *Broiler/Layer/Ubhoy:* Broiler
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 150 kg on average after every 7 days
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 150 kg
6. *How many days does it take to provide/sell and how much kg?:* 1050 kg on average after every 7 days
7. *To whom do you sell?:* Land owners/Brokers
8. *How much is the rate per kg? :* BDT 50-55/- per sack on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :* Winter
11. *When does it decrease? :* November-March
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 200/300/600 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	08.11.14
2	Name of Owners	Md. Belal
3	Address/Phone	Khailasgura, Gabtoli 0171484691
4	Farm Type	Boiler
5	No of Birds	1500
6	Daily Manure Production	150 Kg (3 Three bag)
7	Annual Operating Days	All Year
8	Total Production	54 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	64875
16	Meter Reading End	64899
17	Distance Travelled	24 KM UP-Down
18	Fuel Volume per Liter	1.60 liters
19	Total Cost of Fuel	Taka 112
20	No of Bags	50
21	Total in Tons	2.5
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	10.05
25	End Loading Clock	11.00
26	Hours	0.55
27	Start Unloading Clock	11.35
27	End Unloading Clock	12.05
28	Hours	0.30
29	Total Labor Work Hours	2.00

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	08.11.14
2	Name of owners	Md. Belal
3	Address/Phone	Khailasgura, Gabtoli 0171484691
4	Farm Type	Boiler
5	No of Birds	1500
6	Daily Manure Production	150 Kg (3 Three bag)
7	Annual Operating Days	All Year
8	Total Production	54 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0422
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	5085
16	Meter Reading End	5109
17	Distance Travelled	24 KM UP-Down
18	Fuel Volume in Liter	1.60 liters
19	Total Cost of Fuel	Taka 112
20	No of Bags	40
21	Total in Tons	2
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	11.33
25	End Loading Clock	12.15
26	Hours	0.42
27	Start Unloading Clock	12.58
27	End Unloading Clock	01.29
28	Hours	0.31
29	Total Labor Work Hours	1.56

V. ANNEX-1

Information Table

(Chicken manure)

2

1. *Provider's name & address:* Md. Farid Uddin Hujur; Chatimtola, Bogra, Phone # 01718-663857
2. *Broiler/Layer/Ubhoy:* Layer
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 100 kg on average
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 55 kg
6. *How many days does it take to provide/sell and how much kg?:* After 60-70 days 3300 Kg
7. *To whom do you sell?:* Land owners/Fisheries/**Brokers**
8. *How much is the rate per kg? :* BDT 60/- per sack (50kg sack) on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :* Winter
11. *When does it decrease? :* November-March
12. *What is the reason for anincrease? :* In winter it is used as organic fertilizer
13. *What is the reason for adecrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 500 yards/1/2 km
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	09.11.14
2	Name of owners	Md. Fariduddin Huzur
3	Address/Phone	Chatimtola Bogra, Shadar
4	Farm Type	Layer
5	No of Birds	2200
6	Daily Manure Production	55Kg
7	Annual Operating Days	All Year
8	Total Production	19.8 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	60Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	65003
16	Meter Reading End	65031
17	Distance Travelled	28 KM UP-Down
18	Fuel Volume in Liter	1.87 litre
19	Total Cost of Fuel	Taka 131
20	No of Bags	50
21	Total in Tons	2.5
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	09.35
25	End Loading Clock	10.15
26	Hours	0.40
27	Start Unloading Clock	12.05
27	End Unloading Clock	12.35
28	Hours	0.30
29	Total Labor Work Hours	3.00

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	09.11.14
2	Name of Pit Latrine owners	Md. FaridduddinHuzur
3	Address/Phone	ChatimtolaBogra, Shadar
4	Farm Type	Layer
5	No of Birds	2200
6	Daily Manure Production	55Kg
7	Annual Operating Days	All Year
8	Total Production	19.8 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0422
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	5152
16	Meter Reading End	5180
17	Distance Travelled	28 KM UP-Down
18	Fuel Volume in Liter	1.87 litre
19	Total Cost of Fuel	Taka 131
20	No of Bags	55
21	Total in Tons	2.75
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	08.05
25	End Loading Clock	09.00
26	Hours	0.55
27	Start Unloading Clock	10.35
27	End Unloading Clock	11.10
28	Hours	0.35
29	Total Labor Work Hours	3.05

V. ANNEX-1

Information Table

(Chicken manure)

3

1. *Provider's name & address:* Md. Shahidul Islam; Shabgram Uttarpara, Bogra, Phone # 01716-031046
2. *Broiler/Layer/Ubhoy:*Shonali, Broiler
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 60 kg but after two months 3600 kg on average
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 60 kg
6. *How many days does it take to provide/sell and how much kg?:* 3600 kg after two months
7. *To whom do you sell?:* Land owners/ Brokers
8. *How much is the rate per kg? :* BDT 55/- per kg on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 200/400/500 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	09.11.14
2	Name of owners	Md. Shahidul Islam
3	Address/Phone	Shabgram, SouthParar, Bogra01716-031046
4	Farm Type	Sonali,Boiler
5	No of Birds	2000
6	Daily Manure Production	60Kg on average
7	Annual Operating Days	All Year
8	Total Production	21.6 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0422
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	5202
16	Meter Reading End	5234
17	Distance Travelled	32 KM Up-Down
18	Fuel Volume in Liter	2.13 liters
19	Total Cost of Fuel	Taka 150
20	No of Bags	50
21	Total in Tons	2.5
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	1.15
25	End Loading Clock	2.00
26	Hours	0.45
27	Start Unloading Clock	3.10
27	End Unloading Clock	3.40
28	Hours	0.30
29	Total Labor Work Hours	2.25

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	09.11.14
2	Name of owners	Md. Shahidul Islam
3	Address/Phone	Shabgram, SouthParar, Bogra01716-031046
4	Farm Type	Sonali,Boiler
5	No of Birds	2000
6	Daily Manure Production	60Kg on average
7	Annual Operating Days	All Year
8	Total Production	21.6 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	65053
16	Meter Reading End	65085
17	Distance Travelled	32 KM UP-Down
18	Fuel Volume in Liter	2.13 liters
19	Total Cost of Fuel	Taka 150
20	No of Bags	50
21	Total in Tons	2.5
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	2.10
25	End Loading Clock	2.50
26	Hours	0.40
27	Start Unloading Clock	3.55
27	End Unloading Clock	4.30
28	Hours	0.35
29	Total Labor Work Hours	3.00

V. ANNEX-1

Information Table

(Chicken manure)

4

1. *Provider's name & address:* Md. Shumon; Chatimtola, Bogra, Phone # 01761-751000
2. *Broiler/Layer/Ubhoy:*Shonali, Layer
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 120 kg
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 120 kg
6. *How many days does it take to provide/sell and how much kg?:* After every 60-70 days 7200kg
7. *To whom do you sell?:* Land owners/Fisheries/ Brokers
8. *How much is the rate per kg? :* BDT 45/- per sack on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 150 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	10.11.14
2	Name of Pit Latrine owners	Md.Sumon
3	Address/Phone	Chatimtola, BograsSadar 01761-751000
4	Farm Type	Layer
5	No of Birds	3000
6	Daily Manure Production	120 Kg
7	Annual Operating Days	All Year
8	Total Production	21.6 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1200
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	64109
16	Meter Reading End	64137
17	Distance Travelled	28 KM Up-Down
18	Fuel Volume in Liter	1.87 liters
19	Total Cost of Fuel	Taka 131
20	No of Bags	40
21	Total in Tons	2
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	08.07
25	End Loading Clock	08.39
26	Hours	0.32
27	Start Unloading Clock	10.07
27	End Unloading Clock	10.39
28	Hours	0.32
29	Total Labor Works Hours	2.32

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	10.11.14
2	Name of Pit Latrine owners	Md.Sumon
3	Address/Phone	Chatimtola, BograsSadar 01761-751000
4	Farm Type	Layer
5	No of Birds	3000
6	Daily Manure Production	120 Kg
7	Annual Operating Days	All Year
8	Total Production	21.6 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	50 Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1350
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	5258
16	Meter Reading End	5286
17	Distance Travelled	28 KM Up-Down
18	Fuel Volume in Liter	1.87 liters
19	Total Cost of Fuel	Taka 131
20	No of Bags	45
21	Total in Tons	2.250
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	09.05
25	End Loading Clock	09.45
26	Hours	0.40
27	Start Unloading Clock	10.45
27	End Unloading Clock	11.07
28	Hours	0.22
29	Total Labor Work Hours	2.02

V. ANNEX-1

Information Table

(Chicken manure)

5

1. *Provider's name & address:* Manik Thakur; Kurshapara, Shabgram, Phone # 017923-276031
2. *Broiler/Layer/Ubhoy:* Broiler, Layer
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 150 kg
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 150 kg
6. *How many days does it take to provide/sell and how much kg?:* After every 2 months 9000 kg
7. *To whom do you sell?:* Land owners/Fisheries/ Brokers
8. *How much is the rate per kg? :* BDT 60/- per sack on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 250/400 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	10.11.14
2	Name of Pit Latrine owners	ManikTakur
3	Address/Phone	Kurshapara, Sabgram, BograsSadar 01923-276031
4	Farm Type	Boiler, Layer
5	No of Birds	2200
6	Daily Manure Production	150 Kg
7	Annual Operating Days	All Year
8	Total Production	54 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	60 Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	65149
16	Meter Reading End	65181
17	Distance Travelled	32 KM Up-Down
18	Fuel Volume in Liter	2.13 liters
19	Total Cost of Fuel	Taka 150
20	No of Bags	40
21	Total in Tons	2
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	12.00
25	End Loading Clock	12.50
26	Hours	0.50
27	Start Unloading Clock	02.05
27	End Unloading Clock	02.35
28	Hours	0.30
29	Total Labor Work Hours	2.35

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	10.11.14
2	Name of Pit Latrine owners	ManikTakur
3	Address/Phone	Kurshapara, Sabgram, BograsSadar 01923-276031
4	Farm Type	Boiler, Layer
5	No of Birds	1500
6	Daily Manure Production	150 Kg
7	Annual Operating Days	All Year
8	Total Production	54 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	60 Taka
11	Vehicle No	Bogra Na-11-0422
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	5304
16	Meter Reading End	5336
17	Distance Travelled	32 KM Up-Down
18	Fuel Volume in Liter	2.13 liters
19	Total Cost of Fuel	Taka 150
20	No of Bags	45
21	Total in Tons	2.250
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	01.30
25	End Loading Clock	02.20
26	Hours	0.50
27	Start Unloading Clock	03.30
27	End Unloading Clock	04.05
28	Hours	0.35
29	Total Labor Works Hours	2.35

V. ANNEX-1

Information Table

(Chicken manure)

6

1. *Provider's name & address:* Md. Shamim Gour; Gordoho, Bogra
2. *Broiler/Layer/Ubhoy:* Broiler
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 150 kg
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 150 kg
6. *How many days does it take to provide/sell and how much kg?:* After every 60 days t o 70 days 9000 kg
7. *To whom do you sell?:* Land owners/Fisheries/ Brokers
8. *How much is the rate per kg? :* BDT 70/- per sack on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 200/300/500 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	10.11.14
2	Name of Pit Latrine owners	Md. ShamimGhor
3	Address/Phone	Gordha
4	Farm Type	Boiler
5	No of Birds	1800
6	Daily Manure Production	150 Kg
7	Annual Operating Days	All Year
8	Total Production	54 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	70 Taka
11	Vehicle No	Bogra Na-11-0255
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	65189
16	Meter Reading End	65219
17	Distance Travelled	30 KM Up-Down
18	Fuel Volume in Liter	2 liters
19	Total Cost of Fuel	Taka 140
20	No of Bags	50
21	Total in Tons	2.50
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	03.30
25	End Loading Clock	04.08
26	Hours	0.38
27	Start Unloading Clock	05.18
27	End Unloading Clock	05.45
28	Hours	0.27
29	Total Labor Works Hours	02.15

V. ANNEX-1

	Individual Poultry Manure Collection Data Sheet	
1	Date	10.11.14
2	Name of Pit Latrine owners	Md. ShamimGhor
3	Address/Phone	Gordha
4	Farm Type	Boiler
5	No of Birds	1800
6	Daily Manure Production	150 Kg
7	Annual Operating Days	All Year
8	Total Production	54 Ton
9	Weight Per Bag	50 kg
10	Price Per Bag	70 Taka
11	Vehicle No	Bogra Na-11-0422
12	Truck Rent in Taka	1500
13	Size LxBXH	8'x6'x2'
14	Capacity in Ton	2.5
15	Meter Reading Start	5342
16	Meter Reading End	5372
17	Distance Travelled	30 KM Up-Down
18	Fuel Volume in Liter	2 liters
19	Total Cost of Fuel	Taka 140
20	No of Bags	50
21	Total in Tons	2.50
22	No of Loading Labor	2
23	No of Unloading Labor	2
24	Start Loading Clock	05.00
25	End Loading Clock	05.40
26	Hours	0.40
27	Start Unloading Clock	07.00
27	End Unloading Clock	07.28
28	Hours	0.28
29	Total Labor Works Hours	02.28

V. ANNEX-1

Information Table

(Chicken manure)

8

1. *Provider's name & address:* Md. Mohidul Islam; Choukibari, Ramchondropur, Sariakandi, Bogra
2. *Broiler/Layer/Ubhoy:* Broiler
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 120 kg
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 120 kg
6. *How many days does it take to provide/sell and how much kg?:* After every 30 days to 45 days 3600 kg on average
7. *To whom do you sell?:*Uses on own land and the excess is sold to Brokers
8. *How much is the rate per kg? :* BDT 40-45/- per sack on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 300/500 yards ½ km
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town
17. *Number of chickens:* 1500
18. Uses it in the, bamboo bush, lipiyar grass and vegetable plant

V. ANNEX-1

Information Table

(Chicken manure)

9

1. *Provider's name & address:* Md. Mahburbur Rahman; Choukibari, Ramchondropur, Sariakandi, Bogra Phone # 01740-919909
2. *Broiler/Layer/Ubhoy:* Broiler
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :* 80 kg
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 80 kg
6. *How many days does it take to provide/sell and how much kg?:* After every 10 days 450 kg
7. *To whom do you sell?:* Uses on own land and the excess is sold to brokers
8. *How much is the rate per kg? :* BDT 35-40/- per sack on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 500/700 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced if it is outside the town
17. *Number of chickens:* 700
18. Uses in own land/biogas production. After using biogas for 6 months the excess manure is sold at BDT 2.50-3.00/- on average.

V. ANNEX-1

Information Table

(Chicken manure)

10

1. *Provider's name & address:*Al-Haj Abdul Kalam AjadShafla Poultry; Kurshapara, Shabgram.
2. *Broiler/Layer/Ubhoy:* Layer
3. *Do you provide/sell now? Yes/no:* Yes
4. *How much do you provide daily? :*100 kg
5. *How much chicken manure is produced in your poultry every day (in kg)?*: 100 kg
6. *How many days does it take to provide/sell and how much kg?:* After 60-70 days 120 bags 6000 kg
7. *To whom do you sell?:* Uses on own land and the excess is sold to brokers
8. *How much is the rate per kg? :*BDT 150/- per kg on average
9. *Does the rate fluctuate? Yes/No:* Yes
10. *If yes, then when does it increase? :*November-March
11. *When does it decrease? :* April-October
12. *What is the reason for an increase? :* In winter it is used as organic fertilizer
13. *What is the reason for a decrease? :* It is not used as fertilizer in the lands in the rainy season
14. *How much is the distance from your poultry to other poultries? :* 300/500 yards
15. *How many days in a year does your farm run? :* All year round
16. *What are the problems you face if the chicken manure is not cleaned? :* No problems faced as it is outside the town

Annex 8

Story Board

Cornstover Logistics Test Action Research (LTAR)

Location: Ghoraghat in Dinajpur and Shariakandi in Bogra.

27 August 2014

Report Submitted on
30 October 2014

I. Introduction

This is the first Study Board Report on the Logistics Test Action Research (LTAR) dealing with the Cornstover logistics test carried out in Bogra and Dinajpur on 27 August 2014. The report presents an assessment of collection from the maize growing field, moving through the rural roads, loading and unloading and finally trucking to its final disposable destination in the GKSS Organic Fertilizer premises in Sariakandi in Bogra. The Logistics Test outcomes are documented in the following pages including pictures with narratives. The LTAR simulates the actual collection and operation of feedstock to run a biogas plant based on, among others, cornstovers. The report presents findings including observations and conclusions.

II. Background

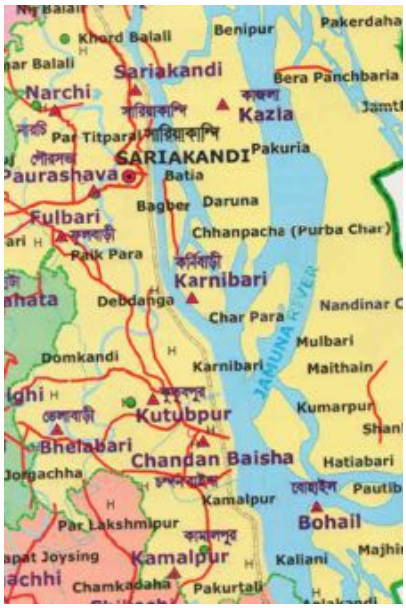
BioSol Energy is implementing the back-to-back feasibility study on Technical Feasibility and Commercial Viability of the Processing of Pit Latrines Contents in Bangladesh, in short, Safe Processing of Pit Latrine Content. The study will rollout pilot testing of the installation and operation of the Biogas plant in Bogra based on cornstovers, chicken manure and faecal sludge in the 6:3:1 mixing ratio respectively; the annual combined feedstock requirement is 10,000 metric tons.

The Logistics Test Action Research (LTAR) data provides confirmation of the assumptions within the financial parameters of the feasibility study design. The purpose is also to come up with alternative solutions, where applicable. The outcome of LTAR provides the foundation for setting up of a biogas pilot plant in Bogra that will use annually 1000 metric tons of faecal sludge from pit latrines installed and used by rural households in the Bogra district in Bangladesh; together with 3,000 metric tons of chicken manure, and 6,000 metric tons of cornstovers or similar adequate cellulose material to produce more than 3000 MWh electricity (net), 2,800 Mwh of heat and about 1500 tons of high quality bio-fertilizer.

For LTAR implementation in Bogra, BioSol Energy has contracted GKSS, a Bogra based organization that owns and runs an organic fertilizer enterprise in Sariakandi, Bogra.

III. Findings and Observations

Bogra has been an important maize/corn production district in Bangladesh; the BRAC agricultural farm seed supply has largely contributed to this development. An estimate from the field is as follows: one acre grows 24,000 plants: each plant weighs 0.50 kg. Therefore, one acre produces 12 tons of corn plants. With a reported 12,000 acres of land under maize cultivation, total estimated production of corn plants in Bogra is 120,000 tons.



Corn fields are everywhere from metalled roadside to river islands (chars) on the Jamuna and Korotoa rivers. Chars that dominate maize production are around Sariakandi, the GKSS farm location, which is about 12 kilometres from the Bogra municipality.

Corn production is an organized activity, and runs into two seasons. The prime sowing season is from October to December and the harvesting season is from March to June. The off-peak sowing season is June to August and harvesting is August to September. The Logistics Test Action Research (LTAR) for 60

metric tons (10% of the feed requirement), planned in February 2014 ,could not be mobilized in time from the Philippines. So the actual test was planned in the off-peak season in August 2014 to collect from the chars by engine boats/ country trawlers from char to the mainland Shariakandi, Bogra. However, the plan was abandoned as the entire char land was submerged by flood water in August; the situation since then has seriously worsened. The ultimate cornstover collection site was relocated in Krishnarampur village, Union: Bulakipur,Upazila: Ghoraghat, District: Dinajpur about 60 km from the GKSS organic-fertilizer Enterprise. However, the volume was limited and the cornstovers dried in the field. The farmers were identified, contacted and contracted for supply of 510 stalks of cornstovers. To meet the supply commitment, the farmers employed 17 laborers to cut and bundle 510 stacks of cornstovers working in the field from 8 am in the morning till 3 pm in the afternoon on the 27 August 2014. Specification of the cornstover lot collected was as follows:

- Each stack consisted of 40 corn plants/stacks;
- Weight of one stack ranged from 13 to 16 kg; so average weight of each bundle was 15 kg;
- Length ranged from 6 to 7.5 feet;
- Circumference of a bundle is 29 inches.

IV. Conclusions:

With an average weight of 15 kg each bundle, the total target was to collect 7,650 kg. However, the small (and cheaper) truck could carry only 370 bundles or 5,550 kg. The larger truck could carry more than 600 bundles; however, that would have required higher costs.

Cornstovers are also extensively used as fuel and considered an important household fuel safety resource. Other uses are coming up fast like particle board making.. The price which is currently estimated at Tk. 0.50 per plant/stack by the farmer is likely to increase, too.

The Logistics Test has established the following cost data:

Payment at Farm Gate and Labor for movement to truck at Ghoraghat.

Particulars	Total Units/ Quantity	Unit Definition	Unit Cost /BDT	Total Cost /BDT
Payment to farmers	510	bundles of 15 kg each	21.57	11,000
Van transportation	28	van trips	50.00	1,400
Horse cart transportation	48	horse cart trips	60.00	2,880
Total weight: 510 stacks @ 15 kg/bundle	7,650	kg	1.99	15,280
Unit Cost in Taka (rounded	01	kg	2.00	2.00
Cost Per MT excluding Trucking				2,000

Computation of One Truck Load of 370 bundles weighing 5,550 kg

Particulars	Total Units/ Quantity	Unit Definition	Unit Cost /BDT	Total Cost /BDT
Cornstover Cost	5,550	kg or one truck load of 5.5 metric tons	2	11,160
Truck	1	Truck; capacity 05 Metric Ton	4,000	4,000
Unloading labor	3	labor person day	200	600
Total Cost	5.5	Metric Tons of Cornstover		15,160
Cost Per MT including Trucking				2,756

Cornstover Collection Story Board in Pictures

Bogra is famous for corn/ maize production in Bangladesh, largely attributed to the BRAC's seed farm. An estimate from the field is as follows: one acre grows 24,000 plants: each plant weighs 0.50 kg. Therefore, one acre produces 12 tons of corn plants; and with an estimated 12,000 acres total, estimated production in Bogra is 120,000 tons.

Beside road side corn growing fields, large scale corn grows on chars (river islands) on the river Jamuna. Some well known Chars are: Char Majhira, Char Chowkibari, Char Karamza, Char Lakhikhola, Char Vhara Borsha, Indur mara char, Char Shakipur, Dakatmara char, Char Panthapra, Char Shimul Taher, and Char Phirnighor.

In general trucks are used for corn transportation from the fields to market by all season metalled roads; however, corn grown in the char is transported by engine boats/ country trawlers to the river bank connected with road. In the logistics test case the trawlers travel 2 to 3 kilometers distance to the mainland Shariakandi dyke accessed by truck. The cornstover unloading site is 2.7 kilometers from the GKSS bio fertilizer farm.

The August 2014, logistics test collection, handling and transportation were planned accordingly by engine boats/ country trawlers from char to mainland Shariakandi.

However, the plan was abandoned as the entire char land had gone into knee deep water due to flood . The situation since then worsened and was alarming as shown in the national newspaper headlines. Pictures show the inundated houses in Rohodoha of Shariakandi upazila of Bogra after the Jamuna washed away 300 metres of a dyke. This was reported/ photograph released in The

Daily Star, August 30, 2014.
The ultimate Cornstover Collection Location selected is in Krishnarampur village, Union: Bulakipur,Upazila: Ghoraghat, District: Dinajpur about 60 km from the GKSS Bio-fertilizer Enterprise.

Cornstovers are harvested in/collected from the growing field on the *Char* on the bank of the Bangla river.

- Farmers contracted to supply cornstovers employed 17 laborers to cut & bundle 510 stacks of cornstovers from 8 am in the morning till 3 pm in the afternoon.
- Each stack consisted of 40 corn plants
- The weight of one stack ranged from 13 to 15 kg; so the average weight of each bundle was 14 kg.
- The length ranged from 6 to 7.5 feet
- The circumference of a bundle was 29 inches

The loading of 510 bundles into the boat and transportation (by boat) to the other riverside embankment required 28 boat trips.

From the embankment to all season metalled road was 3 kms, where truck loading was carried out. Rickshaw van and horse carts were engaged to transport cornstover over the rural earthen, partially brick-soled, road. It took 48 trips to move 370 bundles of the cornstovers.

The truck loading site was in Parbotipur Bazar, Bolgari, Ghoraghat, Dinajpur

(Writer of the report with Nokia mobile phone camera left the loading site to go to the receiving site; so no photographs could be taken at this point)

One truck was hired which had a five (5) metric ton loading capacity with a loading space measuring 14L X 7W X 3H feet to load cornstovers and transport them to the Shariakandi GKSS organic fertilizer production site. Because of its volume, the truck could ultimately load 370 bundles of cornstovers, whose total weight was 5,180 kg (computation: 370x14kg), or 5.18 metric ton.

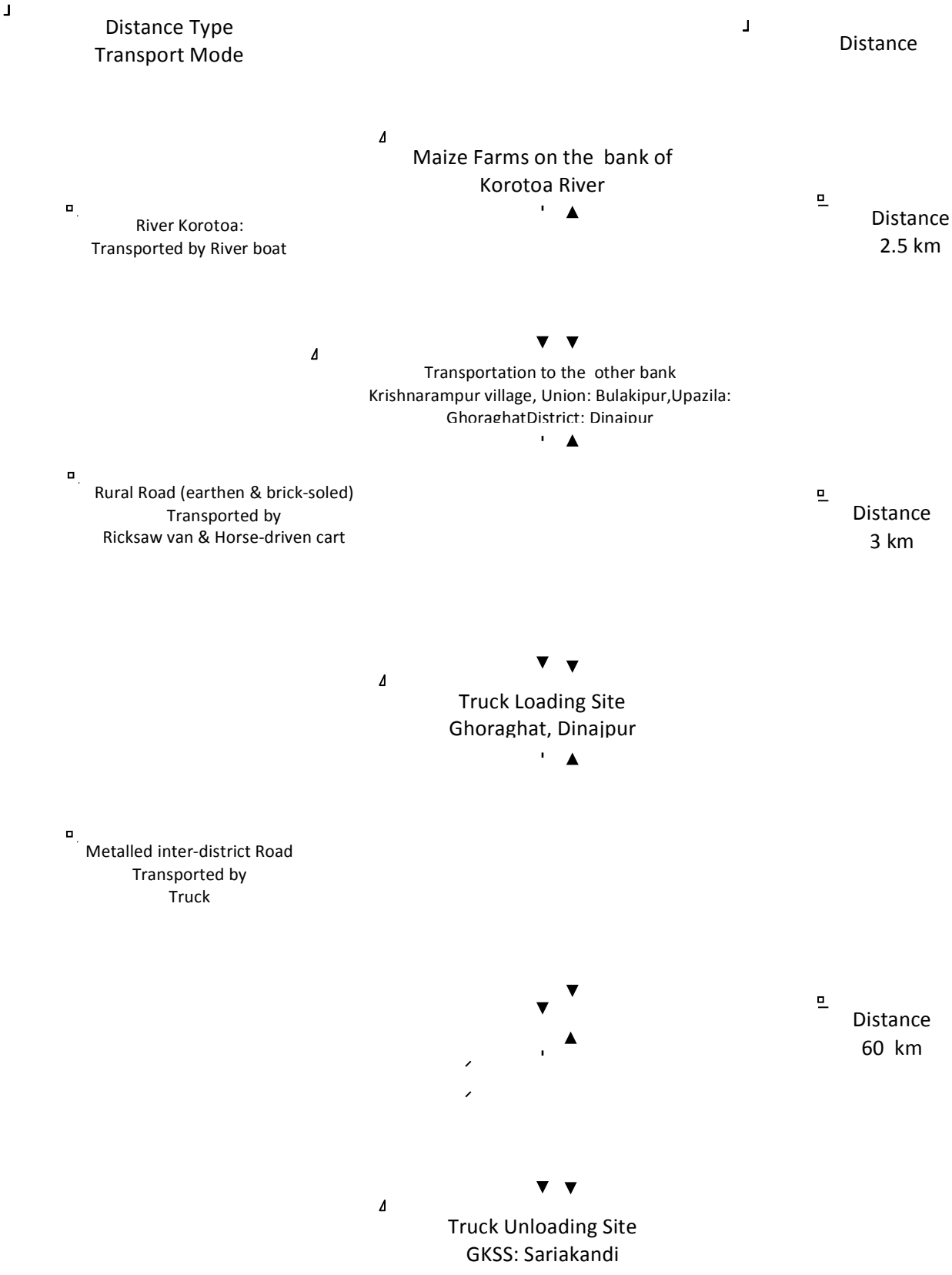
Truck loaded with cornstovers travelled 60 kilometers from Ghoraghat, Dinajpur to Shariakandi, Bogra. In all 3 laborers were employed for unloading from the truck; which was the terms of truck hiring.

Economic Value of Cornstovers

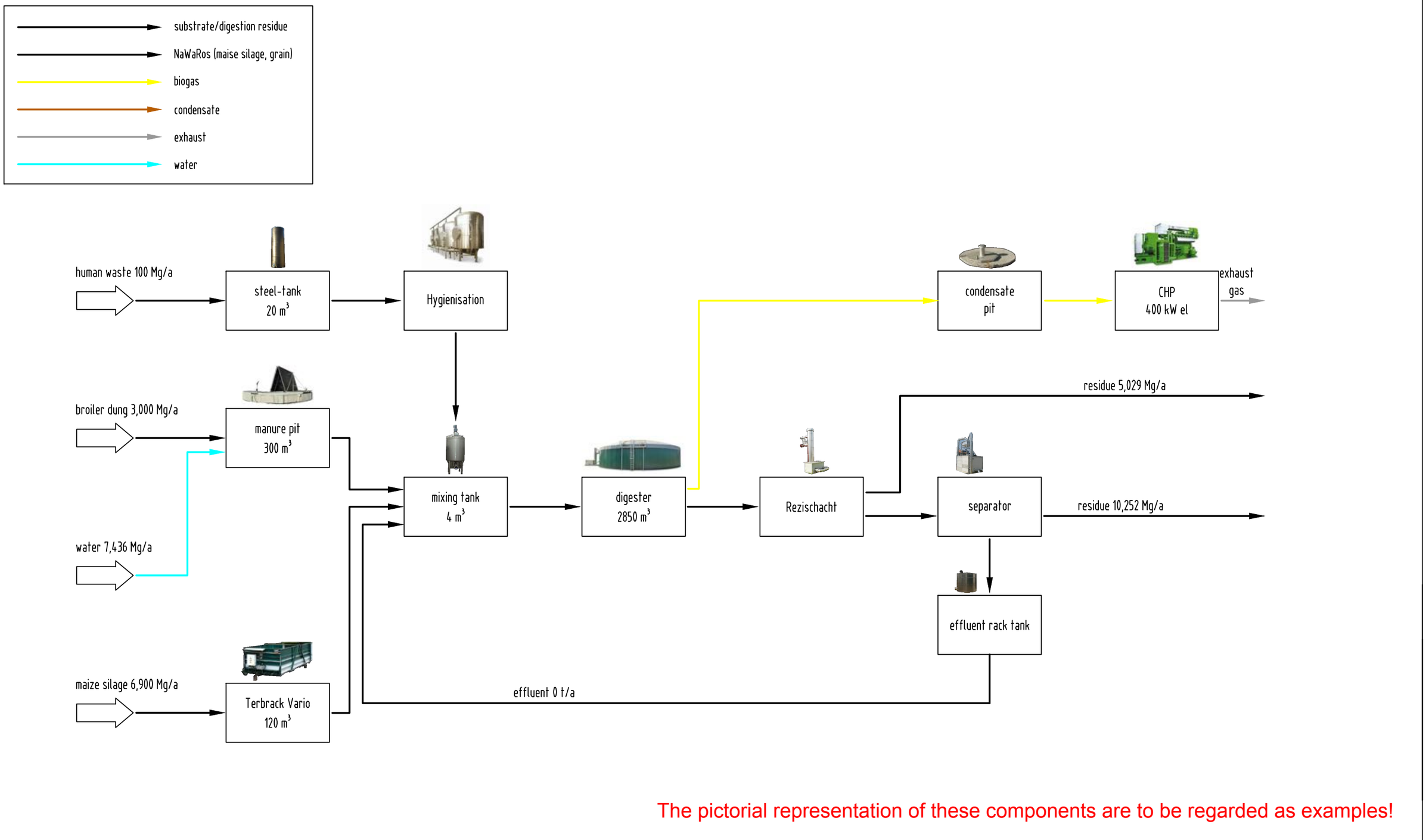
Cornstover is largely used as fuel by the rural households and preserved prudently as fuel-security for the family's fuel need. Because of its importance in the household fuel need throughout the year, cornstovers are carefully protected from rain.

Farmers generally price per bundle of 14 kg for sale, which is Tk 20 per bundle (computed as follows: per stalk price is Tk.0.50; each bundle consists of approximately an average 40 stalks, which is approximately 14 kg).

Schematic diagram illustrates the Collection and Disposal Process in the Logistics Test.



Annex 9



The pictorial representation of these components are to be regarded as examples!

drawing number: 14-xxxxxx_1.VT00/3-00
projekt number: 14-xxxxxx
scale: without
date: 30.10.2014
drawn: S.Selzer

representation: basic flow chart approval planning

EnviTec Biogas

Biogas plant Human Waste

EnviTec Biogas AG
Boschstr. 2 - 48369 Saerbeck
T +49 25 74 / 88 88-0
F +49 25 74 / 88 88-800
E info@envitec-biogas.de
W www.envitec-biogas.de

27.07.2012 11:17:36

Selzer, Sonja

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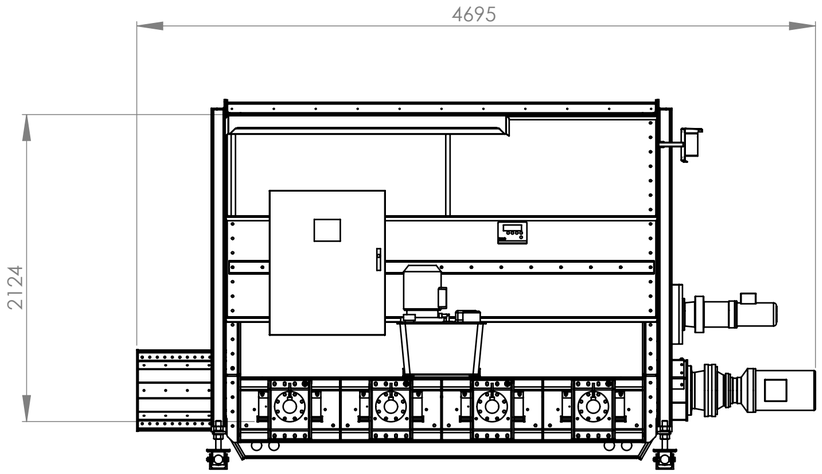
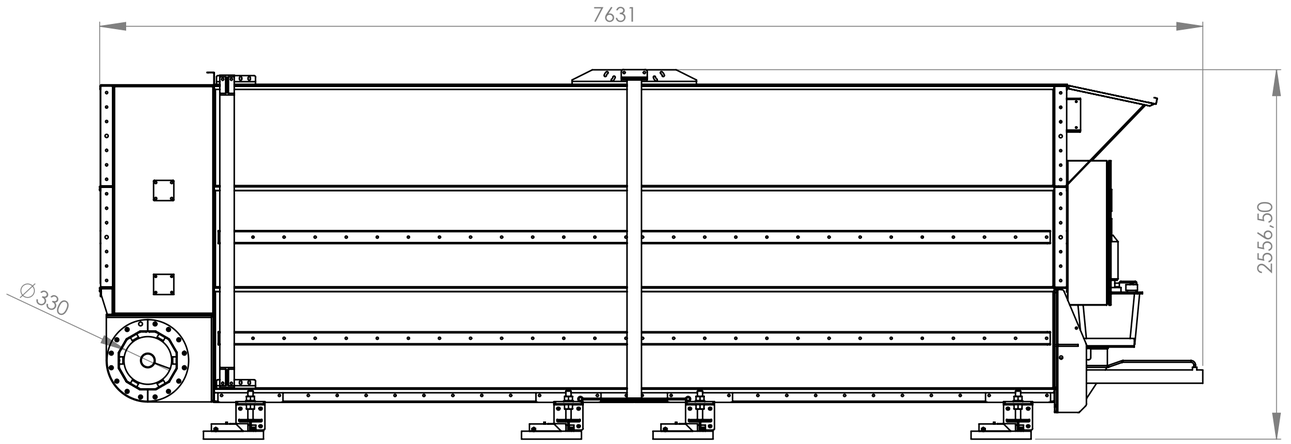
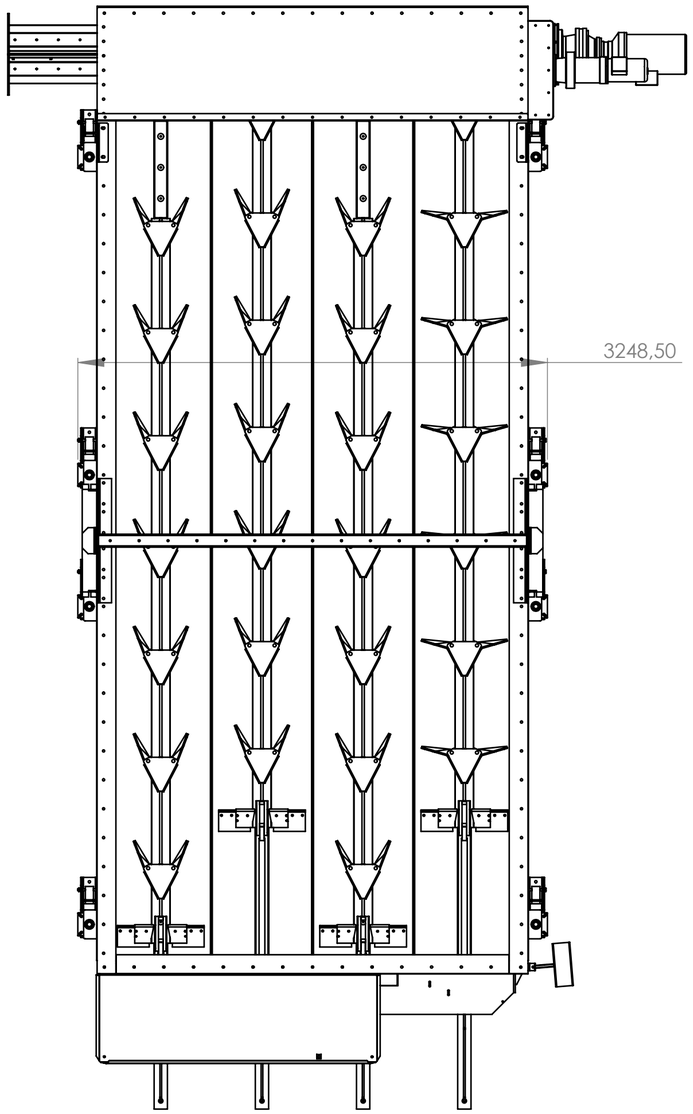
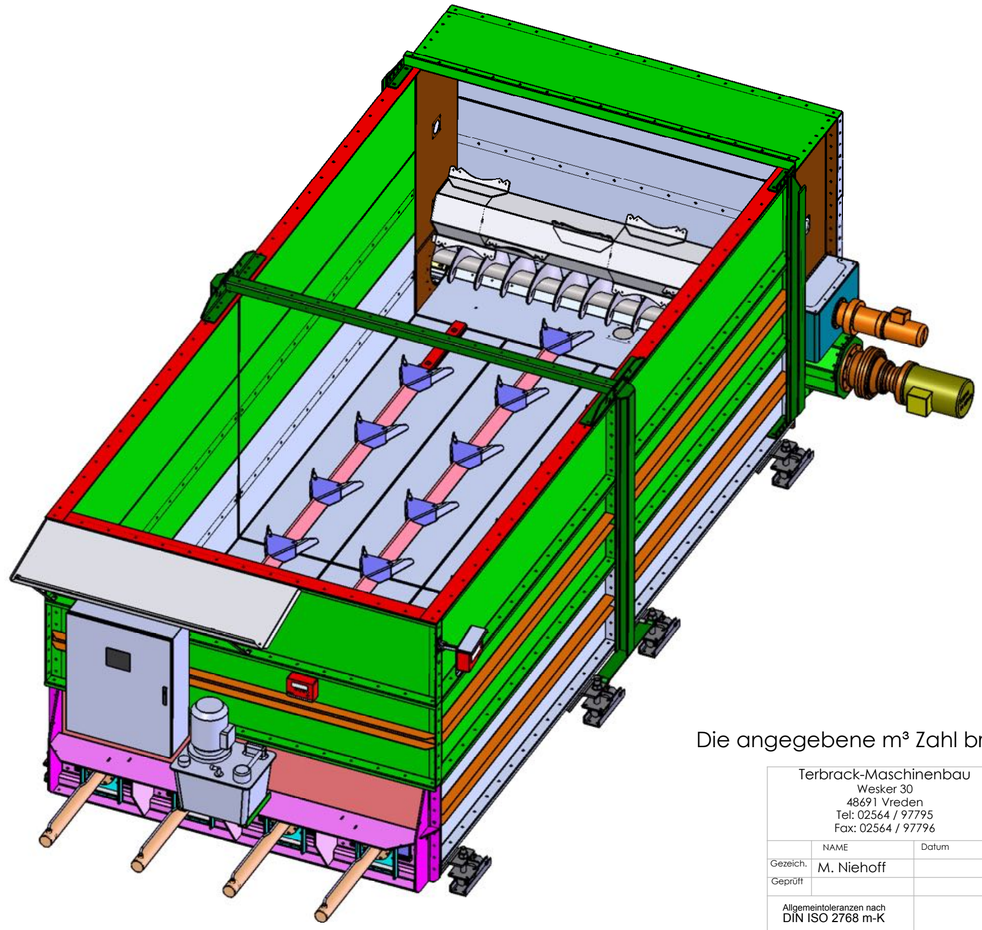
ISO full bleed A3 (420.00 x 297.00 mm)

Annex 10









Die angegebene m³ Zahl brücksichtigt den gesamten Füllbereich.

Terbrack-Maschinenbau
Wesker 30
48691 Vreden
Tel: 02564 / 97795
Fax: 02564 / 97796

Für Schneid- und Kantteile gilt:

Alle Konturen nach DXF lasergeschnitten.
Alle Kanten sauber entgratet.
Bohrungen die nicht gelasert werden können, werden angezeichnet.

	NAME	Datum
Gezeich.	M. Niehoff	
Geprüft		

Allgemeintoleranzen nach DIN ISO 2768 m-K

Benennung

Vario 38 m³

MATERIAL:

Gewicht:

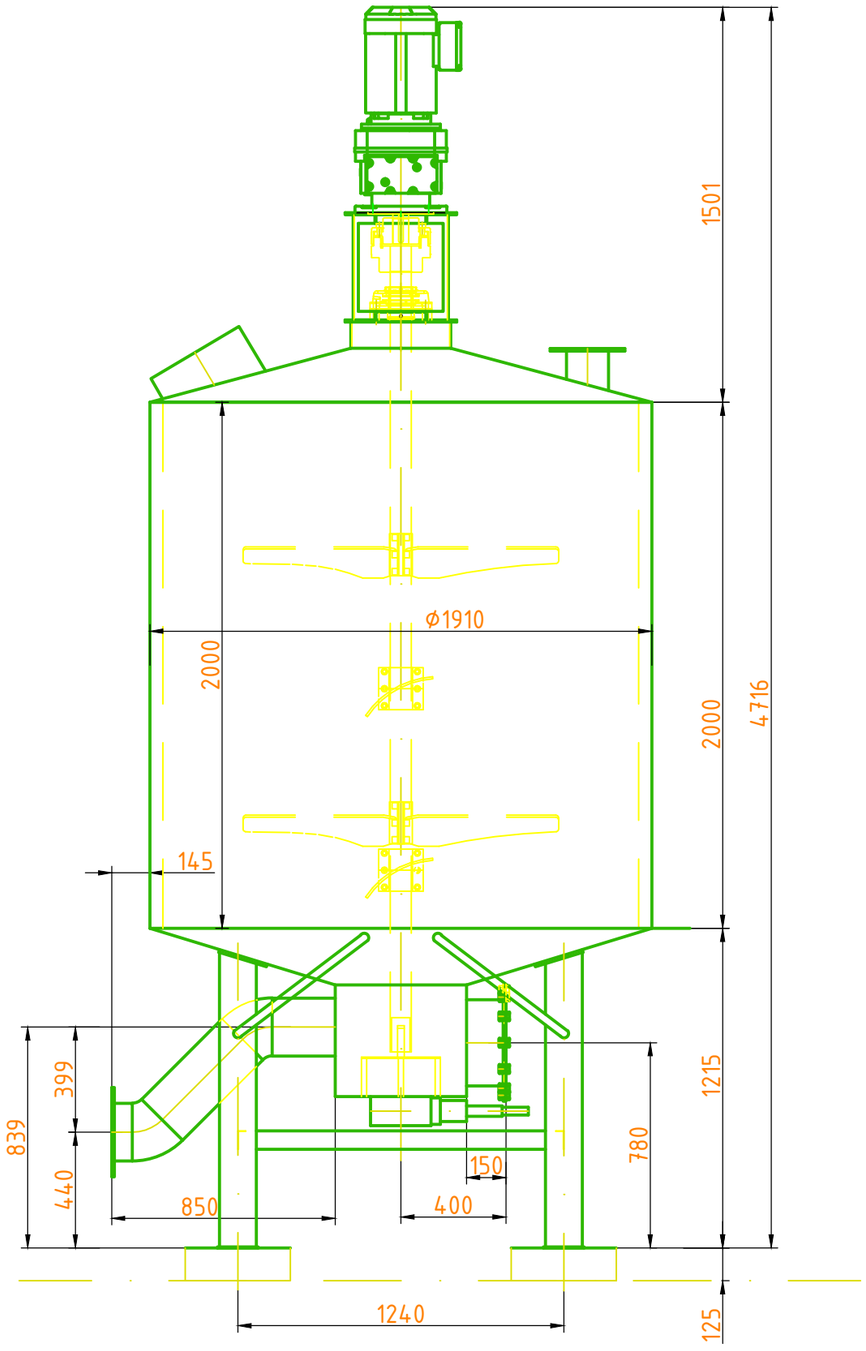
Zg.Nr T460-00-101- 11 - 01

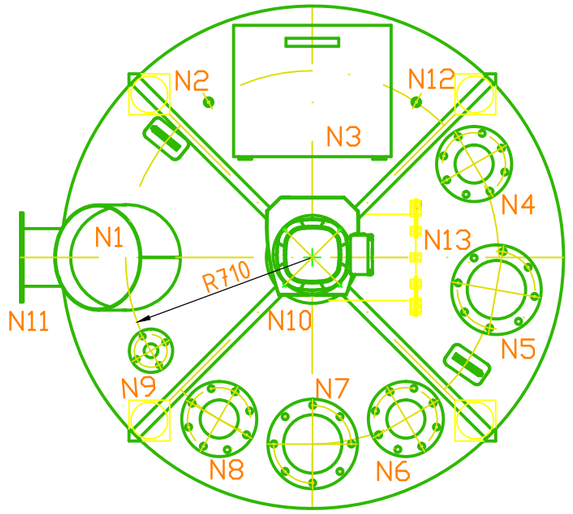
REVISION A2

Maßstab 1:30

Seite 1 von 1

Annex 11





N1 = Stutzen für Steigschnecke
N2 = Stutzen 1" für Füllstandsmessung
N3 = Revisionsöffnung
N4 = Stutzen für Be- und Entlüftung DN 150
N5 = Reservestutzen DN 200 mit Blinddeckel
N6 = Stutzen für Rezierkulat DN 150
N7 = Stutzen für Biomix DN 200
N8 = Stutzen für Güllezufuhr DN 150
N9 = Stutzen DN 50 für Silagewasser
N10 = Rührwerksaufnahme
N11 = Stutzen DN 200
N12 = Stutzen 1" zur manuellen Füllstandsmessung
N13 = Revisionsöffnung am Steinfang mit Blinddeckel DN 300

Stutzenbelegung und -durchmesser oben auf dem Deckel und unten am Steinfang je nach Anlage variabel!

Annex 12

FAN Separator

Press Screw Separator

FAN Press Screw Separator

The FAN Press Screw Separator PSS

- **The FAN PSS can handle thick (20% solids) as well as thin slurries (down to 0.1% solids)**
- **Dryness of the separated solids can be adjusted between 25% and 55% TS (depending on application and model)**
- **High capacity and production of very dry solids**
- **Minimal maintenance, no special training required**
- **Very low power consumption**
- **The FAN PSS is optionally equipped with an oscillator unit (patented) for improved performance and higher capacity**
- **Main components are constructed out of stainless steel**
- **Auger of the PSS is hard coated for longer life**
- **Body available in cast iron, stainless steel or cast stainless steel**
- **Screen will be cleaned continuously by the auger because of very tight tolerances**
- **The FAN PSS is optionally equipped with a flushing device inside the body**

The PSS is fed by pump or gravity from a holding tank. It is also possible to feed the PSS by hopper. The optimal feeding method depends on the raw material consistency and the site conditions.

Inside of the inlet section, an oscillator unit (patented) inducts oscillating pressure into the liquid. This leads to an improved performance and a higher capacity, especially with viscous liquids.

In the slotted screen, the fibrous solids are screened out from the liquid. The fibres build up a layer which also acts as a filter to separate finer particles from the liquid. The auger flights convey this layer to the solids outlet. The screen surface is cleaned and a new filter layer is formed.

The design of the screens is not conducive to plugging. The pressure in the first part of the screen is low but increases with the solid consistency to the solid output. The friction of the solid plug in the cylindrical mouthpiece and the double flap of the output regulator provide counter pressure for further dewatering of the solids.

The dryness of the solid cake can be adjusted by the number and position of the weights (patented output regulator).

Biogas

Food

Separation Solutions for Processing Industries and Agriculture

Agricultural applications:

Solid-liquid separation of pig, cattle and poultry manure for:

- Volume reduction
- Odour reduction
- Nutrient reduction
- Easier irrigation
- Reuse of solids for bedding
- Reuse of liquids for flushing
- Cleaning of lagoons
- Composting of solids
- Further slurry treatment possibilities

Biogas and bio-ethanol plants:

- Solid-liquid separation before and after biological treatment

Slaughterhouse applications:

- Waste water treatment and fibre recovery
- Dewatering of paunch and intestines
- Separation of pig manure, straw, sand, shavings and stomach contents
- Dewatering of truck wash water
- Separation of tannery waste water
- Separation of rendering products
- Separation of coagulated blood products

Food industry applications:

- Treatment of vegetable, fruit, cereal, sludge and waste water
- Treatment of olive remaining after 2-phase decanter
- Treatment of distillery and brewery grains

Pulp and paper applications:

- Rejects of stock preparation
- Sludge from water treatment
- Precleaning of waste water streams
- Water cleaning for reuse
- Dewatering of stock
- Fibres recovery
- Compacting of waste
- Chip wash water
- Pulp washing

Fibres and panel board applications:

- Chip wash water
- Waste water
- Cleaning water circles of filter systems

Plastic recycling:

- Cleaning of wash water
- Dewatering of rejects

Pulp and paper

Agriculture

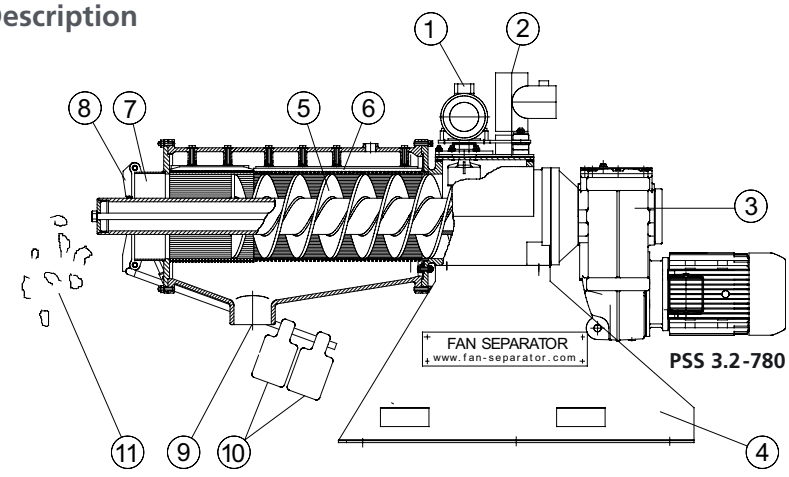
PSS 1.2-520

PSS 3.2-780

PSS 3.2-1040

PSS 5.2-1040

Description



1 Oscillator	5 Auger	9 Exit for separated liquid, 5“
2 Inlet, 4“	6 Screen	
3 Gearmotor	7 Mouthpiece	10 Counterweight
4 Stand	8 Output regulator	11 Separated solids

Major patent rights

Separation principles (Patent EP 0 367 037 / USA Patent No. 5, 009, 795) consisting of:
- relationship between of screen diameter and auger pipe diameter is designed that a hollow cylindrical solid plug is produced
- transfer of tangential force from the screen via guide rails
- screen construction, made of screen bars
- output regulation with flaps and weights for regulating dryness of cake

Oscillator system (Patent EP 0 443 385 / USA Patent No. 5, 118, 427):
- transmits vibrations into the liquid to increase the viscosity

Technical Data

Separator Model	Power kW	Power HP	Max. capacity m^3/h*	Max. capacity USgpm*	Max. capacity bd t/d*	Max. capacity cubic yards/d*
PSS 3.2 / 4.2 / 5.2 - 520	4.0 – 5.5	5.5 – 7.5	50	220	8	10
PSS 3.2 / 4.2 / 5.2 - 780	5.5 – 7.5	7.5 – 10.0	80	352	10	13
PSS 3.2 / 4.2 / 5.2 -1040	7.5 – 11.0	10.0 – 15.0	100	440	12	15
PSS 8 - 800	18.5	25.0	150	660	30	40
PSS 8 -1200	18.5 – 30.0	25.0 – 40.0	250	1100	40	50
PSS 8 -1600	30.0	40.0	350	1540	50	60

*) depending on material to be separated, inlet consistency and screen slot size

Special features of the FAN Press Screw Separator

Flushing device in PSS for separation of waste water e.g. in slaughterhouses

The FAN PSS machines are equipped with a flushing device inside the PSS between screen and housing for separating waste water from the slaughtering process in abattoirs. With this device the screen will be flushed with hot water under pressure in intervals, which are for each application adjustable.
Herewith the screen will be continuously kept clean and prevents that grease blocks the screen when the machine is not in operation.

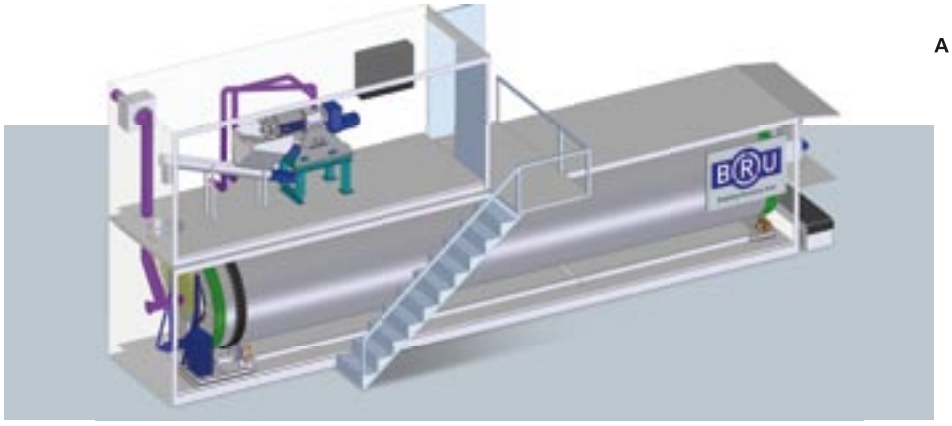
Specially designed augers for various application

The augers of the FAN PSS are equipped with a hard coating on their outer diameter. In addition to the standard coating, there are also special coatings available specifically suited for use with abrasive materials, or an acid-resistant coating for use with wastewater having a low ph-value. In the area with the highest pressure at the front of the auger, the flights are completely wear-protected. Augers with a larger distance between flights are also available. When separating the paunch manure of cattle for instance, which can sometimes contain medication tubes, an auger is available which allows the tubes to be transported through the PSS without clogging inside of the machine.
For sticky materials, augers can be equipped with a teflon coating which prevents such material from rotating together with the auger and blocking the machine.

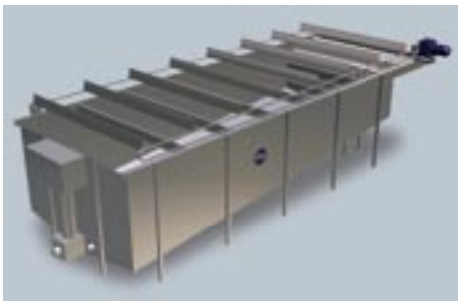
Newly designed inlet housing of PSS

The inlet body of the PSS is now equipped with a tooth-system so that long fibers cannot build up on the outer diameter of the auger and block the machine. In addition, there are adjustable „straw bolts“ at the inlet of the screen for preventing long fibers from adhering to the auger and causing wear on the screen. Between the screen and the inlet body, there is also an exchangeable body protection ring which reduces wear. Only the ring itself needs to be replaced when necessary.

A BAUER Group company



FAN Bedding Recovery Unit



FAN Dissolved Air Flotation Unit

FAN Submersible Mixer

FAN Submersible Pump

FAN Centrifuge Classifier Separator

FAN Filter Oscillating Separator

FAN Separator addresses

Main office:
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Fax: +852-2528 1167
E-mail: fhml@netivator.com

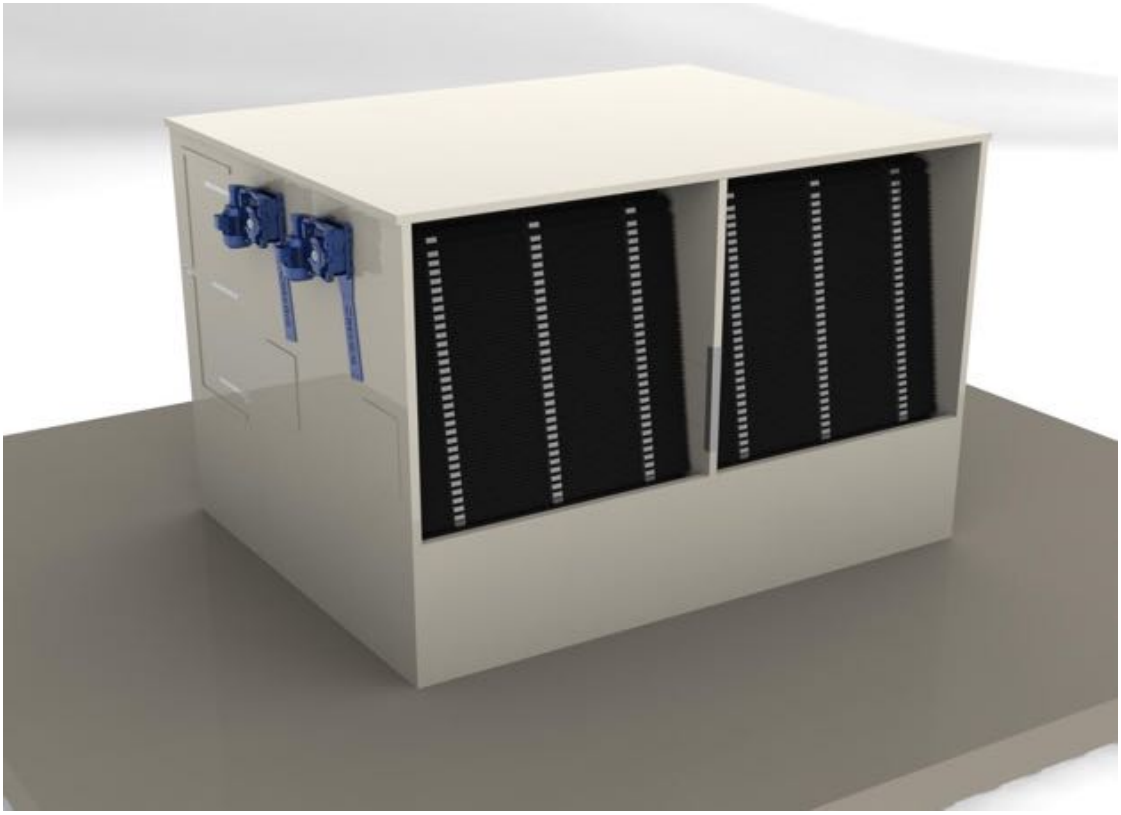
FAN Separator (USA) Inc.
107 Eastwood Road
Michigan City, IN 46360 USA
Phone: +1-219 879 4986
Fax: +1-219 879 5160
E-mail: fanusa@fan-separator.com

Representative:
Our listing of additional FAN representatives is available on request.

Annex 13

Datasheet Cascata Type E

The Cascata dryer (thickener), is developed to utilize residual heat in order to increase the TS (total solids) content in liquid manure. The process is as follows: a rotating chain with lamellae is pulled through a basin with manure. Then the lamellae are exposed to hot air. Due to the large surface area for drying the moisture will evaporate and the TS content in the substance increases. The thickener functions as dust collector as well. As process air the residual heat from, for example, a belt dryer can be used. In this set up one makes the maximum use of (residual) heat.



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Green machines b.v.
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Cascata one step	max. 250 KW	max. 500KW	max. 1MW	max. 1,5 MW
Type	20E	40E	80E	120E
Dimensions mm (LxWxH)	2659x2076x2800	3806x1950x2800	7510x1950x2800	11214x1950x2800
Number of compartments	1	2	4	6
Number of stages	1	1	1	1
Weight	1200 kg	2000 kg	4000 kg	5400 kg
Number of lamellae	150	300	600	900
Surface area for drying	90m^2	180m^2	360m^2	540m^2
Efficiency	0,6 – 0,8 kg Wasser p/kWth			
Air				
Air velocity	1,6 mtr./sec	1,6 mtr./sec	1,6 mtr./sec	1,6 mtr./sec
Pressure drop	30 Pa	30 Pa	30 Pa	30 Pa
max. Temperature	70°C	70°C	70°C	70°C
Air flow m3/h max.	20.000 m3/h	40.000 m3/h	80.000 m3/h	120.000 m3/h
Air flow m3/h gem.	12.000 m3/h	24.000 m3/h	46.000 m3/h	72.000 m3/h
Ammonia expected 4kg/m3	1 kg/h	2 kg/h	4 kg/h	6 kg/h
Emisson	0,1 kg/h	0,2 kg/h	0,4 kg/h	0,6 kg/h
Acid consumption	2,7 kg/h	5,4 kg/h	10,8 kg/h	16,2 kg/h
ASL production	20 lt/h	40 lt/h	80 lt/h	120 lt/h
Aircleaner				
Two step aircleaner	Filter surface load 5.500 m3/m2			
Three step aircleaner	Filter surface load 5.500 m3/m2			
Trickle-bed reactor	Filter surface load 2.000 m3/m2			

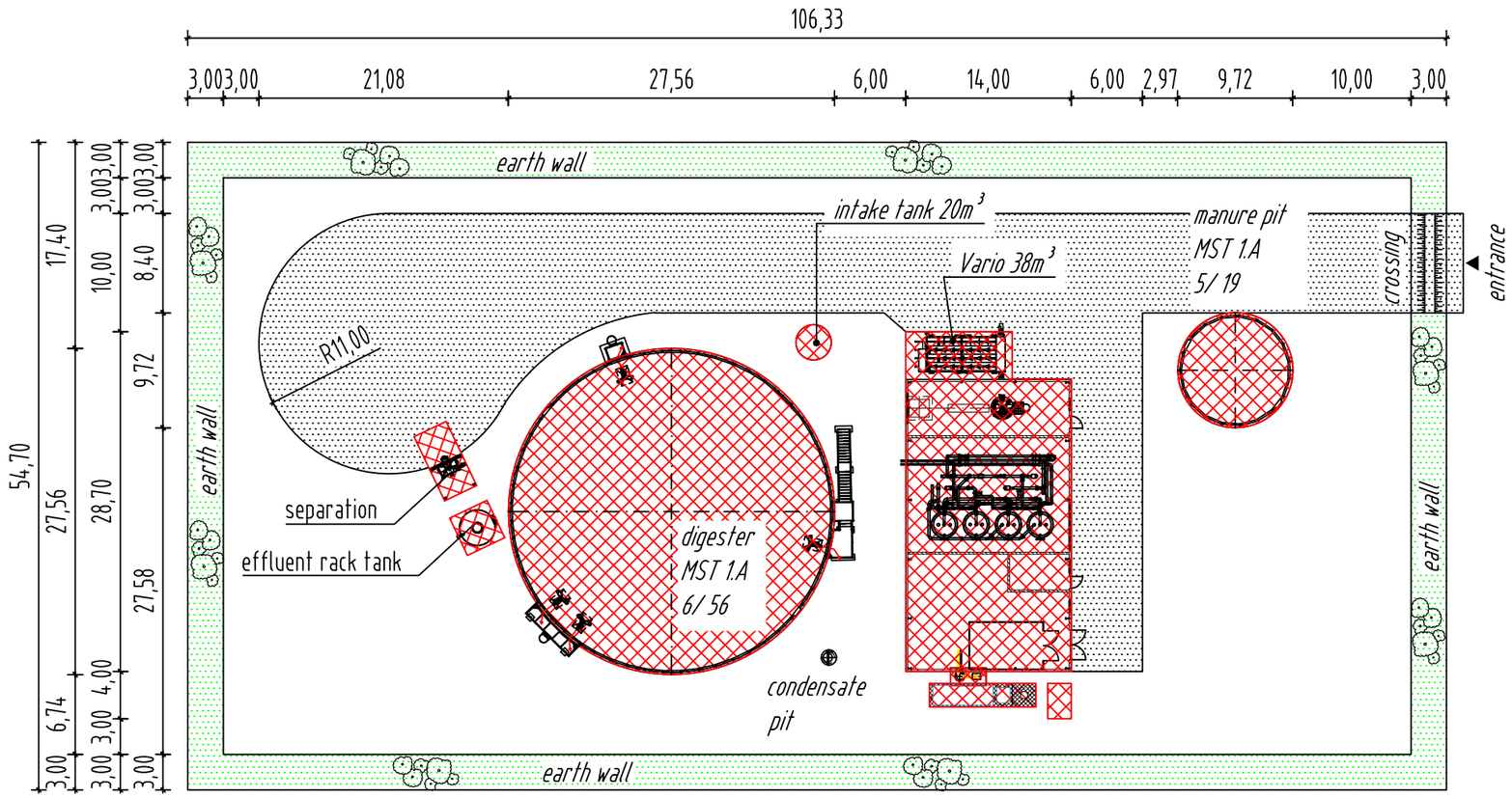
Product				
TS content supply	ca.2-5% 500kg/h	ca.2-5% 1 t/h	ca.2-5% 2 t/h	ca.2-5% 3 t/h
TS content discharge	ca.8-14% 300kg/h	ca.8-14% 0,6 t/h	ca.8-14% 1,2 t/h	ca.8-14% 1,8 t/h

Connected values				
Drive motor	1 x 0,75 kW	1 x 0,75 kw	2 x 0,75 kW	2 x 0,75 kW
Ventilators	1 x 2,2 kW	2 x 2,2 kw	4 x 2,2 kW	6 x 2,2 kW
Digistate pump	2 x 2,2 kW	2 x 2,2 kw	2 x 2,2 kW	2 x 2,2 kW
Lye/acid pump	1 x 0,12 kW	1 x 0,12 kW	1 x 0,12 kW	1 x 0,12 kW
Pump aircleaner	2 x 1,5+1,5 kW	1,5+2,2+1,5 kW	2,2+4+2,2 kW	4,0+5,5+4,0 kW
Pump trickle-bed reactor	1 x 1,5 kW	1 x 1,5 kW	1 x 3,0 kW	1 x 4,0 kW

Total KW	13,47	16,37	26,22	36,72
Average power consumption KW	10	11	17	26

The manure feed pump is not included.

Annex 14



LEGEND

- existing puplic traffic surface
- planned public traffic surface
- planned private traffic surface
- existing private traffic surface
- existing residantial building, firm
- existing farm buildings, work building, immovable auxiliary building, garage etc
- planned structural facility
- planned private gravel surface
- green area
- outline of structural facilities
- delimitation of distance areas
- planned property border
- building border

drawing number: xx-xxxxxx_1.LP00/3-00
type: xx-xxxxxx
scale: 1:500
representation: Layout plan

date: 30.10.2014
drawn: S.Selzer

draft

EnviTec Biogas

Biogas plant Human waste

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T:\2014\Angebote 2014\Roell\14-xxxxxx Human Waste\14-xxxxxx_1.LP00-00-LP_SOS.dwg

05.10.2012 09:12:07

Selzer, Sonja

ISO full bleed A3 (420.00 x 297.00 mm)

ANNEX 15

Story Board

Fecal sludge & organic waste recycling management: Study Mission in China

Location: China

December 07-10th, 2014; Beijing
11-14th, 2014; Chengdu

I. Traditional fecal sludge management in Beijing Urban City

- Approach road for sludge truck to fecal sludge treatment plant.

- Separation of foreign and other non-organic wastes from sludge

- Manual carrying of foreign substances

- Agitation tank

- Digester (not seen) & composting

- Use of heat

- Bio gas container

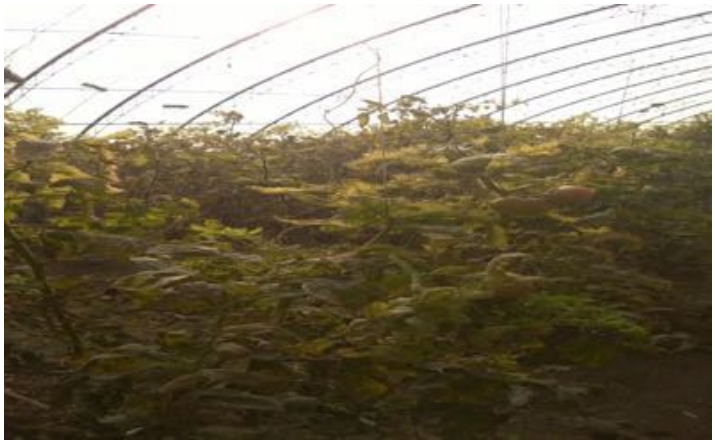
- Control panel for measuring temperature and conditions of sludge in the digester.

- Fecal sludge transformed into liquid organic fertilizer transferred to storage tank (underground) by pipe.

- Vegetable growing yard (covered) next to organic fertilizer underground tank (tip of the tank can be seen)

- Vegetable growing yard inside the area made of bricks and plastic sheet

- Organic fertilizer piped to yard for growing vegetable



- Inside the vegetable (tomato) growing yard.

- Health & safety guidelines for farmers growing vegetable with fecal sludge based organic fertilizer.

II. Heat Exchange & Chilling plant for a super market air conditioning system in Chengdu, China (Thermax brand)

- Running air conditioning of buildings and super markets.

- Heat exchanger-hot water to chilled air

- Address in Bangladesh:
  Thermax Ltd, Bangladesh
  Ph #: +8802 934 7754/934 1129
  Email: mvready@citech

型号		单位	SG 6M C	SG 6N C	SG 7K C	SG 7L C	SG 8K C	SG 8L C	SG 8M C	SG 8N C
制冷量		RT	661	711	744	810	909	992	1108	1190
		10^4kcal/h	200	215	225	245	275	300	335	360
冷冻水	流量	m³/h	400	430	450	490	550	600	670	720
	蒸发器流程					1+1				
	压力损失	mH₂O	11.9	12.2	4.8	4.9	3.8	4	6.5	6.6
	连接管径	DN	250				350			
冷却水	流量	m³/h	760	818	855	932	1045	1140	1275	1370
	吸收器流程		1,1		2,2					
	冷凝器流程		1,1							
	压力损失	mH₂O	6.3	6.6	9.1	9.6	8	8.2	12.6	12.9
	连接管径	DN	300		350		400			
热水	流量	m³/hr	126	136	144	157	176	192	215	231
	发生器流程		1+1							
	压力损失	mH₂O	1	1	1.2	1.2	1.2	1.3	2.1	2.1
	连接管径	DN	250		250		300			
外形尺寸	长 (L)	mm	7380		7380		7510		8760	
	宽 (W)	mm	2350		2840		3030		3030	
	高 (H)	mm	3310		3450		3770		3770	
运行重量		ton	28.5	29.4	36.4	39.2	47.9	49.5	55.5	56.8
运输重量		ton	23.75	24.35	32.05	32.55	39.3	40.05	46.65	46.6
拔管空间		mm	6650				6730		7980	
电气参数	溶液泵	kW (A)	6.6 (17.0)		4.5 (13.0)				5.5 (17.0)	
	制冷剂泵	kW (A)	1.5 (5.0)							
	真空泵	kW (A)	0.75 (1.8)							
	电源容量	kVA	18.1		15.2				18.1	
	电源		380V/ ±10%, 50 Hz (±5%), 3 Phase+N							

备注:
1 SG××C – 热水两段型溴化锂吸收式冷水机组
2 冷冻水进出口温度为12/7℃
3 冷却水进出口温度为32/38℃
4 热水进出口温度为130/90℃
5 水室标准承压为0.8MPa

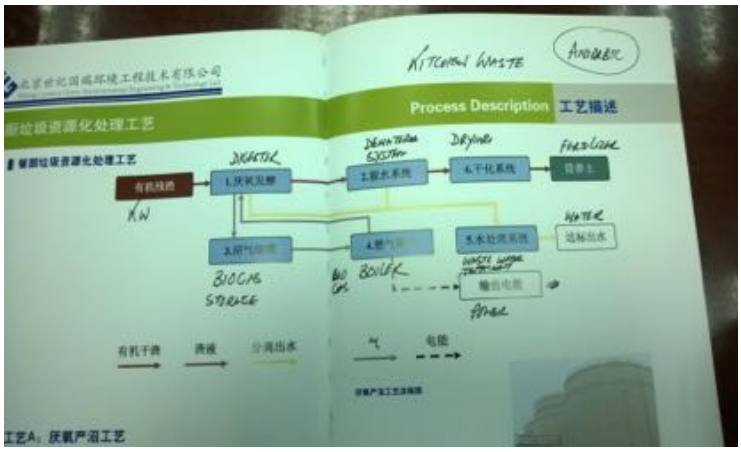
型号		单位	SG 3M C	SG 4K C	SG 4L C	SG 4M C	SG 5K C	SG 5L C	SG 6K C	SG 6L C
制冷量		RT	248	281	331	347	397	430	496	546
		10^4kcal/h	75	85	100	105	120	130	150	165
冷冻水	流量	m³/h	150	170	200	210	240	260	300	330
	蒸发器流程		1+1							
	压力损失	mH₂O	3.1	3.1	3.3	3.4	3	3	5.4	5.6
	连接管径	DN	150				200		250	
冷却水	流量	m³/h	285	323	380	400	456	493	570	628
	吸收器流程		2.2							
	冷凝器流程		1.1							
	压力损失	mH₂O	8.7	9.5	10.1	10.7	9	9.2	8	8.2
	连接管径	DN	200				250		300	
热水	流量	m³/hr	48	54.5	64	67.5	77	83	96	106
	发生器流程		1+1							
	压力损失	mH₂O	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5
	连接管径	DN	150	200			200		250	
外形尺寸	长 (L)	mm	4620	4660			4750		5920	
	宽 (W)	mm	1930	2090			2270		2260	
	高 (H)	mm	2730	3050			3210		3310	
运行重量		ton	12.5	14.9	15.4	15.8	19.1	19.6	21.1	24.3
运输重量		ton	10.8	12.7	13.0	13.3	15.9	16.25	17.85	20.1
拔管空间		mm	4070				4160		5200	
电气参数	溶液泵	kW (A)	1.5 (5.0)		3.7 (11.0)				5.5 (14.0)	
	制冷剂泵	kW (A)			0.3 (1.4)					
	真空泵	kW (A)	0.75 (1.8)							
	电源容量	kVA	6.9		11.2				13.4	
	电源		380V/ ±10%, 50 Hz (±5%), 3 Phase+N							

III. Fecal sludge management in Beijing Metropolitan Area

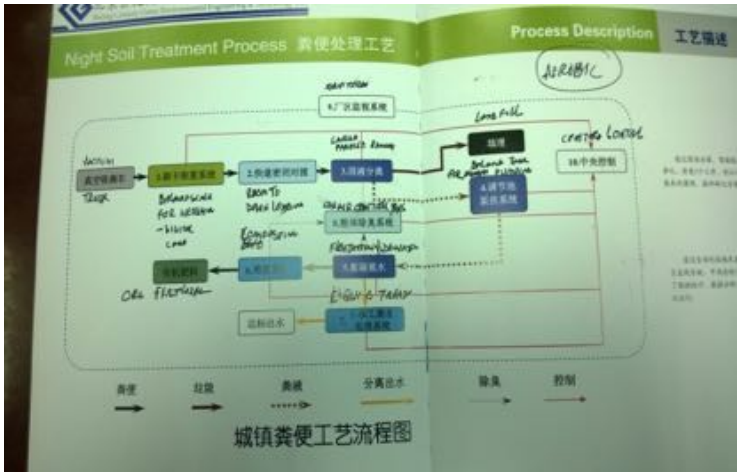
- Beijing Century Green Environmental Engineering & Technology Ltd., Beijing, China.
  Process technology and equipment supplier

- Waste samples; pre and past treatment

- Kitchen waste aerobic process schematic diagram



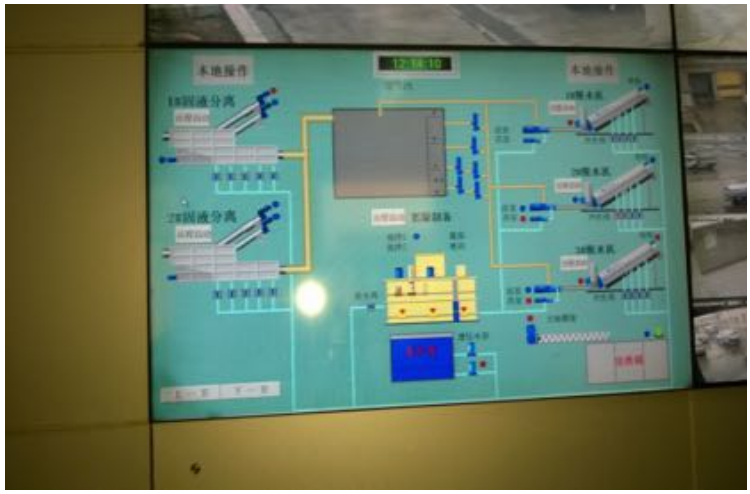
- Night soil (Fecal sludge)/Aerobic process schematic diagram



- Fleet of fecal sludge transportation trucks

- Waiting logistics support vehicles

- Monitoring system



- Fecal sludge composting chamber inlet pipes.

- Monitoring personnel

- Truck for loading fecal sludge to unloading chamber

- Truck of loading fecal sludge to composting chamber through inlet pipes.

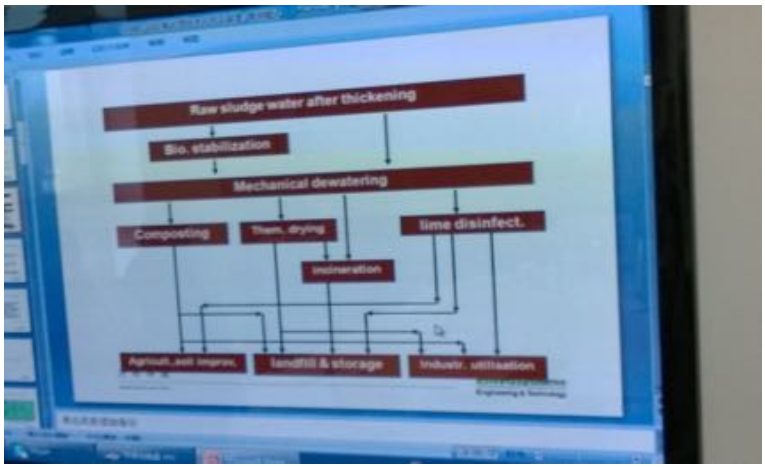
- Feeding of kitchen waste to composting chamber

- Stainless steel extruder for feeding waste to composting chamber

- Separating foreign elements

- Moving organic compost (fertilizer) to truck loading station

- Control panel inside the monitoring station



- Loading (dropping) of semi0-solid fecal sludge compost (organic fertilizer) to covered truck to carry it to public greenery in Beijing.

- Gas discharged from the system/plant is treated with chemical to make it into not harmful odour that is released into the air.

IV. Bio fertilizer factory from chicken manure in Chengdu, China

- Organic fertilizer enterprise in Chengdu, China. The enterprise uses chicken manure and tobacco plant stems to produce organic fertilizer.

- Mixing of ingredients

- Mixing of ingredients

- Transporting the organic fertilizer

- Finished product

- Packaging

V. Chengdu Institute of Biology, Gas, Chengdu Test Base of Bio transformation and recycling

- Pilot project for the promotion of bio-gas based organic fertilizer plant; originally designed on truck based collection of fecal sludge.

- The truck (no longer used)

- Name & contact details of the vehicle/truck manufacturers

- Display board on the uses of the truck

- Digester construction demonstration (sectional view)

- Digester construction (sectional view)

- Underground digester

- Underground digester

- Digester to consumption point piping

- Water heater running on bio-gas, connected by a pipe.

- Gas connection to kitchen

- Gas connection to kitchen

- Gas storage tank either abandoned or under construction.

- Gas storage tank

- Bio-gas plant setup parts and burner store in the front part of the pilot project

- Bio-gas burners being sold to customers

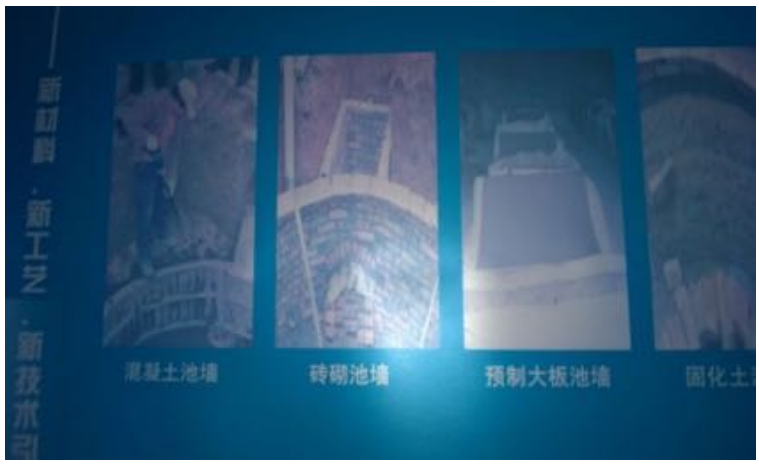
- Full view of the store

- Close-up view of the organic composting.

- Household use of organic fertilizer composting close to piggery shed; underground composting.

- Vegetable growing close to organic fertilizer composting

- Guide to setting up a bio-gas plant



- Guide to setting up bio-gas plant

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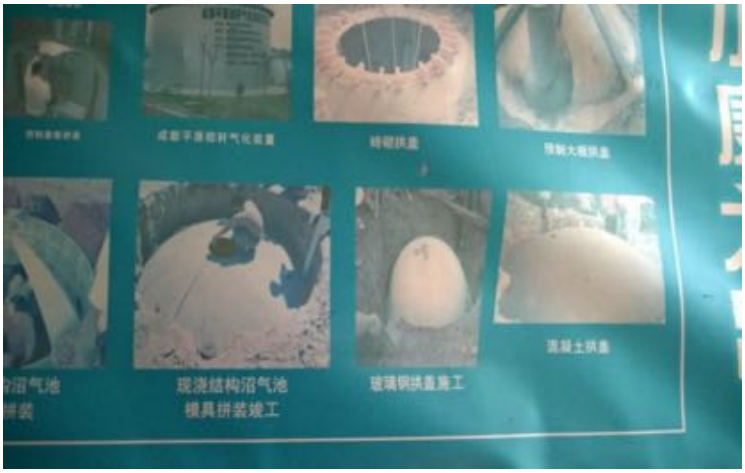

- Guide to setting up a bio-gas plant