RE Practices in Bangladesh - Biogas

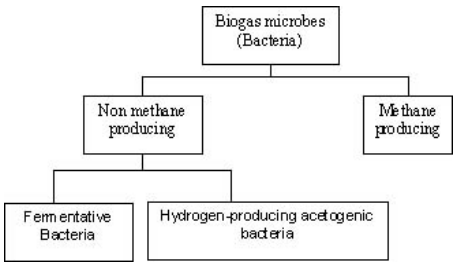
DESIGN OF BIOGAS PLANT

1.1 Introduction:

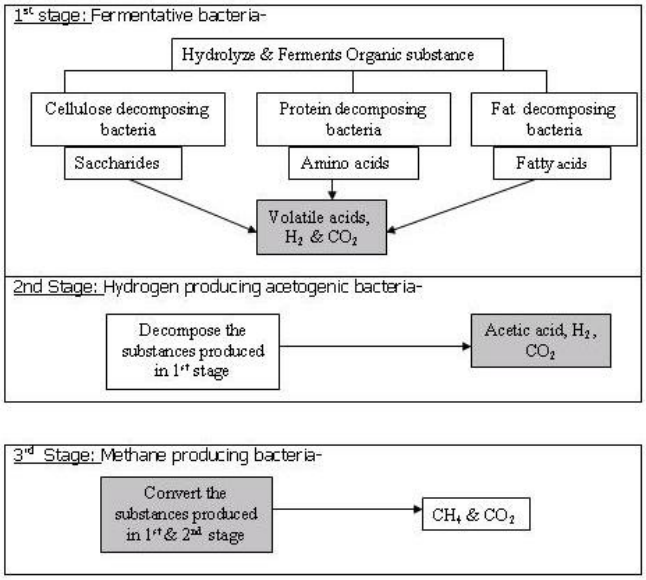
Biogas can be obtained from any organic materials after anaerobic fermentation by three main phases.

1.2 Mechanism of biogas fermentation:

A) Groups of Biogas microbes-



B) Groups of microbes involved in the 3 stages of biogas fermentation



1.3 Design parameter:

A) Selection of materials.

B) Total solid (TS) contains calculations of organic materials Organic materials-

Solid part: Total solid contained in a certain amount of materials is usually used as the material unit to indicate the biogas- producing rate of the materials. Most favourable TS value desired is 08%.

Liquid part : As per Annexure-I

C) Favourable temperature, P^H value & C/N ratio for good fermentation-

Temperature : Mesophilic; 20^o c to 35^o c (Annexure-II).
P^H value : Neutral P^H and ranges 6.8 to 7.2
C/N ration : Ranges from 20:1 to 30:1 (Annexure- VI)

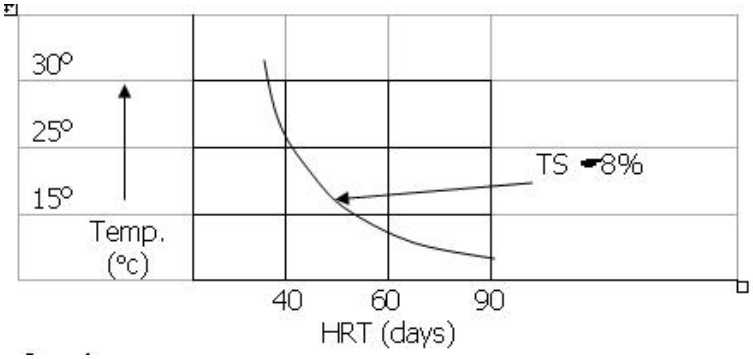
D) Table showing discharge per day, TS value of fresh discharge and water to be added to make favorable TS condition-

Kinds	Body weight (kg)	Discharge per day (kg)	TS value of fresh discharge (% by wt.)	Water to be added with fresh discharge to make the TS value 8% (kg)
Human	50	0.5	20	0.75
Cow	200	10	16	10
Chicken	1.5	0.1	20	0.15
Pig	50	5	20	7.5

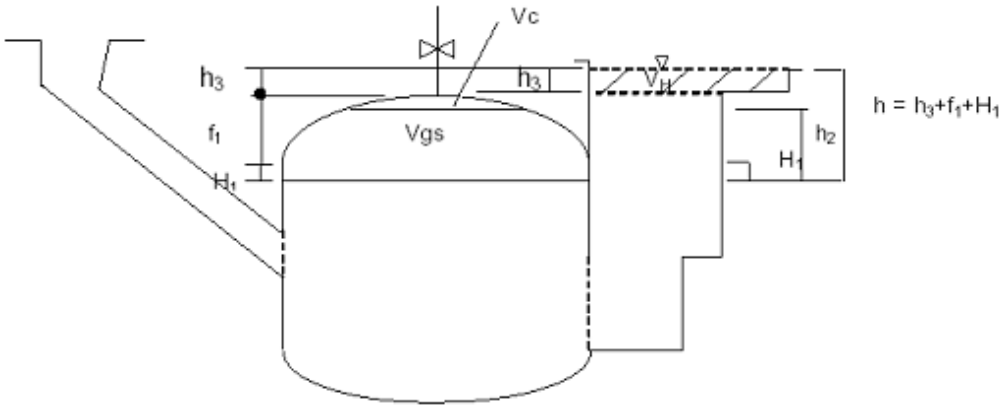
E) Hydraulic retention time (HRT)-

For Mesophilic digestion where temp. varies from 20^o c to 35^o C and HRT is greater than 20 days.

1.4 Relationship between temperature, HRT & TS value of 8% :

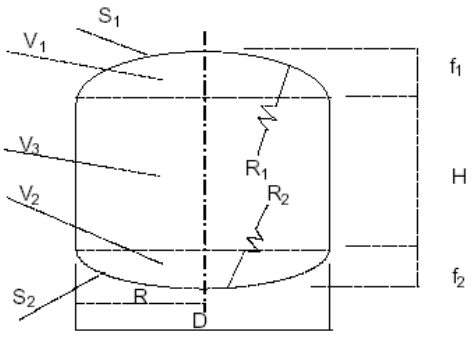


1.5 Cross-section of a digester:



a. Volume of gas collecting chamber = Vc
b. Volume of gas storage chamber = Vgs
c. Volume of fermentation chamber = V_f
d. Volume of hydraulic chamber = V_H
e. Volume of sludge layer = Vs
Total volume of digester **V** = $Vc+Vgs+V_f+Vs$

1.6 Geometrical dimensions of the cylindrical shaped biogas digester body:



1.7 Assumptions:

For volume	For geometrical dimensions
Vc = 5% V	D =1.3078 X $V^{1/3}$
Vs =15% V	V_1 =0.0827 D^3
Vgs + V_f = 80% V	V_2 = 0.05011 D^3
Vgs = V_H	V_3 = 0.3142 D^3
Vgs = 0.5 (Vgs + V_f + Vs) K	R_1 = 0.725 D; R_2 = 1.0625 D
Where K= Gas production rate per m^3 digester volume per day. For Bangladesh K = 0.4 m^3/m^3d.	f_1 = D/5; f_2 = D/8
	S_1 = 0.911 D^2; S_2 = 0.8345 D^2

1.8 Volume calculation of digester and hydraulic chamber:

A) Volume calculation of digester chamber-

Given: 6 cows of body weight 200 kg each.; Temp. = 30^{O}C (average)

Sol^n:

Let HRT = 40 days (for temp. 30^O C)
Total discharge = 10 kg X 6 = 60 kg/day
TS of fresh discharge = 60 kg X 0.16 = 9.6 Kg.

In 8% concentration of TS (To make favourable conditions)
8 kg. Solid = 100 kg. Influent
1 kg. Solid = 100 / 8 kg influent
9.6 Kg Solid = 100 x 9.6/ 8 = 120 kg. Influent.

Total influent required = 120 kg.

Water to be added to make the discharge 8% concentration of TS =120 kg - 60 kg. = 60 kg.
Working volume of digester = Vgs + V_f
Vgs + Vf = Q.HRT
= 120 kg/day X 40 days = 4800 kg. (1000 kg = 1 m^3) = 4.8 m^3.

From geometrical assumptions:
Vgs + V_f = 0.80 V
Or V = 4.8/0.8 = 6.0 m3. (Putting value Vgs + Vf = 4.8 m3)
& D = 1.3078 $V^{1/3}$ = 2.376 m @ 2.40 m.

Again

$$V_s = \frac{3.14 \times D^2 \times H}{4}$$ (Putting V_3=0.3142D^3) $$Or, H = \frac{4 \times 0.3142 \times D^3}{3.14 \times D^2} = 0.96m$$

Say H = 1.00m

Now we find from assumption as we know the value of 'D' & 'H'

f_1 = D/5 = 2.40 /5 = 0.480 m ; f_2 = D/8 = 0.30m
R_1 = 0.725 D = 1.74 m ; R_2 = 1.0625 D = 2.55 m
V_1 = 0.0827 D^3 = 1.143 m^3 ; Vc = 0.05V = 0.3 m^3

Now the dimension of digester chamber is known & drawn below-

B) Volume calculation of hydraulic chamber-

From assumptions:
Vc = 0.05 V = 0.3 m^3
Vgs = 0.50 x (Vgs + V_f + Vs) x K (Where K = Gas production rate per m^3digeste vol./day)
= 0.5 x 5.7x 0.4 =1.14 m^3 ---------- **(A)**

Again,
Vgs = 50% of daily gas yield
= 0.5 x TS x gas producing rate per kg TS
= 0.5 x (60 kg x 0.16) x 0.28 m^3/kg TS (See Annex- III)
= 1.344 m^3 ---------- (**B)**

From **A & B, let Vgs = 1.344** m^3**.**

Vc + Vgs = 0.3 m^3 +1.344 m^3 = 1.644 m^3

Again, V_1 = [{(Vc + Vgs) - {p D^2 H_1}/4]

= [1.644 - {3.14 x $(2.4)^2$ x H_1}/4]

Or, H_1 = 0.110m

We have fixed **h** = 800 mm water volume (I mm = 10 N/ m^2)

h = h_3 + f_1 + H_1

Or, h_3 = 0.210m.

Again we know that

Vgs = V_H

Or, 1.344 m^3 = 3.14 x $(D_H)^2$ x h_3/4

Or, D_H = 2.85m

Now we know the dimension of hydraulic chamber. Moreover keeping h = 800 mm, we can choose or re-arrange the dimension considering availability of site and construction suitability. For most suitable dimensions we can select the drawing of Annexure- IX for 60 Kg cow dung per day as raw material.

Note: For ready reference 4 family type Biogas plant's drawing is shown(std. dimension's) in Annexure-VIII, Annexure-IX, Annexure-X & Annexure-X1 where 40kg, 60kg, 80kg and 100Kg cow dung is considered as raw material per day respectively. If bigger size plant is required, it can be designed keeping all safety considerations in design and construction.

Annexure- 1

Table 1: The Total Solid Content of Common Fermentation Materials in Rural Areas (Approx.)

Materials	Dry matter content (%)	Water content (%)
Dry rice straw	83	17
Dry wheat straw	82	18
Corn stalks	80	20
Green grass	24	76
Human excrement	20	80
Pig excrement	18	82
Cattle excrement	17	83
Human Urine	0.4	99.6
Pig Urine	0.4	99.6
Cattle Urine	0.6	99.4

Annexure-II

Table 2: Biogas-Producing Rates of Some Common Fermentation Materials at Different Temp. (m^3/kg TS)

Materials	Medium temperature (35° C)	Ordinary temperature (8 ^{o} ~25^o C)
Pig manure	0.45	0.25 ~ 0.30
Cattle dung	0.30	0.20 ~ 0.25
Human wastes	0.43	0.25 ~ 0.30
Rice straw	0.40	0.20 ~ 0.25
Wheat straw	0.45	0.20 ~ 0.25
Green grass	0.44	0.20 ~ 0.25

Experimental conditions: The fermentation period of the excrement materials lasts 60 days and that of the stalk type lasts 90 days. The fermentation material concentration (total solid content) is 6%.

Annexure- III

Table 3: Biogas Producing Rates of Some Fermentation Materials and Their Main Chemical Components.

Materials and their main components	Yield of Biogas m^3/kg TS	Methane content (%)
Animal barnyard manure	0.260 ~ 0.280	50 ~ 60
Pig manure	0.561	
Horse droppings	0.200 ~ 0.300	
Green grass	0.630	70
Flax straw	0.359	
Wheat straw	0.432	59
Leaves	0.210 ~ 0.294	58
Sludge	0.640	50
Brewery liquid waste	0.300 ~ 0.600	58
Carbohydrate	0.750	49
Liquid	1.440	72
Protein	0.980	50

Annexure- IV

Table 4: Biogas Producing Rates of Several Substances

Material	YpCMDV (m^3/m^3d)	YpkgM (m3/kgTS)	Amount of biogas produced in a period of time (as a % of the total yield)			
			0 ~15 (d)	15 ~ 45 (d)	45 ~ 75(d)	75 ~ 13 (d)
Water Hyacinth	0.40	0.16	83	17	0	0
Alligator Weed	0.38	0.20	23	45	32	0
Water Lettuces	0.40	0.20	23	62	15	0
Cattle Dung	0.20	0.12	11	33.8	20.9	34.3
Pig Manure	0.30	0.22	19.6	31.8	25.5	23.1
Human Wastes	0.53	0.31	45	22	27.3	5.7
Dry Grass	0.20	0.21	13	11	43	33
Rice Straw	0.35	0.23	09	50	16	25

Note: - The fermenting temperature is 30^{o}C. It is batch-fed fermentation. YpCMDV refers to the average yield of biogas per cubic meter of the digester volume during the period of normal fermentation (m^3/ m^3d). YpkgM refers to the yield of biogas per kilogram of the fermentation material (m^3/kg TS)

Annexure-V

Table 5: The Speed of Biogas Production with Common Fermentation Materials.

Speed	Amount of biogas produced in a period of time (expressed as a percentage of the total yield of biogas)									Biogas Producing rate
Time(d)	10	20	30	40	50	60	70	80	90	(m^3/kg TS)
Materials										
Human wastes	40.7 *	81.5 *	94.1 **	98.2	98.7	100				0.478
Pig manure	46.0 *	78.1 *	93.9 **	97.5	99.1	100				0.405
Green grass	-	-	-	98.2 **	-	100				0.410
Cattle dung	34.4 *	74.6 *	86.2	92.7 **	97.3	100				0.300
Wheat straw	8.8	30.8	53.7 *	78.3 **	88.7	93.2 **	96.7	98.9	100	0.435

* Biogas production is at the highest speed.

** Amount of Biogas produced to more than 90% of the total yield of a fermentation period.

Experimental conditions: - Fermenting temperature 35^{o}C, the total length of fermentation period being 60 days for the excrement material and 90 days for the stalk type, the materials concentration; total solid content of the fermentative fluid being 6%.

Annexure- VI

Table 6: Carbon-Nitrogen Ratios of Some Common Fermentation Materials (Approx.)

Material	Carbon content of material (%)	Nitrogen content of materials (%)	Carbon-nitrogen ratio (C/N)
Dry wheat straw	46	0.53	87:1
Dry rice straw	42	0.53	67:1
Corn stalks	40	0.75	53:1
Fallen leaves	41	1.00	41:1
Soybean stalks	41	1.30	32:1
Wild grass	14	0.54	27:1
Peanut stems and leaves	11	0.59	19:1
Fresh sheep droppings	16	0.55	29:1
Fresh cattle dung	7.3	0.29	25:1
Fresh horse droppings	10	0.42	24:1
Fresh pig manure	7.8	0.60	13:1
Fresh human wastes	2.5	0.85	29:1

Annexure- VII

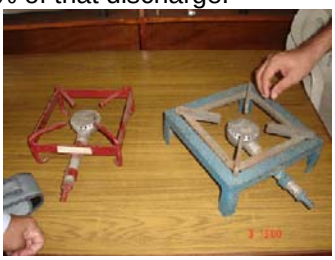
Table 7: Amount of Human and Animal Waste Discharged per Day (Approx.)

Kinds	Body weight (kg)	Daily amount of excrement (kg)	Daily amount of urine (kg)	Annual amount of excrement discharged (kg)	Annual amount of excrement collection (kg)	Daily yield of biogas per capita (m3)
Pig	50	6	15	2190	1752	0.18 ~ 0.25
Ox	500	34	34	12410	9928	0.36 ~ 0.96
Horse	500	10	15	3650	2920	
Sheep	15	1.5	2	548	438.4	
Chicken	1.5	0.10	0	36.80	29.44	0.0076 ~ 0.0112
Human	50	0.50	1	182.50	146.00	0.028

Note: The annual amount of excrements collected accounts for 80% of that discharge.

A Complete Plant (Old)

A Complete Plant (New)



Burner

Hajjak light based on biogas

This Fixed Dome type biogas design has been carried out by Bangladesh Council for Science and Industrial Research (BCSIR) and found to be successful.

Source:

Renewable Energy & Environmental Information Network (REEIN)
E-mail: reein@dhaka.net, myreein@yahoo.com, reeinorg@hotmail.com, reeinorg@gmail.com ; **Website: http://www.reein.org**

The Key stakeholders in Biomass Technology application of Bangladesh :

Potential stakeholders for a national programme on domestic biogas in Bangladesh divided into government, civil sector and private sector organizations.

Organizations involved in the dissemination of biogas plants in Bangladesh and number of plants installed:

S No	Organization	Installation Period	Number of Biogas plants installed
1	Bangladesh Council of Scientific & industrial Research (BCSIR)	1973-2005	22,100
2	Local Government Engineering Department (LGED)	1985-2001	7,000
3	Department of Environment (DoE)	1979-1983	260
4	Bangladesh Rural Advancement Committee (BRAC)	1987-2005	300
5	Department of Livestock Services (DLS)	1988-1994	70
6	Thengamara Mohila Sabuj Sangha (TMSS)		
7	Bangladesh Small & Cottage Industries Corporation (BSCIC)	1983-1988	30
8	Bangladesh Agricultural Development Corporation (BADC)	1983-1984	20
9	Danish International Development Agency (DANIDA)	1982	4
10	Bangladesh Agricultural University (BAU)	1971-1973	2
11	Housing & Building Research Institute (HBRI)	1981	2
12	Bangladesh Academy for Rural Development (BARD)	1974	1
13	Bangladesh Commission for Christian Development (BCCD)	1978	1
14	Bangladesh Rice Research Institute (BRRI)	1983	1
	Total		**29791**
15	**Construction Partner Organization (CPO) under IDCOL (Infrastructure Development Company Ltd)**		
	Grameen Shakti (GS its own programme + IDCOL)		6000
	SOUL		1000
	Kamrul Biogas		517
	Rahman Biogas		367
	Hosain Biogas		301
	RSF		205
	Srizony Bangladesh		240
	Shubashati		116
	BRIDGE		23
	SAPNO		44
	Nirapod Engineering Ltd.		30
	Sangram		25
	BASA		20
	Sonali Unnayan Foundation		35
	DESHA		23
	Practical Action		18
	Nurunnabi Biogas		11
	Change Maker		3
	Palli Shakti		2
	Jahanara Biogas		1
	Total (November 19, 2008)		**8982**
	Grand Total (November 19, 2008)	**1971-2008**	**38,773**

Source:

Renewable Energy & Environmental Information Network (REEIN)
E-mail: reein@dhaka.net, myreein@yahoo.com, reeinorg@hotmail.com, reeinorg@gmail.com
Website: http://www.reein.org

Contact Address of CPOs (Construction Partner Organisations) under National Domestic Biogas and Manure Programme (NDBMP)

National Domestic Biogas and Manure Programme (NDBMP)

Infrastructure Development Company Limited (IDCOL), UTC Building (16th Floor), Panthopath, Dhaka.

CPO Information List - **Date:** 6/12/2008

S No	CPO ID	CPO Name	Address	Agreement Date	Email	Contact Person	Telephone
1	KB	Kamrul Biogas and Compost Fertilizer co ltd	BESIC Road, Police line, Natun BazarRajbari	01/01/2005	kollol116@hotmail.com	Mr. Kamrul Islam, Managing Director	01711-264842
2	HB	Hosain Biogas and Compost fertilizer company	90-Chuadanga Road, Jhenidah-7300.Jhenaidah	02/01/2005	uttoron05@yahoo.com	Mr. Ismail ossain, Executive Director and CEO	01711-248243
3	SL	Save our Urban Life - SOUL	16 Noya polton (3rd floor), Dhaka-1000.Dhaka	03/01/2005	soulbangla@yahoo.com	Mr. Ahashan abib, Executive Director	01713-442540,01713-442541
4	RB	Rahman Renewable Energy Company Limited	Jamalganj Road, Professor Para, SadarJoypurhat	04/01/2005	redwanoor@yahoo.com	Mr. Redwanoor Rahman, Managing Director	01712-586110
5	RS	Rural Services Foundation (RSF)	74/D, Arjotpara, Mohakhali, Dhaka-1215Dhaka	05/01/2005	rsf@siriusbroadband.com	Mr.Ruhul Quddus. General Manager	01713-049415,8143685,9114061
6	BR	Bangladesh Rural Integrated Development for Grub-Street Economy (BRIDGE)	House# 7, Road # 113, Khalishpur Housing state, KhulnaKhulna	05/30/2006	bridge@khulna.bangla.net	Mr.Zahirul Haque, Executive Director	041-760038,01711-807740
7	SR	Srizony Bangladesh	111, Pabahati Road, PabahatiJhenaidah	07/01/2005	srizonyb@accesstel.net	Mr. Harun or Rashid, Executive Director	0156-315570
8	GS	Grameen Shakti	Grameen Bank Bhaban, Mirpur Road, Dhaka-1216Dhaka	08/01/2005	g_shakti@grameen.net	Mr. Abser Kamal, General Manager	9004314,9004081
9	SA	SAPNO	Shahid Khokon Road , JaleswaritolaBogra	03/25/2007	sapno_sng@yahoo.com	Md. Ziaur Rahman, Executive Director	01712-869291,05167775
10	BS	Bangladesh Association for Social Advancement	House# 247, Road# 18, New DOHS, Mohakhali kzamanbhuiyan@yahoo.comDhaka	04/02/2007	edbasa@worldnetbd.net	A.K.M. Shirajul Islam	9862464, 01730-044902
11	SB	Shubashati	I/31, Lane-6, Block-D, Mirpur-12, Pallobi, DhakaDhaka	05/08/2007	qis@bol-online.com	Ms. Reba Paul, Director (Programme)	02-9013431,01715-073367

12	KP	Kushtia Pally Unnayan Sangstha (KPUS)	18/5, 1 No. Masjid Bari Lane, AruaparaKushtia	04/09/2007	kpus@kushtia.com	Md. Enamul Haque, Director	01711-310126,071-62056
13	SG	Sangram (Sangathita Gramunnayan Karmasuchee)	Shahid Srity Sarak, SadarBarguna	04/08/2007	sangrammasum@yahoo.com	Mr. Chowdhury Md. Masum, Executive Director	01713001528,0448-62828
14	PA	Practical Action	House No-32, Road No-13A, Dhanmondi R/ADhaka	06/21/2007	mamun@practicalaction.org.bd	Veena Khaleque, Country Director	01819149415,9113065 (134)
15	PM	Padakhep Manobik Unnyan Kendra (PMUK)	House No 548, Road No 10, Baitul Aman Housing Society Adabar, MohammadpurDhaka	04/15/2007	padakhep@bdonline.com	Iqbal Ahmed, Executive Director	01713003166,9128824
16	SU	Sonali Unnayan Foundation (SUF)	218, Begum Rokeya Sarani, Sher-E-Banglanagar,West kafrul, Dhaka-1207 Dhaka	03/28/2007		Md. Shamsuddin Azad, M.A, Director General	01711838760, 9136588
17	SD	Shariatpur Development Society(SDS)	Sadar Road,Shariatpur,Post Box No-1,Post Code-8000 Shariatpur	04/16/2007		Mozibur Rahman, B.A/L.L.B, Executive Director	01714011901, 060155554
18	DE	DESHA	Dar-Us-Shefa,317, Jhenaidah Road Majampur,Post Box-1, Kustia-7000 Kushtia	04/24/2007		Md. Robiul Islam, B.Com, Executive Director	01711217623, 071171402
19	UD	Uttara Development Program(UDP)	South Malotinagar, Bhai Pagla Mazar Lane,Bogra-5800 Bogra	04/16/2007		AFM Akteruddin, M.A, Executive Director	01711419110 ,8120632
20	NB	Nurunnnabi Biogas Company Limited	Gaibandha	04/13/2008			
21	PS	Palli Shakti	Gaibandha	04/13/2008			
22	NL	Nirapad Engineering Limited	Dhaka	04/13/2008			
23	CM	ChangeMaker	H#8, R#13(New), Suite F-3 Dhanmondi, Dhaka-1209Dhaka	04/07/2008	info@changemaker-bd.org	Syed Tayubur Rahman	8159970,9126784
24	BB	Barisal Biogas Construction Company Limited	Barisal	05/22/2008			

Source:

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