ICRC

The International Committee of the Red Cross, NEPAL

The International Committee of the Red Cross (ICRC) started its operations in Nepal after the emergence of internal armed conflict. Since then it has been providing protection and assistance to the victims of armed conflict. With this in view since 2004 the ICRC's Water and Habitat (WatHab) department has carried out emergency water and infrastructure projects for conflict-affected communities, for medical facilities particularly badly affected by violence and has improved hygiene conditions in places of detention. However, following the Comprehensive Peace Accord of 2006 in Nepal, and the end of conflict, the ICRC has gradually scaled back its assistance activities.

Water and Habitat in Nepal

"The objective is to respond to urgent needs but with a view to long-term solutions designed to improve the living conditions of the conflict-affected population and provide recommendations to the authorities and Nepalese partners"

A team composed of expatriates, national engineers and technicians has worked in collaboration with; the Prison Management Department, Biogas Sector Partnership – Nepal, Centre for Rural Technology – Nepal, the Department of Water Supply and Sewerage, the District Water Supply Offices, and experts from the Kathmandu University. The ICRC keeps its neutrality and independence, but shares technical information in order to facilitate the development phase and to support the local and national authorities to coordinate their efforts.

The WatHab unit of the ICRC has maintained high priority focus on the promotion of renewable energy technologies and has supported programmes such as biogas, improved cooking stoves, bio-briquettes, rainwater harvesting etc. It specifically recognizes the role that sustainable and renewable energy plays in improving living conditions in places of detention, having with BSPN constructed five digesters (between 10-35m^3) in three jails in Nepal.

The ICRC considers it beneficial to disseminate widely the recommendations and lessons learnt for the experience gained in Nepal to enhance the expertise and knowledge currently available concerning institutional biogas. An independent evaluation by SANDEC (Switzerland) was commissioned in 2009 and the Executive Summary is in Annex 1. The findings of the independent evaluation were overall positive. The biogas systems have fulfilled their basic objectives of improving the sanitation, providing alternative renewable energy and improving the kitchen environment through indoor pollution reduction. Additionally, the biogas systems are favourably perceived by the users, notwithstanding the feedstock being predominantly human faeces rather than the more traditional use of animal dung.

It is acknowledged that the information regarding institutional biogas plants is based on a very limited sample within the specific economic, social, institutional and climatic context of prisons in Nepal. Furthermore it is based on a very limited timescale (plants are operational since the beginning 2008) and therefore cannot be considered definitive. However the WatHab unit of ICRC has endeavoured to set out below some rules of thumb and general advice for the possible successful replication of such institutional biogas projects also elsewhere.

The design used for the institutional biogas plants was based on the fixed-dome digesters (modified GGC2047 design) by Biogas Sector Partnership Nepal. As an example the design and bill of quantity for the 10m3 digester is in Annex.

Based on the experience gained, the following points were considered significant in the layout, construction and operation of the plants;

Design aspects

- the construction of multiple digesters is preferable to one single larger digester (for maintenance work e.g. internal re-coating with acrylic emulsion paint)
- the inclusion of an internal baffle wall in the digester or the 'non straight/off-set' line layout of the compensation chamber would increase hydraulic retention time without increasing the digester sizing (and therefore not increasing construction costs)
- a prior settlement tank to the digester could be considered if there is high water content of the digester feedstock that cannot be separated a priori

Technical aspects

- the gas tightness of the dome is imperative
- the slope of sewer lines to the digester should be maintained between 5-7% (possibly existing toilets will need to be raised to accommodate this)
- separation of the bathing/kitchen water from the effluent used to feed the digester is necessary (no more than 3 litres per flush is used in design calculation).

Organisational aspects

- prior agreement of the users concerning use and maintenance
- the understanding and agreement of not to use chemical cleaning products (which are not biodegradable)
- the understanding and agreement to use kitchen waste as feedstock for the digester
- user training on the use and basic repair of biogas plants including the distribution of spare parts and tools as necessary (examples in Annex)
- a regular maintenance & monitoring schedule following construction
- sludge management

To facilitate the calculations to achieve an approximate biogas digester size according to the number of full time residential users, such as the case for prisons in Nepal, there is an excel file attached with a 'Design Template'. It is sufficient to input the actual number of users to generate an approximate total digester size in cubic meters. An example of the Design Template calculated for 300 persons is in Annex.

Hoping that the present compilation is of some assistance to those who wish to further investigate biogas plants, the WatHab Unit of ICRC, Nepal would like to wish you good luck in your future endeavours.

Summary (SANDEC independent Evaluation Report 2009)

In 2007, the frequently overflowing septic tanks in three Nepalese District Jails (Kaski, Chitwan, Kanchanpur) were replaced with biogas sanitation systems under the mandate of the International Committee of the Red Cross (ICRC). The new biogas plants aimed to reduce the health risks of the detainees by improving the sanitary conditions and by providing a smoke-free renewable source of cooking fuel.

After one year of operation, an independent evaluation was assigned to Eawag/Sandec to assess the new systems, its impact and acceptance. Three monitoring cycles were conducted between April and June 2009. Based on findings from the first visit, repairing work and user trainings were executed on the second visit. Final results were generated on the third visit when plants were considered to be running under optimal conditions.

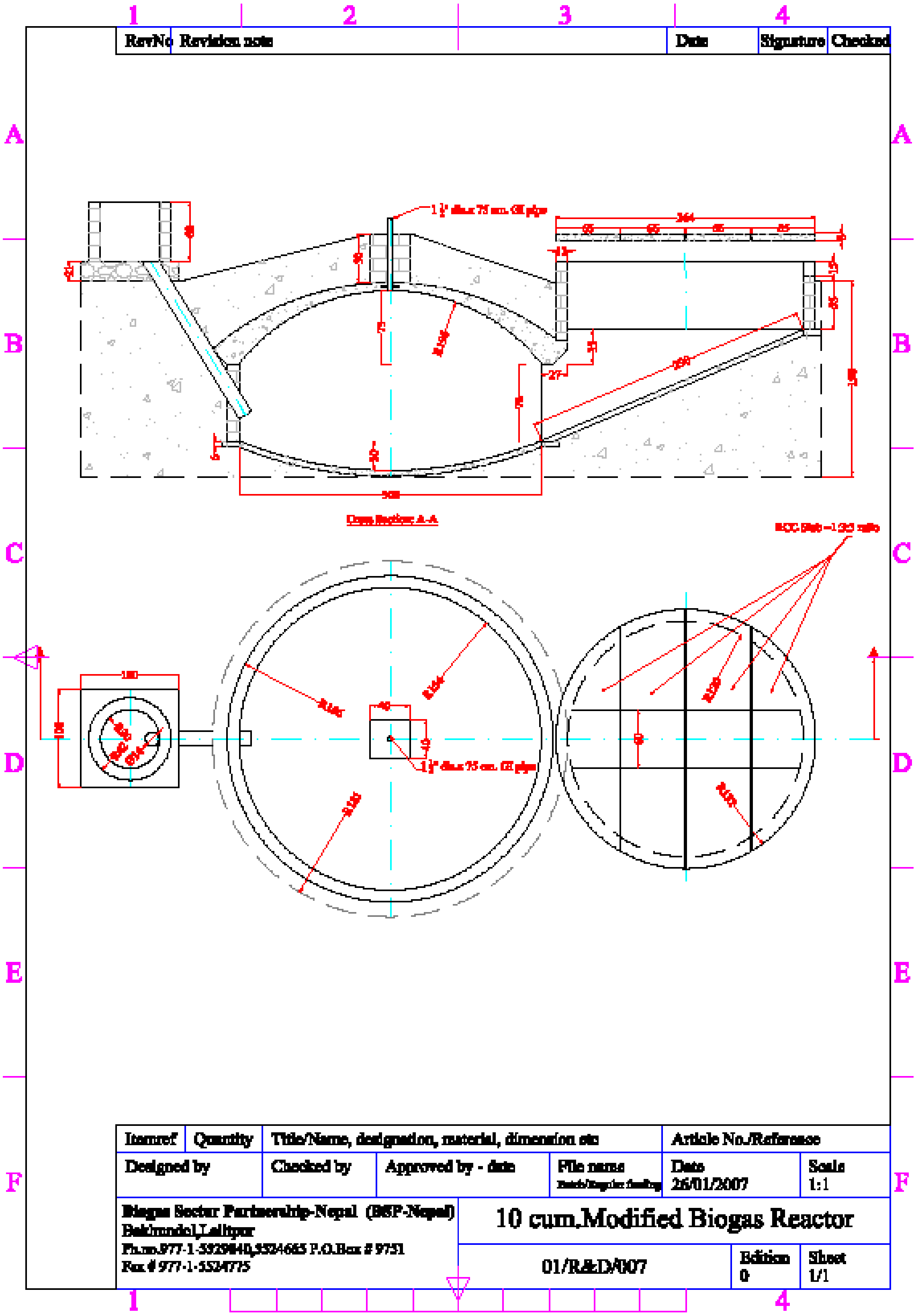
All five fixed-dome digesters (modified GGC2047 design, 10m3, 20m3 and 35m3) revealed gastight domes and showed high process stability (pH: 7.1 - 7.4, temperature: 26-30°C, Redox: -380mV) with no accumulation of inhibitory substances (VFA, NH4-N). During the last monitoring cycle, daily gas production of four out of five digesters was measured to be above the planned biogas output of the pre-construction period.

Average gas production from human waste exclusively results in 27NL/person/day, with additional feeding of the entire kitchen waste 62NL/person/day. Methane contents varied between 57 and 78 Vol-%, depending on the feedstock; concentration of hydrogen sulphide in biogas of all systems exceeded 1000ppm. As a consequence of the 3L of water used for flushing per defecation instead of 1L as planned, the hydraulic retention time was registered between 13 and 32 days which is far below the intended 70 days. Yet as an indication of the satisfactory efficiency of the systems, the effluent of all digesters displayed very low total solid (TS) content around 4g/L with volatile solids (VS) between 24 and 44%. Pathogen analyses of effluent in the storage pits revealed E.Coli concentration acceptable for restricted irrigation (<10^5CFU/100ml). However, helminth eggs were not completely eliminated by anaerobic digestion and sedimentation processes in some cases. In none of the monitored jails, the nutritious effluent (N total: 760mg/L of which 63% is NH4-N, P total: 61mg/L) is used as fertilizer.

The technology is favourably perceived by the vast majority of detainees who reported a general improvement of living conditions since the installation of the biogas systems. 59% of the interviewed inmates indicated reduced smoke in the kitchen (less respiratory health problems) and 49% mentioned improved sanitary and hygienic conditions. In Kaski Jail where kitchen waste is added to the digesters as recommended, 41% of the money previously spent for conventional cooking fuel is saved due to biogas substitution, 17% in Chitwan Jail and 22% in Kanchanpur Jail.

Apart from insufficient slope of the inlet pipes in Chitwan Jail, no major problems were encountered which could not be rectified. It is recommended that future biogas sanitation systems include an internal buffer wall in the digester to increase the solid retention time, thus further improving efficiency and pathogen reduction. Neither an internal (regular check-ups) nor an external (annual monitoring) maintenance strategy was observed, thereby jeopardizing the long-term operation and the reputation of biogas sanitation technology, which in the Nepalese prison context proved to be suitable for the treatment of waste from toilets and kitchen.

Modified GGC 2047 Design of 10m3 bio digester



BIO GAS DIGESTER – SIZE 10 M^3
BILL OF QUANTITY

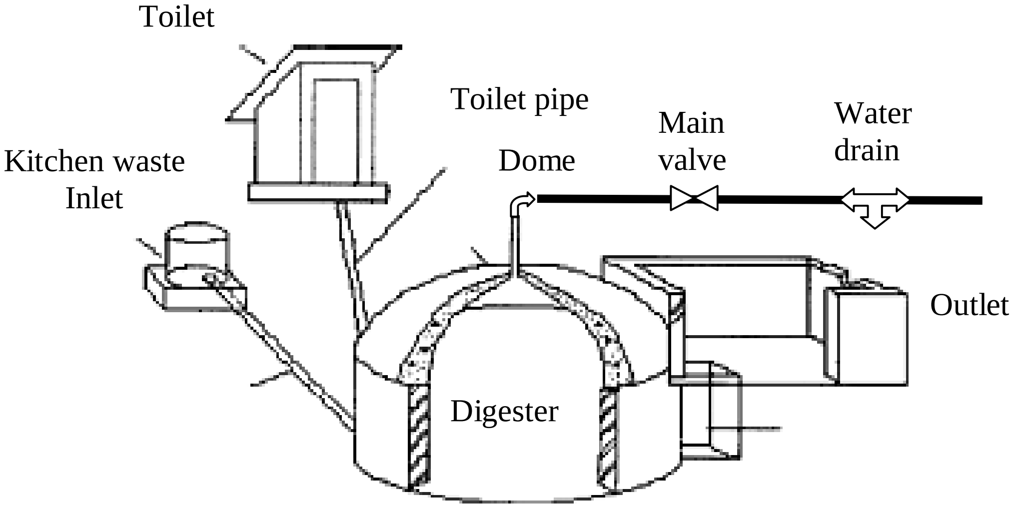
SN	A. Materials	Unit	Quantity	Rate* NPR (excl VAT)	Amount (NRs)	Amount (US $)
1	Cement (bag)	50kg	25	595.00	14875.00	195
2	Brick	nos	2200	6.90	15180.00	199
3	Stone	m^3	2	850.00	1700.00	22
4	Sand	m^3	5	1100.00	5500.00	72
5	Aggregate	m^3	4	1200.00	4800.00	63
6	MS rod 10 mm	kg	40	94.19	3767.60	49
7	Binding wire	kg	2	120.57	241.14	3
8	Acryline emulsion paints	litre	3	420.00	1260.00	17
	Sub Total A				*47323.74*	621
	B. Appliances					0
9	Biogas Stove	set	2	944.00	1888.00	25
10	Main gas valve	pcs	1	600.00	600.00	8
11	Water drain	pcs	1	247.00	247.00	3
12	Gas tap	pcs	2	405.00	810.00	11
13	Rubber hose pipe	meter	3	69.50	208.50	3
14	Mixer	set	1	1319.00	1319.00	17
15	Dome gas pipe	pcs	1	810.50	810.50	11
16	6" HDPE pipe for toilet connection **	rm	6	595.00	3570.00	47
17	GI pipe for stove connection**	meter	15	206.50	3097.50	41
18	Other tool, pipe & fittings	ls			1500.00	20
19	Teflon tape	pcs	5	20.00	100.00	1
20	Pressure Gauge	pcs	1	456.00	456.00	6
21	Skilled labor	day	17	430.00	7310.00	96
22	Unskilled labor	day	35	275.00	9625.00	126
	Sub Total B				*31541.50*	414
	Grand Total (without VAT)				**78865.24**	**1'036**

** - Rates for A. Particulars have been drawn from the DCC, Kaski rate for the fiscal year 2008/2009 and rates for B. Appliances were taken from BSPN recognised Biogas Company in Pokhara*

*** - Quantity of item no.16 and 17 has taken approximately and might vary as per the site conditions*

Summary of Instructions for Biogas Users

Different Parts of Bio digester



Dos and Don'ts

Toilet
ü Use as little water as possible for toilet flushing

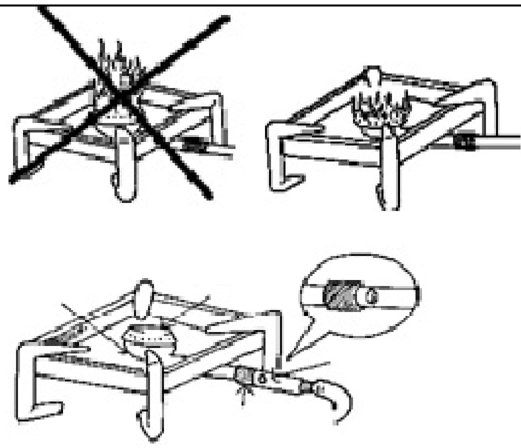
û Do not use any chemicals to clean toilet (only water!)

When : û NEVER, ü ALWAYS

Kitchen: Waste
ü Feed as much kitchen waste as possible to increase gas production
ü Slice the wastes into smaller pieces
û Do not feed peeling from citrus fruits such as lime, lemon and orange
When : û NEVER, ü ALWAYS

Kitchen: Cooking
ü Consume daily gas production fully, 0- pressure by the evening

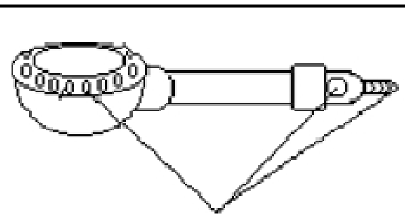
When: DAILY



Kitchen: Cooking
ü Regulate flame by adjusting the air intake to get a blue flame
When : ü ALWAYS

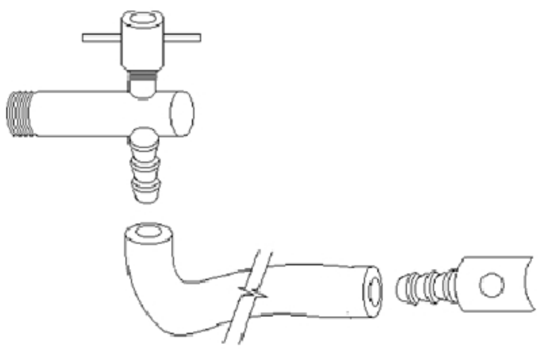
Kitchen: Cooking
ü Cover the pot with a lid while cooking

When : ALWAYS



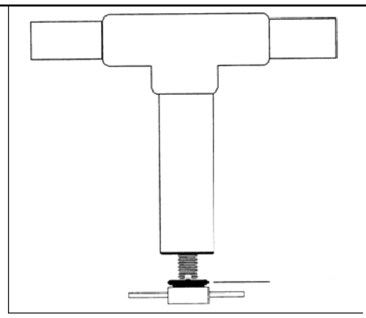
Kitchen: Cleaning
ü Clean the biogas stoves burner

When : TWICE A WEEK



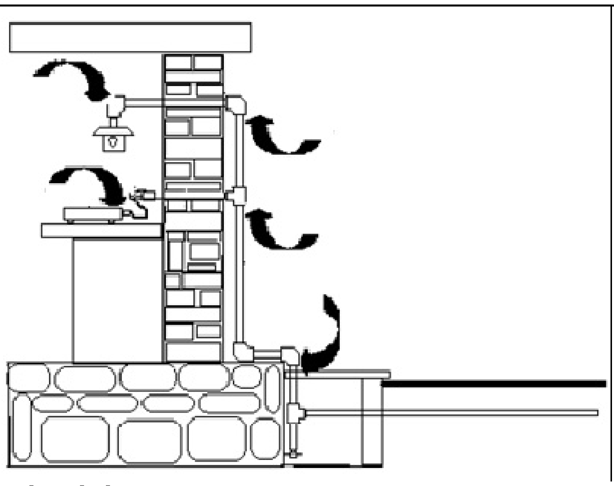
Kitchen: Gas pipe
ü Check gas pipe and joints smelling. If it smells like rotten eggs, inform jailer/construction company

When: ONCE A WEEK



Water Drain:
ü Empty condensed water through the water drain(s)

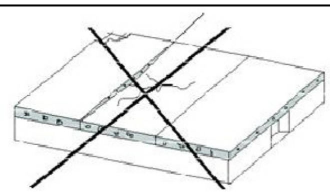
When: ONCE A MONTH or When Gas Does not Reach the Kitchen



Pipe joints:

ü Check the gas pipe joints for leakage using soap water. If bubbles appear, inform jailer/construction company

When : ONCE A MONTH



Slurry outlet:
ü Always cover outlet tank with slabs. If slab is cracked, inform jailer/construction company

Construction Company:

Name of Company

ADDRESS

Phone: XXXXXX

Tools and spare parts for Bio gas plant

A. Basic Tools	Unit	Quantity	Rate (NRs)	Amount (NRs)	Amount (US$)
Pipe wrench (14")	no	1	400	400	5
Pipe wrench (12")	no	1	350	350	5
Slide wrengh (10")	no	1	200	200	3
Knife	no	1	100	100	1
Total A				1050	14
B. Basic spare parts	Unit	Quantity	Rate (NRs)	Amount (NRs)	Amount (US$)
Main valve	no	1	600	600	8
Gas tap	no	1	405	405	5
Nylon hose pipe	meter	5	70	350	5
Nozzle	no	1	50	50	1
Pressur gauge	no	1	456	456	6
O ring for gas tap and drain	no	20	5	100	1
Teflon Tape (seal tape)	no	5	20	100	1
Total B				2061	27
Grand Total (A+B)				**3111**	**41**

Calculation of Biogas Digester Size based on Nepal Experience

E.g. Residential Institution with the use of kitchen waste (recommended)

Design Criteria	Factor		No.of Inmates		Calculated Value	Unit
A. Calculation of number of persons feeding the digester						
1. Determine the numbers of persons to feed the digester (at present) Take nos. of persons			**300**		Input Cell	
2. Expecting an increment of 10% in future designed for number of persons	1.1	*	300	=	330.0	
TOTAL NUMBER OR PEOPLE	1.1	*	300	=	330.0	nos.
B. Calculation of total amount feedstock						
1. Faeces (kg per day) *take 0.4 kg faeces per person per day*	0.44	*	300	=	132.0	kg
2. Urine (litres per day) *take 1.5 litres per person per day*	1.65	*	300	=	495.0	litres
3. Bio waste (kg per day) *take 0.22 kg per person per day*	0.242	*	300	=	72.6	kg
4. Waste dilution water (liters per day) *take equal amount of waste*	0.242	*	300	=	72.6	litres
5. Toilet flush water (liters per day) *take 3 litres per person per day*	3.3	*	300	=	990.0	litres
TOTAL AMOUNT OF FEED (litres per day)	5.874	*	300	=	1762.2	litres
C. Calculation of amount of gas production						
1. Gas production by human waste (litres per day) *take 30 litres per feeder per day*	30	*	300	=	9000.0	litres
2. Gas production by bio-waste (liters per day) *take 115 liter per kg waste per day*	27.83	*	300	=	8349.0	litres
TOTAL GAS PRODUCTION (litres per day)	57.83	*	300	=	17349.0	litres
D. Calculation of Size of Digester						
1. Total equivalent solid waste (kg per day)	0.847	*	300	=	254.1	kg
SIZE OF DIGESTER	0.1694	*	300	=	**50.8**	**m^3**

Choose an appropriate standard size of digester (e.g.10 or 20 or 35 m^3) matching calculated size of digester above (NB: Better to have two digesters of smaller sizes than only one large one for maintenance reasons)

E. Calculation of retention time for chosen digester (without internal baffle wall)

1. 10 m^3 Digester Slurry Volume (liters) 7510						
Hydraulic Retention Time (days)	7510	÷	Total of B	=	4.3	days
2. 20 m^3 Digester Slurry Volume (liters) 15300						
Hydraulic Retention Time (days)	15300	÷	Total of B	=	8.7	days
3. 35 m^3 Digester Slurry Volume (liters) 24875						
Hydraulic Retention Time (days)	24875	÷	Total of B	=	14.1	days

F. Calculation of stove burning hours

1. Total burning hours per day						
take gas consumption rate 400 liter per hour for BSPN design stove	TOTAL OF C	÷	400	=	43.4	hours