POLYETHYLENE BIODIGESTERS (PBD)

Production of biogas and organic fertilizer from animal manure

Integrated Bio-system Network
International Organization of Biotechnology and Bioengineering

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*Illustrations adapted from BOTERO, R.; AGUILAR, F.; PRESTON, T. 1999. The biodigester. **In** Toward a better use of our natural resources. EARTH University, Costa Rica. 28*

PROBLEM STATEMENT

Use of firewood for cooking

- Environmental impact (CO_2, forest)
- Development of illnesses
- Demand of labor

Non appropriate management of excrements

- Contamination of sources of water
- Production of gases (sulphur, methane)
- Increase of vectors of human and animal diseases
- Dissemination of diseases and weeds
- Loss of nutrients

MACRONUTRIENT COMPOSITION OF CERTAIN TYPES OF MANURE

Manure	Composition (%)		
	N	P	K
Human faeces [a]	1.0	0.2	0.3
Cattle faeces [a]	0.3	0.1	0.1
Dairy manure [b]	0.7	0.1	0.5
Pig manure [b]	1.0	0.3	0.7
Poultry manure [b]	1.6	0.5	0.8

Adapted from: Greenland (1997):[a] Qi-xiao Wen (1984) [b] Tisdale and Nelson (1966)

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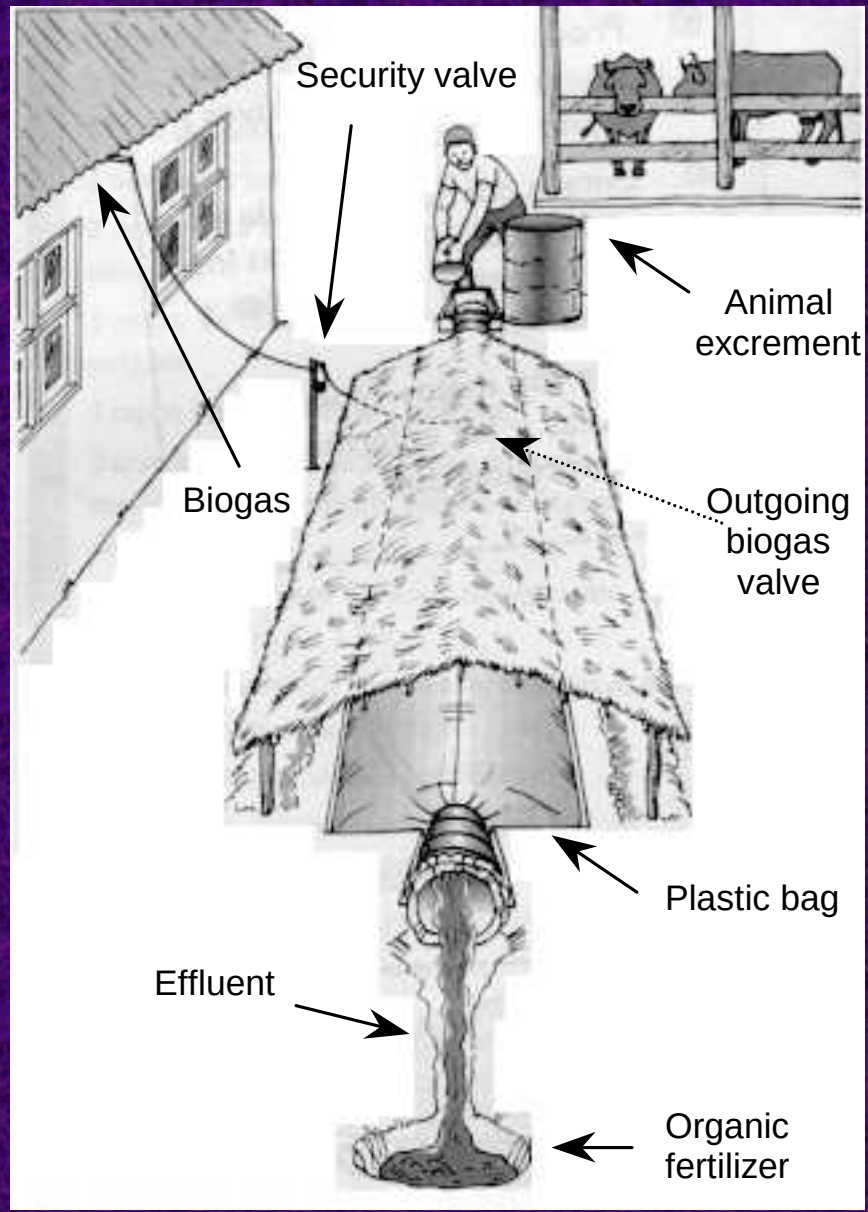
BIODIGESTION PROCESS

- **Conditions for biogas production**
- **Production of methane**
- **Production of organic fertilizer - effluent**



CONDITIONS FOR BIOGAS PRODUCTION

• **Fresh excrement**	**Daily application**
• **Temperature range**	**30-35°C internal / x ‹15°C**
• **C/N rate**	**30 / 1**
• **Anaerobic system**	**methanogenic bacteria**
• **pH**	**6.7- 7.5**
• **Time frame**	**30 days until production**

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WHY DAILY APPLICATION?
Continuous anaerobic digestion process

1. Acid-forming-liquefaction

- Bacteria hydrolyse and ferment organic compounds (carbohydrates, lipids, proteins, etc.)
- High production of acids (especially acetic acid)
- pH ranging from 5.1 to 6.8
- Reduction in volume

2. Gasification

- Organic acids used to produce methane gas (acetic acid ~ 70%)
- Optimum performance when temperature 30°C
- pH ranging from 7.2 to 7.4
- If there is rise or fall of temperature more than 10°C from the optimum value listed above, the bacteria stop working and methane gas production stops altogether.

PRODUCTION AND USES OF BIOGAS

Chemical composition

Amount of biogas produced

Applications

- Lighting
- Engines
- Cooking
- Heating

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Chemical composition of biogas

Component		Percentage
Methane	CH_4	40-70
Carbonic gas	CO_2	30-60
Hydrogen	H_2	1.0
Nitrogen	N_2	0.5
Carbon monoxide	CO	0.1
Oxygen	O_2	0.1
Hydrogen sulphur	SH_2	0.1

Adapted from Instituto de Investigaciones Eléctricas de México, 1980; ISAT & GTZ, 1999.

Back to uses of biogas

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Production of biogas

Biodigester: *10 meters length , 3 meters circumference*

FACTS	
Total volume	7.2 m^3
Biogas bell (25%)	1.8 m^3
Liquid phase (75%)	5.4 m^3
Biogas produced every day *35% of liquid phase*	1.9 m^3
Biogas burned per hour (2 stoves)	150 L
Total # of cooking hours	**12.7 h**

HOW MUCH MANURE IS REQUIRED?

How much manure is required

Liquid phase	**5400.0 L**
50 days inside the biodigester	
Material added every day	**108.0 L**
Water (80%)	86.4 L
Manure (20%)	21.6 L
Fresh manure has 15% of D.M. - mixture 3%	

HOW MANY ANIMALS?

Amount of fresh manure produced by different domestic animals

Animal	Fresh manure (Kg)*	# animals
Bovine	8	1
Equine	7	1
Sheep	4	6
Pig	4	6

** Per every 100 Kg of weight*

Amount required: 22 Kg of fresh manure

Adapted from Botero, 1997

Back to uses of biogas

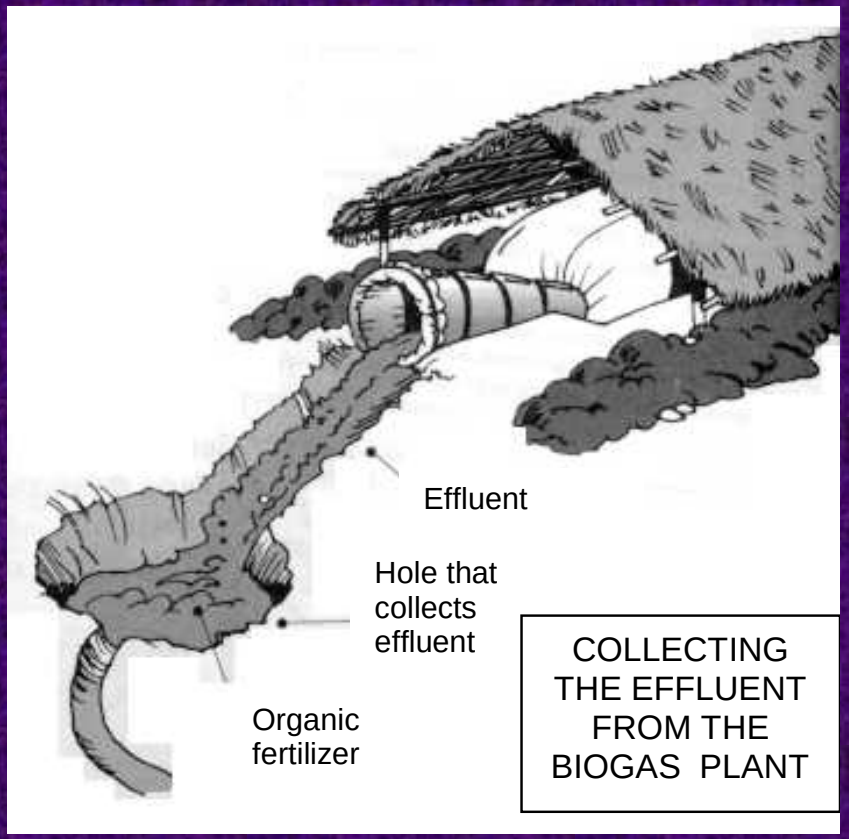
EFFLUENT APPLICATIONS

Benefits

- No loss of nutrient content than fresh manure (composition)
- No dissemination of diseases/weeds through the manure
- No odor

Uses

- Organic fertilizer
- Effective microorganisms
- Aquatic plants (*Eichhornia spp.*, Lemnaceae, *Azolla spp*.)
- Fish production



COLLECTING THE EFFLUENT FROM THE BIOGAS PLANT

How to install a low cost biodigester

Chemical composition of effluent

	Component (% dry matter)	
Nutrient	Fresh manure	Biodigester Effluent
Nitrogen	2.0	2.6
Phosphorus	0.6	1.4
Potassium	1.0	1.7

Adapted from Gómez y Viniegra, 1979

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Nitrogen and Phosphorus content of different species of aquatic plants

Species	N content (%)*	P content (%)*
Azolla pinnata	3.85	0.72
Pistia sp.	1.38	0.43
Ipomoea sp.	2.90	1.11
Eichornia crassipes	1.62	0.65

** Dry weight content*
Adapted from:Singh and Mandal, 2000

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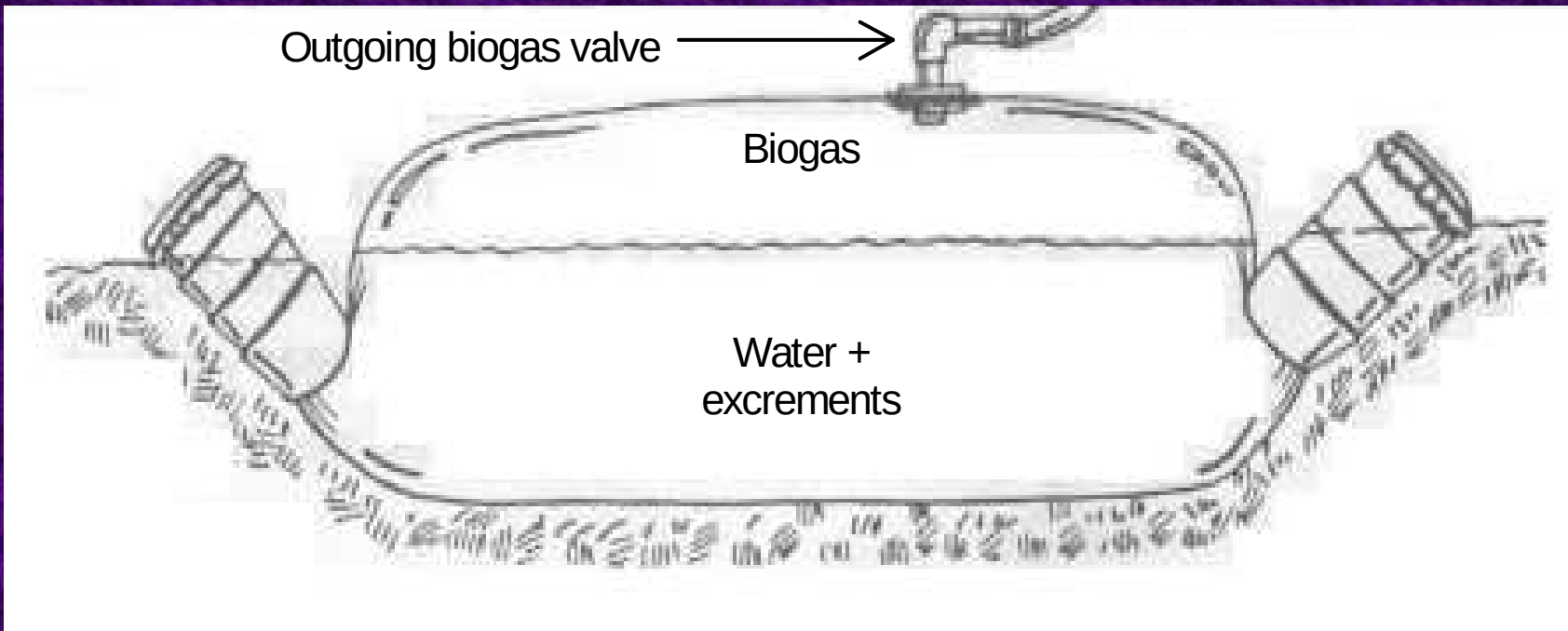
LOW COST BIODIGESTER
Polyethylene Biogas Plant



Installation of a low cost biodigester

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MATERIALS REQUIRED TO INSTALL A POLYETHYLENE BIOGAS PLANT

–28 meters of natural polyethylene plastic tube, 1000 gage and 1.5 or 2 meters width.
–2 cement or clay pipes, 1 meter length, 12 inches width.
–2.5 meters of transparent plastic hose of 1 ¼ inches in diameter
–1 PVC screw (1 inch in diameter)
–1 PVC cap adapter (1 inch in diameter)
–2 - 90º PVC elbows (1 inch in diameter)
–1 meter of pressure PVC pipe (1 inch in diameter)
–1 flat PVC cap (1 inch in diameter)
–2 round plastic disks (20-15 centimeters in diameter with a central hole of 1 inch)
–1 transparent plastic bottle - 1 gallon of capacity
–3 used tires tubes (rubber belts)
–8 used plastic fertilizer sacks
–1 galvanized metallic pipe, 1½ inch in diameter 50 centimeters length
–1 tube of PVC glue
–1 steel wool (iron spongy)
–An automobile or motorcycle as source of exhaust
1 plastic hose to take exhaust from the car to the place where the biodigestor will be installed

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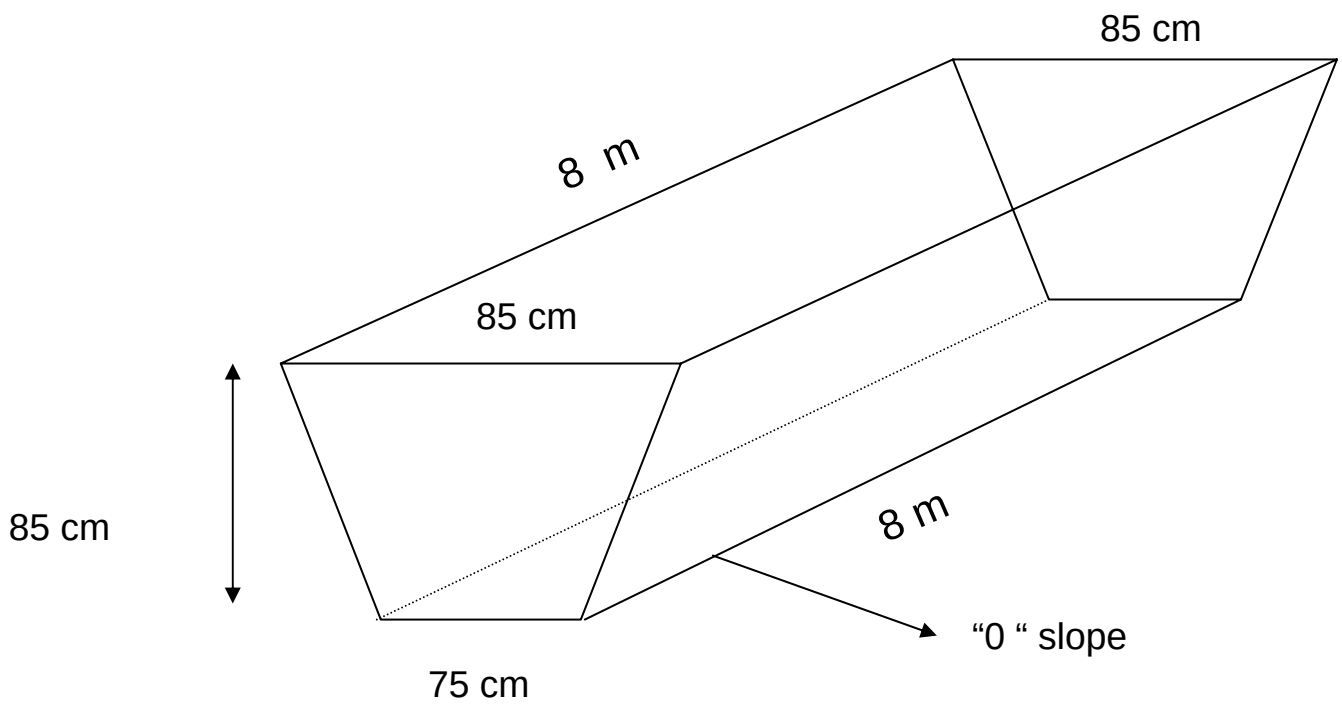
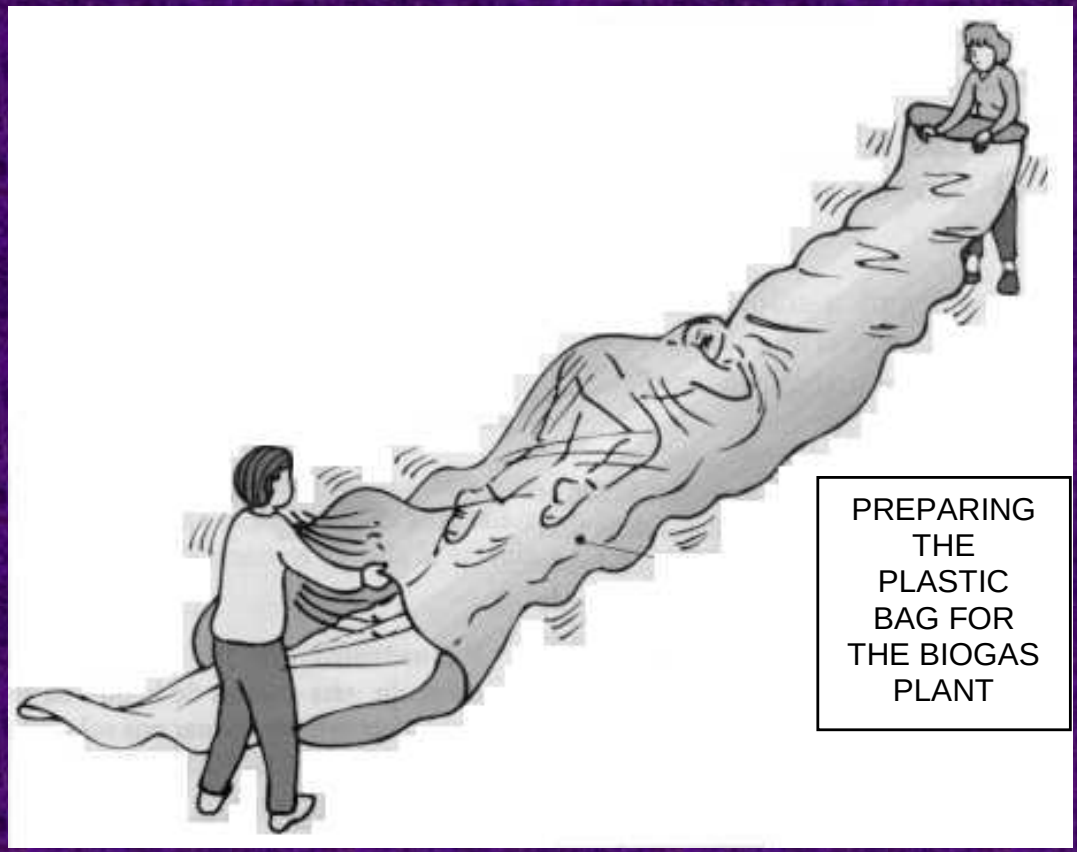
Step 1. DIAGRAM OF THE GRAVE WHERE THE BIODIGESTER WILL BE PLACED



Installation of a low cost biodigester

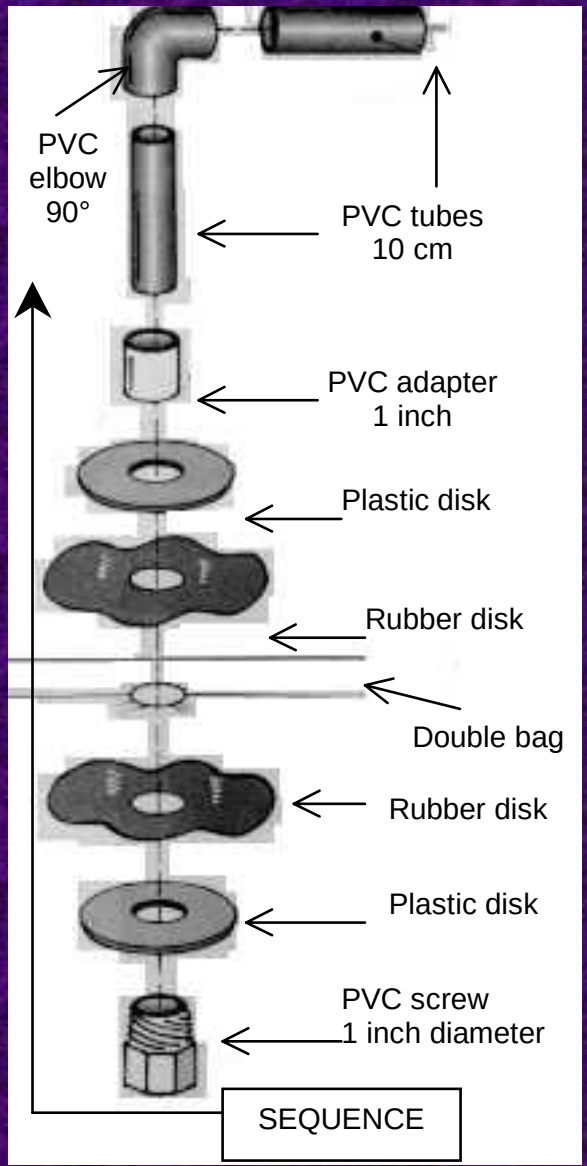
STEP 2

Step 2. PREPARATION OF THE PLASTIC BAG FOR THE PBD



PREPARING THE PLASTIC BAG FOR THE BIOGAS PLANT

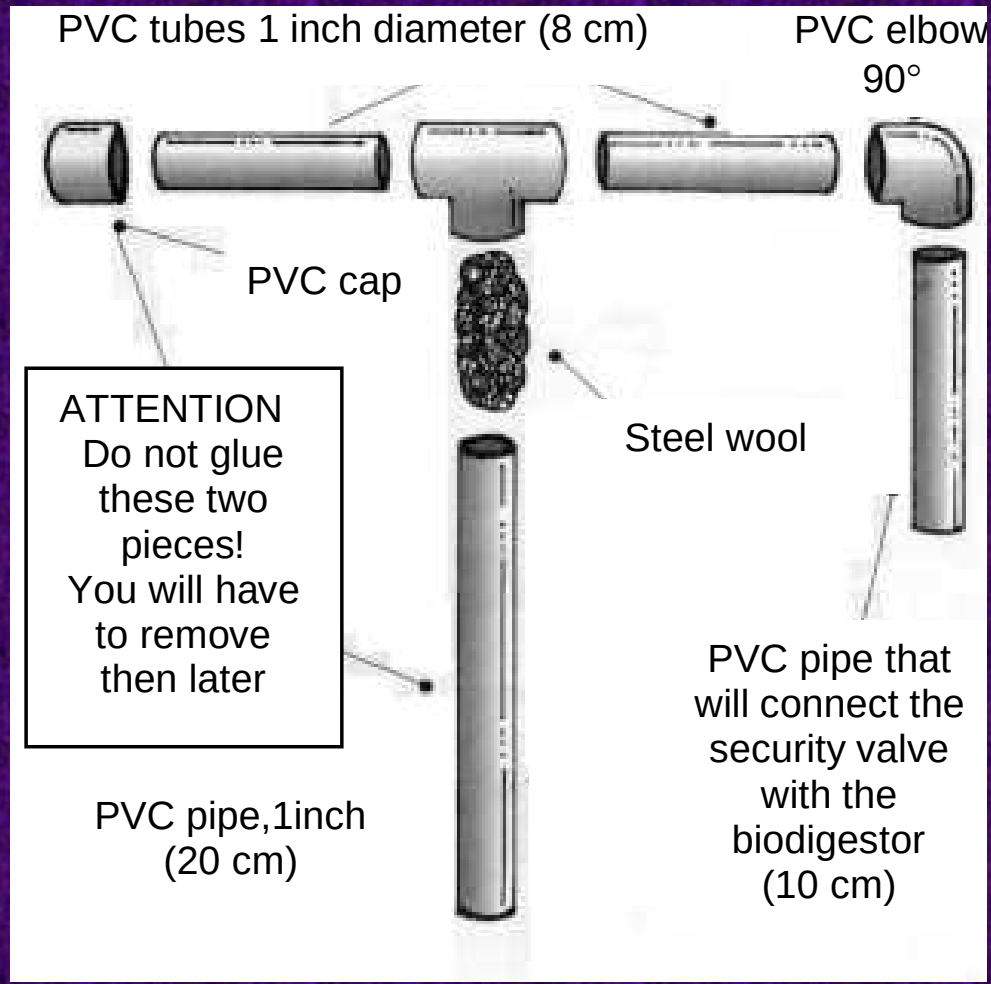
Step 3. SETTING THE OUTGOING BIOGAS VALVE



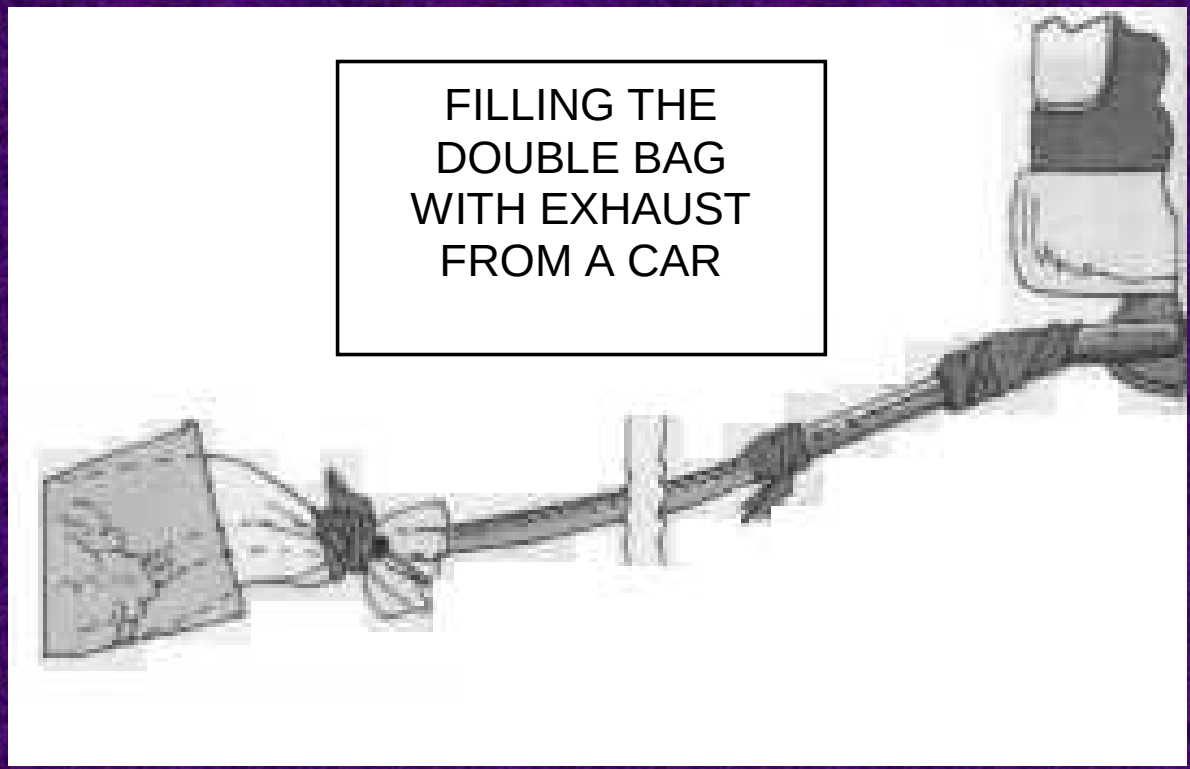
Installation of a low cost biodigester

STEP 4

Step 4. SETTING THE SAFETY VALVE

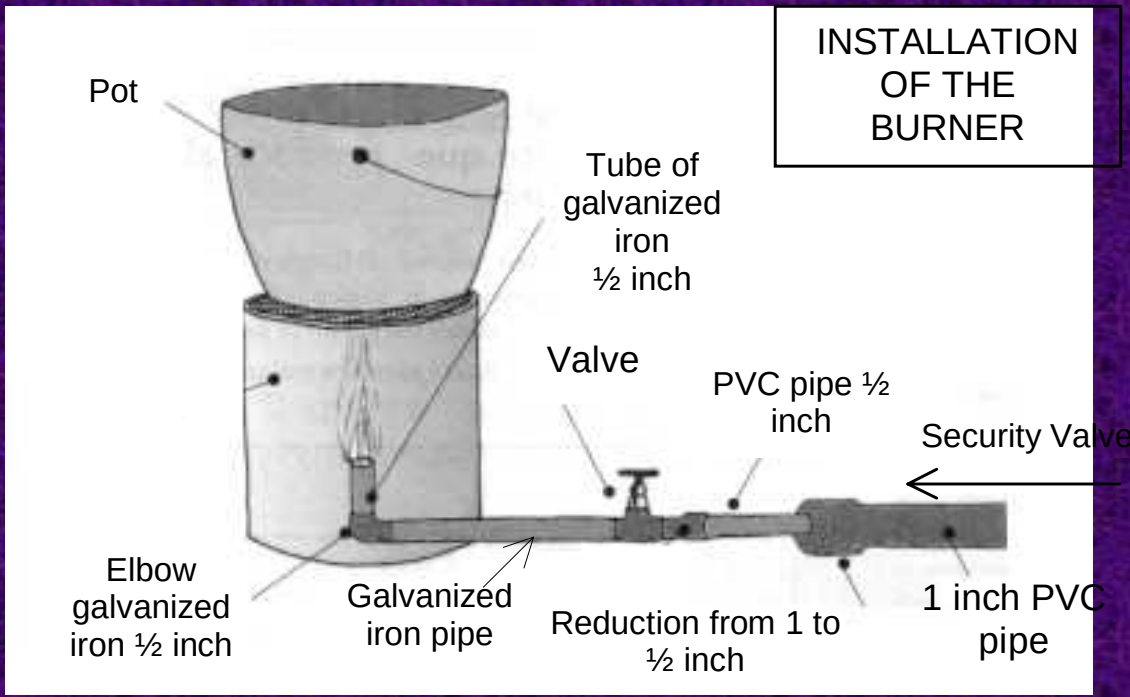


Step 5. FILL UP THE BIOGAS PLANT WITH EXHAUST AND WATER



Step 6. MANAGEMENT OF THE BIOGAS PLANT

Step 7. CONNECTION TO THE BURNER



Installation of a low cost biodigester

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LIMITATIONS of/for PBD

- Daily management
- Quality of the plastic
- Comparative costs with other sources of energy due to subsidies
- Methane: Flame = 870°C
  Ignition 700 °C

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Limitations of/for PBD

Comparison of calorific values of different fuel gases

Gas	Calorific value (Joules cm^{-3} - MJ/m^3)
Methane	33.2 - 39.6
Biogas	20.0 - 26.0
Natural gas	38.9 - 81.4
Propane	81.4 - 96.2
Butane	107.3 - 125.8

Adapted from: Meynell, 1972; Natverkstan, 1999

Volumes of other fuels equivalent to $1m^3$ (1000 L) of biogas *(5500 kcal)*

Fuel	Volume (L)
Diesel	0.62
Petrol (gasoline)	0.70
Liquid butane	0.87
Natural gas	0.57

Adapted from: Meynell, 1972; Natverkstan, 1999

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COST OF PBD INSTALLATION

Plastic, ends (buckets or cement pipes),labour, PVC connections, fence, simplified stove

Country	Costs ($)
Costa Rica	120[a]
Ecuador	130[b]
Sri Lanka	140[b]

[a] Use of plastic buckets for both ends.
[B] Use of cement pipes (1 meter long, 12 inches width)

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CONCLUSIONS

- **Option for excrement management**
- **Clean, cheap and simple technology**
- **Diminishment of environmental impact**
- **Direct economical benefits**