

[search](#)[subjects](#)[titles a-z](#)[organization](#)[how to](#)[DETACH](#)[CONTRACT
CONTENTS](#)[CONTRACT
TEXT](#)**Better Farming Series 31. Biogas: what it is; how it is made; how to use it***(introductory text)*

Preface



Introduction

*(introductory text)*

Biogas



How is biogas made?



How big should your biogas unit be?



How to build a small biogas unit

*(introductory text)*

You will need



Where to put your biogas unit



Building the unit



Testing for leaks



Waste materials



What waste materials to use



How to use them



Making a starter



Putting waste into your biogas unit



Time



Cold weather protection



Stirring the waste mixture



When the gas is made



Using your biogas



Using the fertilizer



Taking care of your biogas unit



Making more biogas

Better Farming Series 31. Biogas: what it is; how it is made; how to use it

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome 1984

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Preface

The first twenty- six volumes in FAO's Better Farming Series were based on the Cours d'apprentissage agricole prepared in the Ivory Coast by the Instiut african de développement économique et social for use by extension workers. Later volumes, beginning with No. 27, have been prepared by FAO's for use in agricultural development at the farm and family level. The approach has deliberately been a general one, the intention being to constitute basic prototype outlines to be modified or expanded in each area according to local conditions of agriculture.

Many of the booklets deal with specific crops and techniques, while others are intended to give the farmer more general information which can help him to understand why he does what he does, so that he will be able to do it better.

Adaptations of the series, or of individual volumes in it, have been published in Amharic, Arabic, Bengali, Creole, Hindi, Igala, Indonesian, Kiswahili, Malagasy, SiSwati and Turkish, an indication of the success and usefulness of this series.

Requests for permission to issue this manual in other languages and to adapt it according to local climatic and ecological conditions are welcomed. They should be addressed to the Director, Publications Division, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.

Introduction

1. Farmers and their families always look for ways to make their lives better.



Farmer families

2. One way farm families can make their lives better is to make their own fuel gas which they can use for cooking.



Use fuel gas

3. Today many farmers are making fuel gas at home. They make it from animal manure or from plant materials or from a mixture of both.
4. Fuel gas made in this way has a lot of methane in it. Methane burns very well.
5. Where you live methane gas may be called by a different name. One of the most common names for this kind of gas, when it is made at home, is biogas. We will use the name biogas in this booklet.

Biogas

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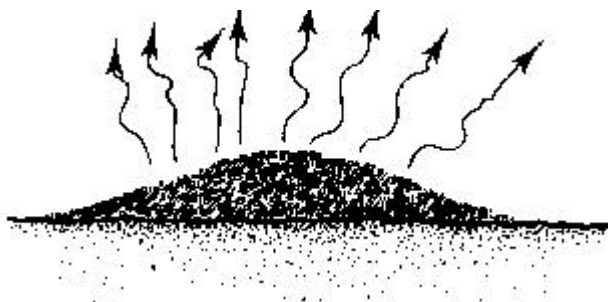
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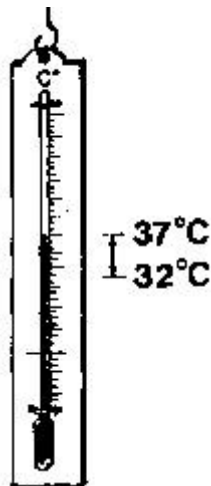
How is biogas made?

12. When animal manure or plant materials rot they give off gas. You collect this gas as it is made when you make biogas.



Make biogas

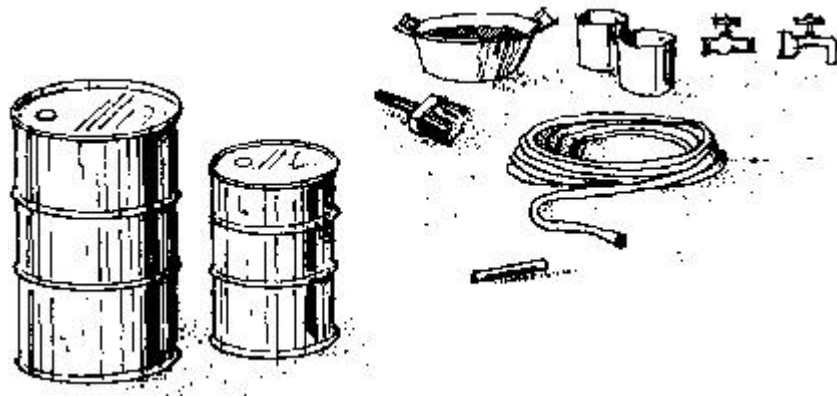
13. In this booklet you will learn how to mix water with animal manure or plant materials, how to put this mixture into a container where it will rot and give off gas, and how to collect the gas in another container which is airtight. We will call these containers the biogas unit.
14. It is not easy to build a biogas unit. When you begin you will have to spend a lot of time and work very hard. It may also cost you money.
15. You must be sure that building a biogas unit will be a good way to use your time and money.
16. You will need a good place to put your biogas unit. Items 26 to 30 will tell you where to put it.
17. If you live where it is too hot or too cold, you may find it hard to keep a biogas unit working.



Keep the biogas unit working

18. Biogas is produced best at a temperature between 32 and 37°C. When the temperature is below 15°C almost no gas is made. Items 31 to 34 will tell you some ways which will help you to keep your biogas unit at the right temperature.

19. You will need oil drums, pipe, valves, a gas line and sealing materials to build a biogas unit.



Materials

You will need a good supply of animal manure or plant material.



Animal manure or plant material

20. If there is a biogas unit near where you live, you should go to visit it. Talk to those who have built it and are running it to see how it works.

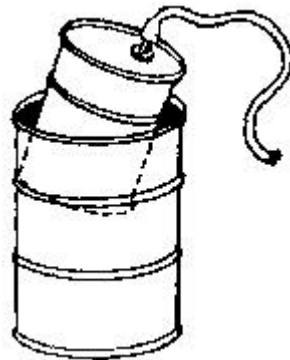
21. When you are thinking about building a biogas unit, you may be able to get advice from your extension officer.



Build a biogas unit

How big should your biogas unit be?

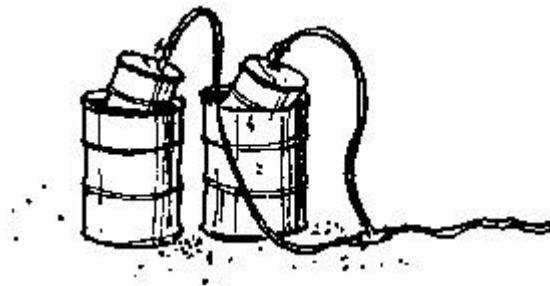
22. Begin by building a small unit. Items 35 to 57 will tell you how. With a small biogas unit, you will need less animal manure and plant materials. A small unit will cost less to build and it will be easier to run.



A small unit

23. When you have learned how to run your biogas unit and have made and used your own gas, you may decide that you need more gas.

24. You can get more gas by building one or more biogas units just like your first one. Items 126 to 130 will tell you how to run several biogas units together.



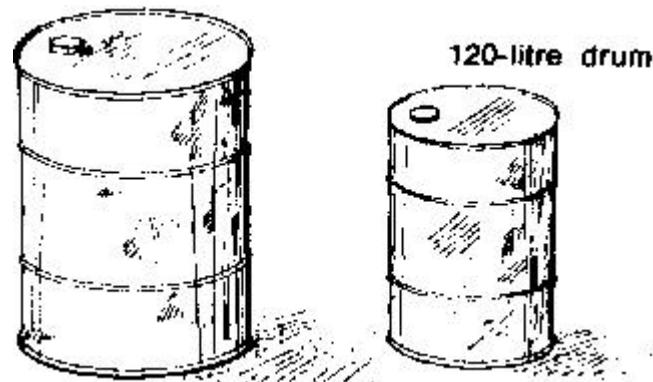
Run biogas units together

How to build a small biogas unit

25. You can build a small biogas unit from two oil drums.

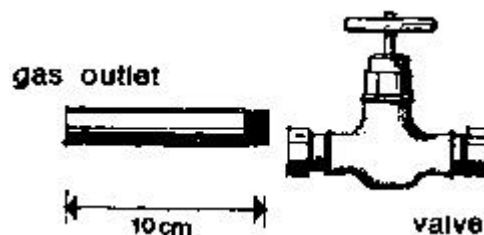
You will need

- an oil drum of about 200 litres, to hold the waste
- an oil drum of about 120 litres, to collect the gas



Oil drums

- a piece of pipe about 10 centimetres long and about 2 centimetres in diameter, for the gas outlet
- a valve to fit the gas outlet



Gas outlet and valve

- at least 10 metres of rubber or plastic tube about 2 centimetres in diameter, for the gas line

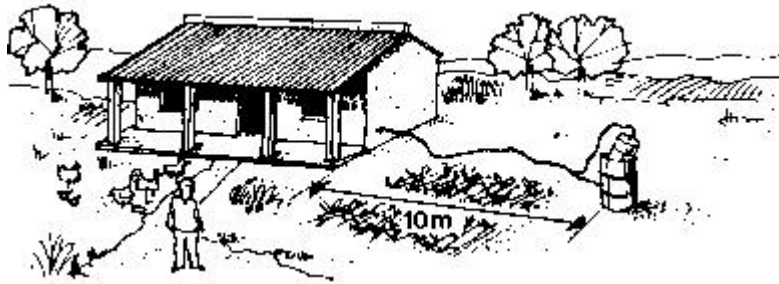


Gas line

Where to put your biogas unit

26. Be careful not to put your biogas unit too close to your home or your cooking area or your water supply.

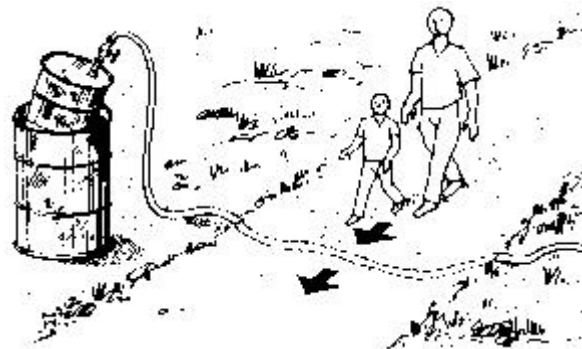
27. A biogas unit should be at least 10 metres from your home so that when you put waste into your unit it will not be too close to where you and your family live and cook your meals.



Put the unit away from house

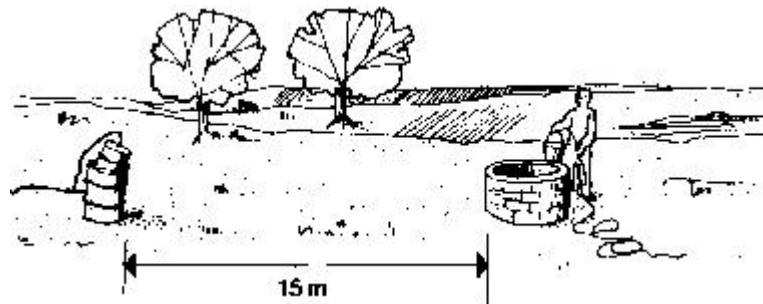
28. Do not put your biogas unit too far from where you cook or you will need a long gas line. Gas lines are hard to find and may cost a lot of money.

29. If your gas line is moved or damaged, it may leak when gas is made. If your gas line crosses a path, bury it a little underground to protect it from being moved or damaged.



Protect the gas line

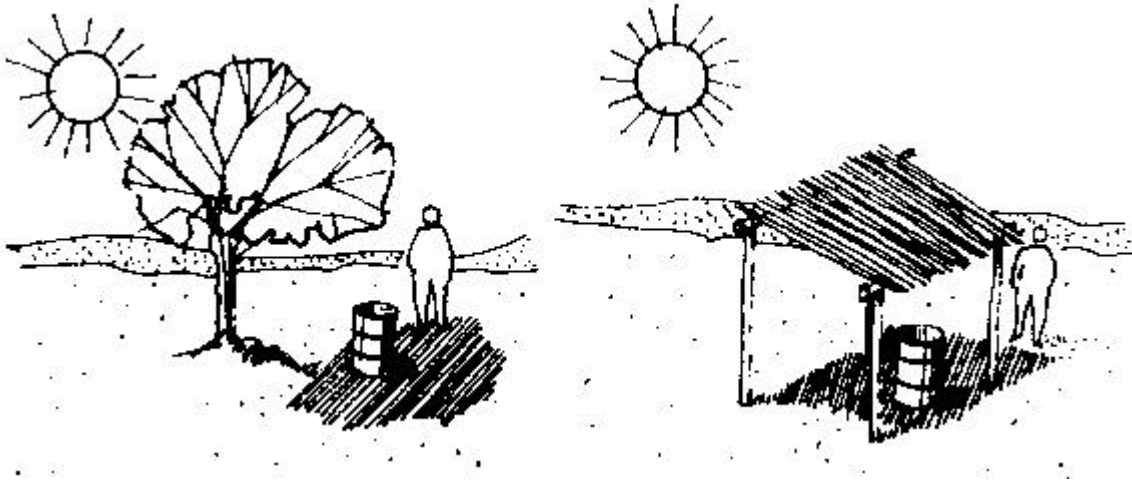
30. A biogas unit should be at least 15 metres from your water supply, so that the waste in your unit will not make your water dirty and unhealthy to drink or use.



Put the unit away from the water supply

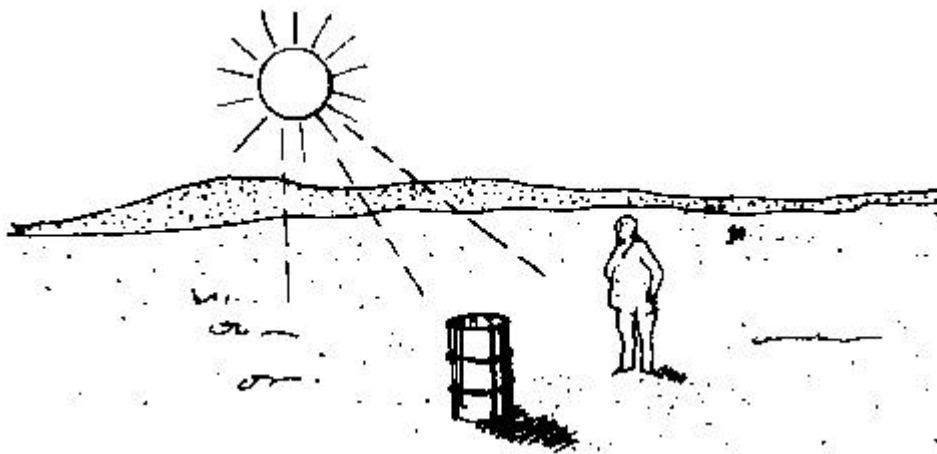
31. You have already been told that you will get most gas if the temperature of your unit is between 32 and 37°C.

32. If you live in a very hot place, put your unit out of the sun, in the shade or under trees to keep it getting too hot.



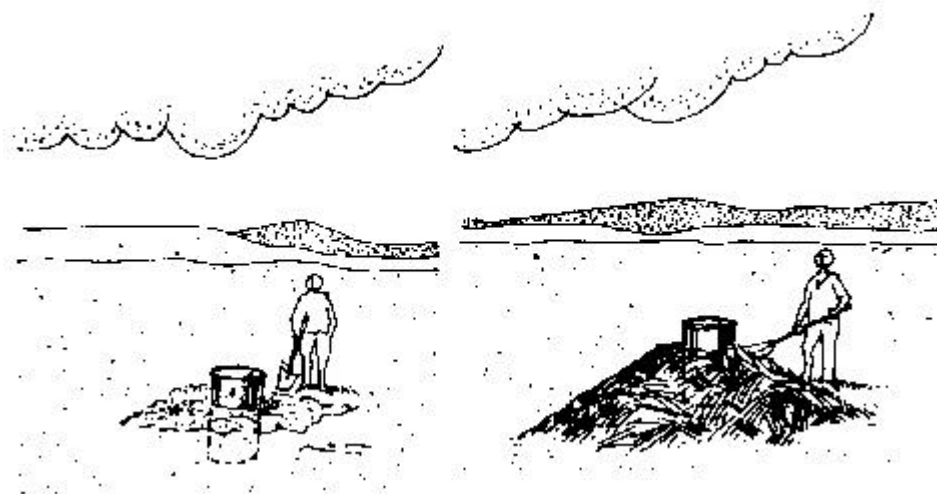
Put the unit out of sun - in hot places

33. If you live in a place that is not very warm, put your unit in the sun to keep it warm.



Put the unit in the sun - in not warm places

34. If you live in a cold place, put the unit underground or cover it with earth or straw to keep it warm.



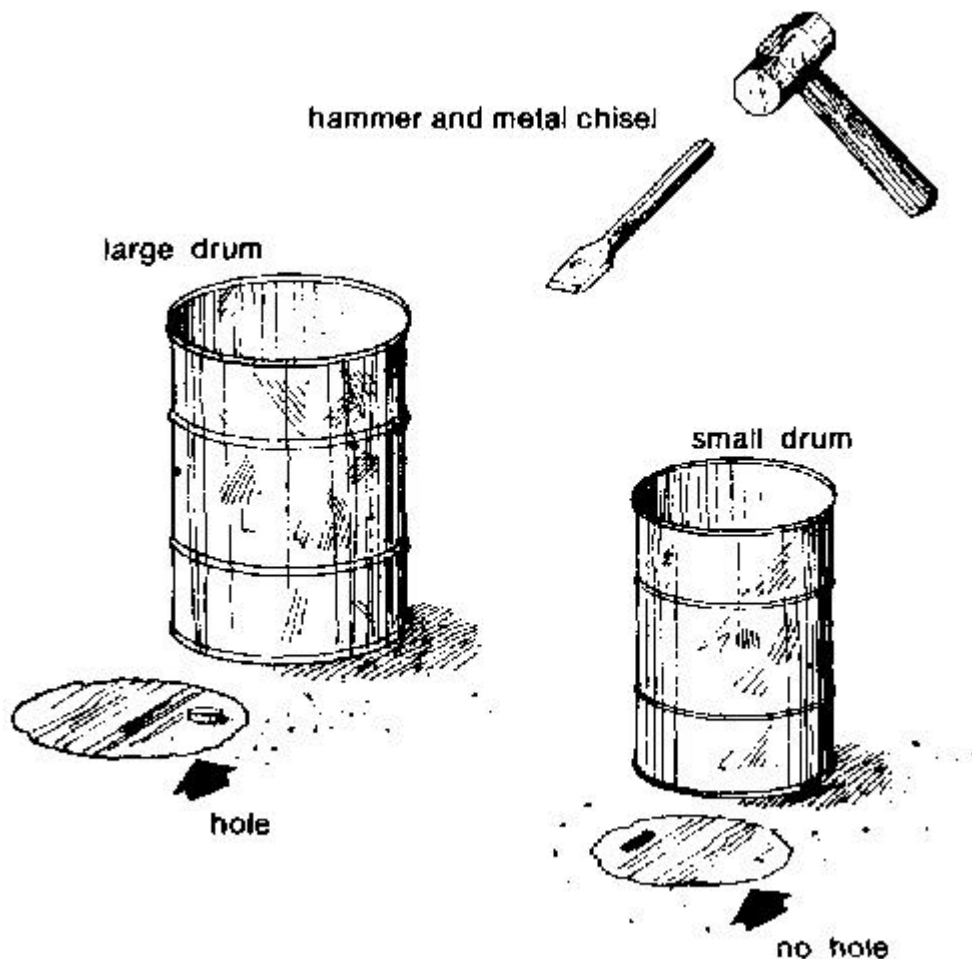
Cover the unit - in cold places

Building the unit

35. The bottom part of the unit, which holds the waste mixture, is made from the bigger drum. The top part of the unit, which holds the gas, is made from the smaller drum which you put inside the bigger drum.

36. Most drums have a hole in the top. You will not need a hole in the top of the bigger drum but you will need a hole in the top of the smaller drum for the gas outlet.

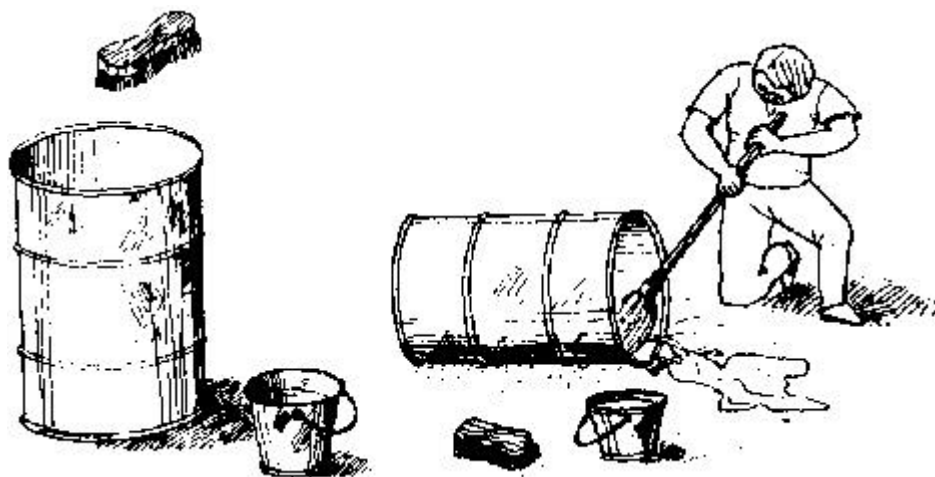
37. Cut out one end from each drum. You can do this using a hammer and metal chisel. Cut the end of the bigger drum that has a hole in it. Cut the end of the smaller drum that does not have a hole in it.



Use a metal chisel and a hammer

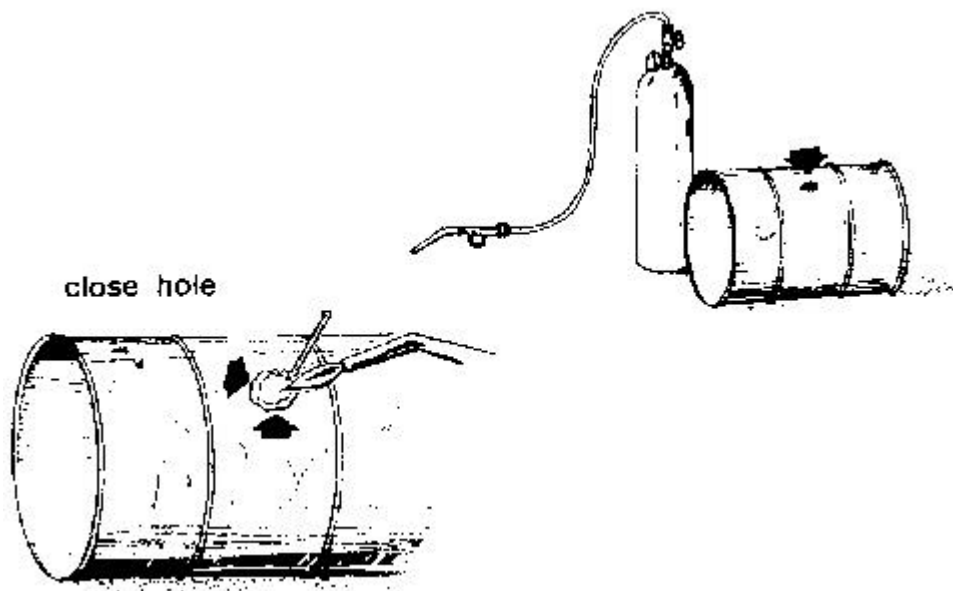
38. If the small drum does not have a hole in the top, you will have to cut one (see Item 45).

39. Now clean both drums well inside and outside to remove oil and grease .



Clean the drums

40. If either drum has a hole in the side, close it tightly. This can be done with a metal plug or by welding a piece of metal in the hole as shown in the drawings.

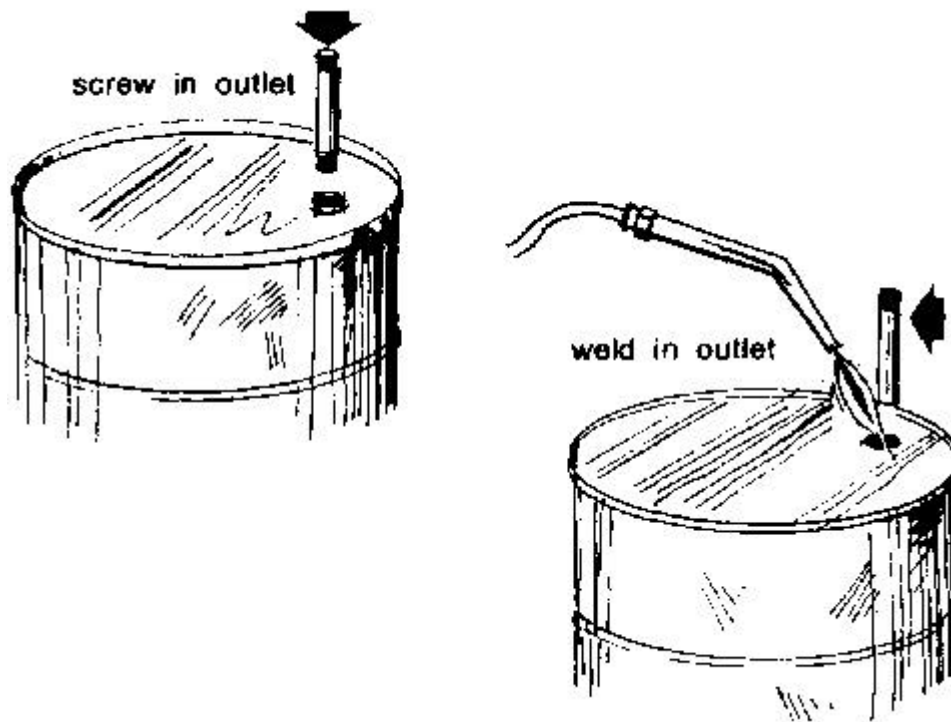


Close hole

41. Now you are ready to put the gas outlet in the top of the small drum.

42. The gas outlet is made from a short piece of pipe about 10 centimetres long and about 2 centimetres in diameter.

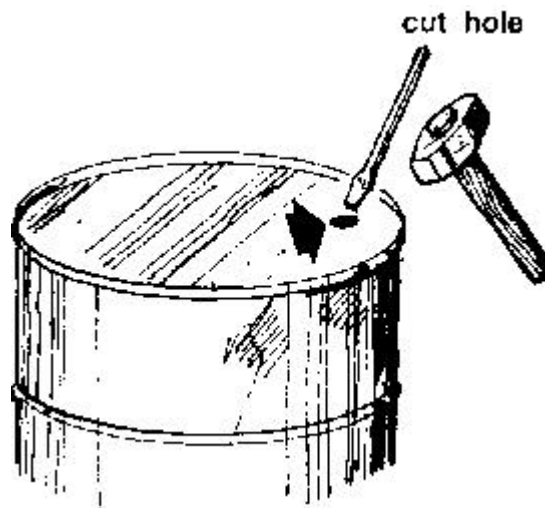
43. If there is a threaded hole in the top of the small drum, use a gas outlet which is threaded on both ends and screw it tightly into the hole.



Screw in outlet

44. If the hole in the top of the small drum is not threaded, use a gas outlet which is threaded on one end and weld it into the hole with the threaded end up

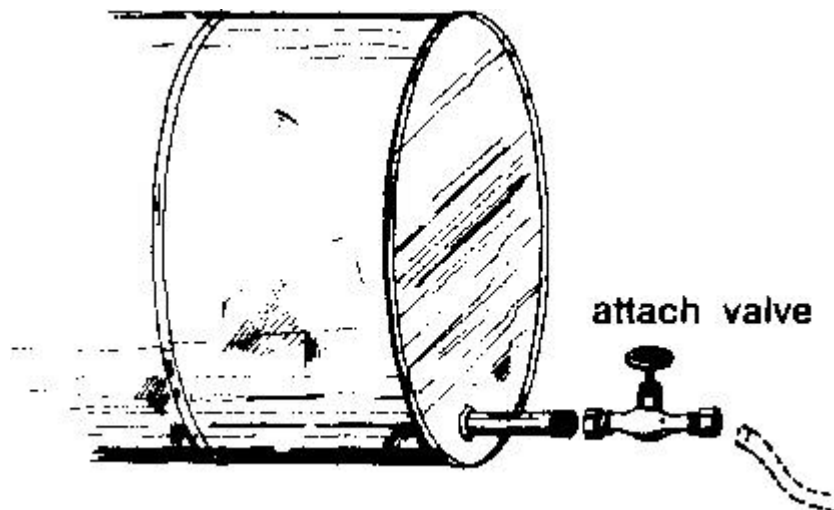
45. If there is no hole in the top of the small drum, cut one about 2 centimetres in diameter and using a gas outlet which is threaded on one end weld it into the hole with the threaded end up, as you were told in item 44.



Cut hole

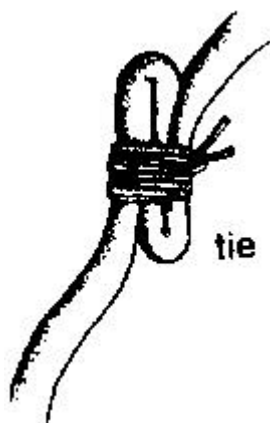
46. Now you are ready to attach a valve to the top of the gas outlet. You can use valves like the ones shown in the drawing.

47. The valve you use must be airtight so that it will not leak gas and you must be sure to screw it tightly to the gas outlet.

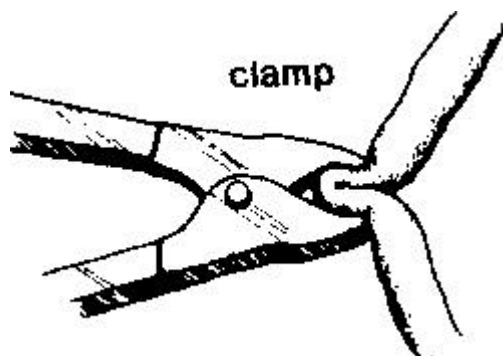


Attach valve

48. If you do not have a valve, attach the rubber or plastic tube you are using for the gas line directly to the gas outlet. To close the gas line, you can fold it once and clamp it shut or you can fold it twice and tie it tightly with cord as shown in the drawings



Tie



Clamp

Testing for leaks

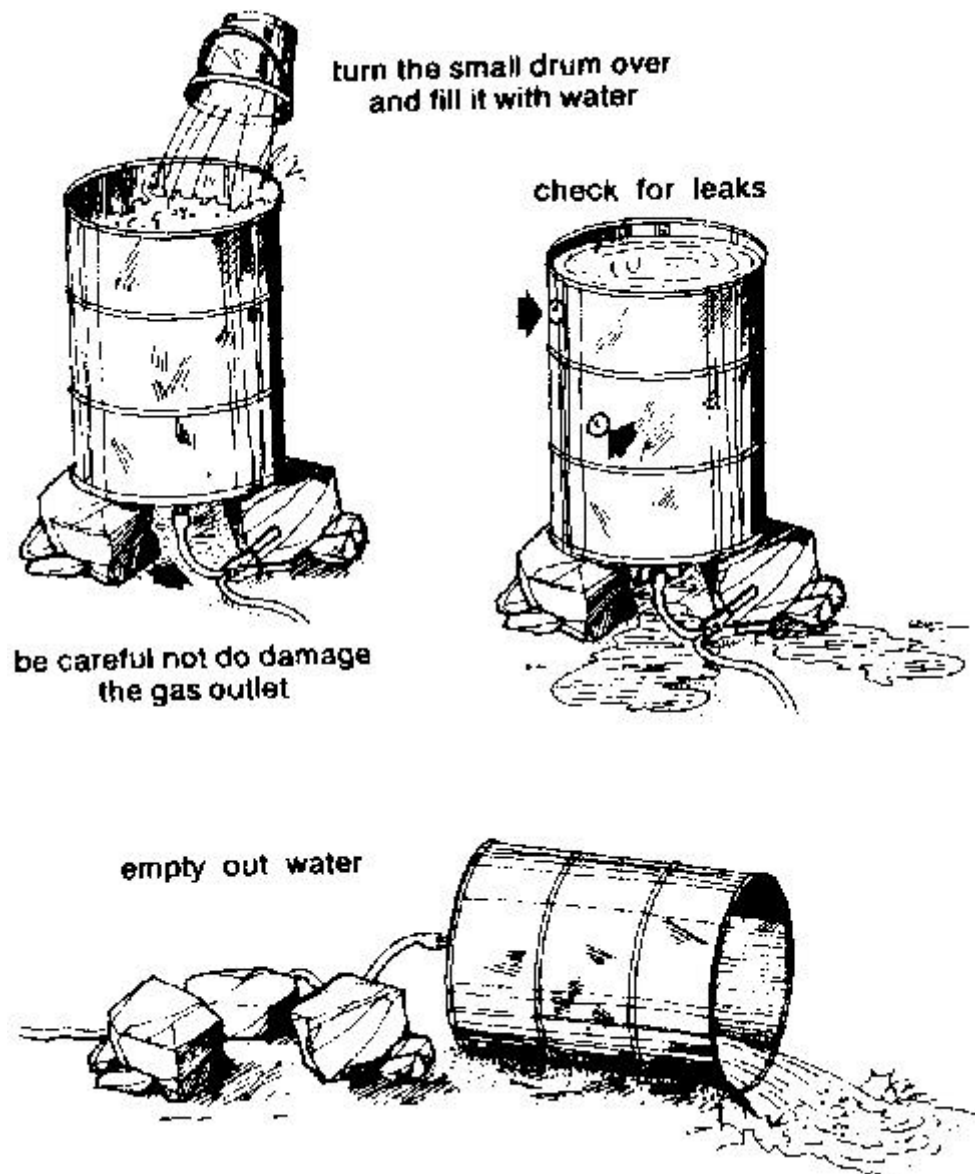
49. Now you are ready to test the small drum for leaks. To hold gas it must be airtight.

50. To check for leaks, close the valve or if you have no valve clamp or tie the gas line tightly as you

were told in item 48.

51. Turn the small drum over and place it above the ground on stones or pieces of wood, but be careful not to damage the gas outlet or the valve or to loosen the clamp or the cord on the gas line. Now fill the small drum with water.

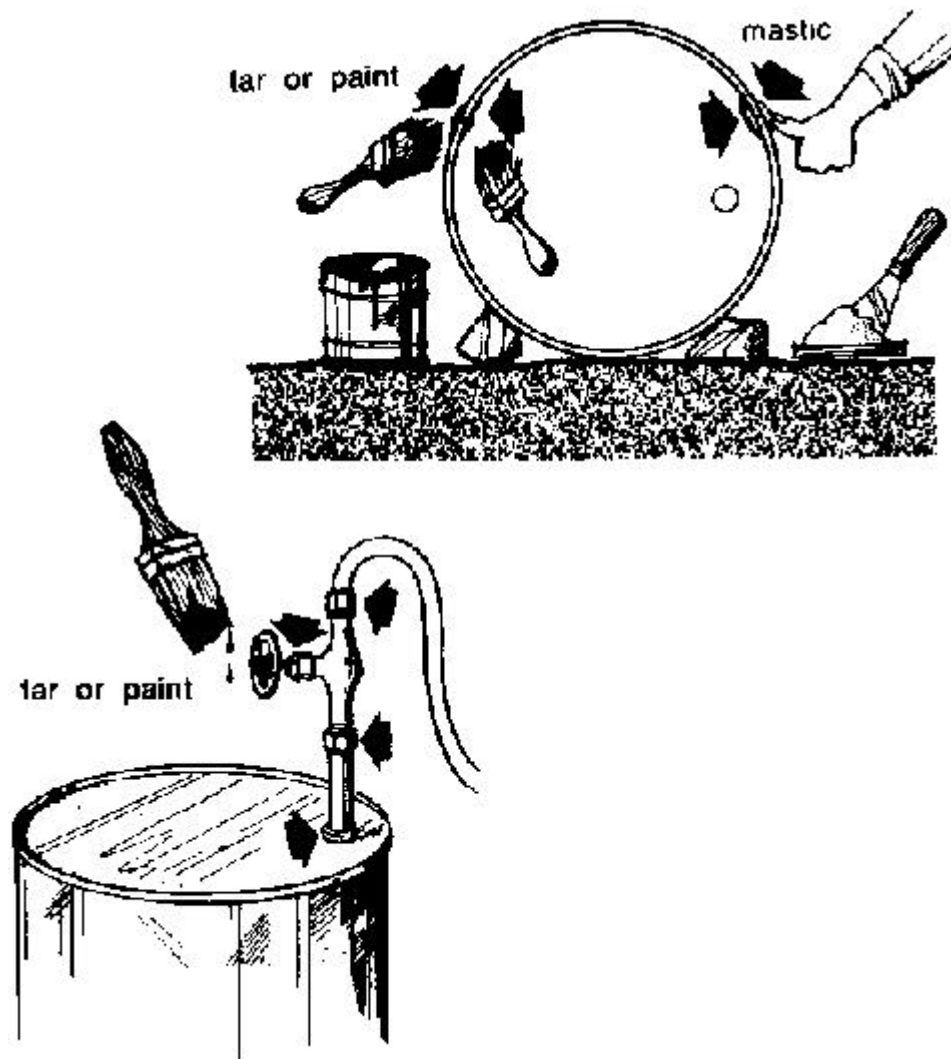
52. If you see water leaking from the drum, the gas outlet, the valve or the tied gas line, mark the place of each leak. Then empty out the water, being careful not to damage the gas outlet, and let the drum dry.



Mark the places of leak

53. Seal the leaks by coating them with tar, mastic or paint on the inside and the outside of the drum.

54. If there are leaks around the gas outlet or valve, tighten the outlet or valve again and coat the joints with tar, mastic or paint.



Tar or paint

55. When the sealing is dry, fill the drum with water again to be sure that the leaks are well sealed. If water still leaks, start over again.

56. When the small drum is well sealed and no longer leaks, your biogas unit is ready to use.

57. It is very important to seal all leaks carefully.

Waste materials

What waste materials to use

58. Animal manure from cows, pigs and chickens, and crop and plant wastes are good materials for making biogas.



Materials for make biogas

59. You can use animal manure alone or plant materials alone or you can use both mixed together.

60. Straw which is mixed with manure, which you may have where you keep your pigs or chickens, is usually a good mixture of animal manure and plant material for making biogas. Be careful to chop it fine before you use it.



Straw mixed with manure

61. When you first begin, it is best to use only animal manure or a mixture of animal manure and very little plant material. Later when you have learned more about how your biogas unit works, you can use more plant materials.

62. When you do begin to use plant materials, remember that dry plant materials must be chopped or shredded very fine and fresh plant materials must be left outside to rot for 10 days or more before you put them into a biogas unit.



Rot 10 days

How to use them

63. Whether you are going to use animal manure or plant materials in your biogas unit, you must mix them with water. Use one bucket of water with every bucket of animal manure or plant material.



Animal manure and plant material

64. Plant materials which are not mixed well may not make gas later. When you mix plant materials with water, they pack together.

65. If you are using plant materials, break them apart and stir them well so that they will be well mixed.

66. Mix the animal manure or the plant material with water until the waste mixture is easy to pour. The waste mixture will work best if it is like a thin paste.

Making a starter

67. About two months before you are ready to use your biogas unit for the first time, put 2 litres of animal manure and 2 litres of water in a bucket and mix well. You can also add some finely chopped plant material such as grass.



Plant material

68. We call this mixture a starter. A starter helps the biogas unit to make gas sooner.

69. Pour the starter mixture into a container which holds a little more than 4 litres. You can use a bottle or a jug but do not close it, leave it open.



Pour starter into a container

70. Keep the starter warm and shake the container three or four times each week to mix the contents. In about two months it will be ready to use.

Putting waste into your biogas unit

71. Now you are ready to put the waste into your biogas unit. Put the large drum open end up where you want the unit to be. Put the small drum next to it with the gas outlet up.



Drums

72. Now put the waste and water you are going to use into the large drum. Put 3 buckets of waste and 3 buckets of water into the large drum and stir it well.



Put waste and water

73. Now put another 3 buckets of waste and 3 buckets of water into the large drum and stir all of the waste mixture again.

74. Put more waste and water into the large drum, stirring well each time, until the waste mixture in the large drum is level with the top of the small drum. The drawing on page 29 will show you how.



Stir starter

75. Stir the starter you have made, (see Items 67 to 70) into the waste mixture in the large drum. The starter which has already begun to work will help you to make gas sooner.

76. Now open the valve or clamp or untie the gas line of the small drum to let out the air. Push the small drum down into the waste mixture until it touches the bottom of the large drum.



Open valve

7. The small drum must be full of waste mixture. It must be full to the top so that there will be no air

in it.

78. You can be sure that the small drum is full to the top if you can see that the waste mixture inside the large drum rises a little above the top edge of the small drum when it has been pushed down.



Small drum full

79. If it does not rise above the top edge of the small drum, take the small drum out and put a little more waste and water into the large drum. Then put the small drum back and push it down into the waste again.

80. When you are sure that the small drum is full of waste mixture to the top, close the valve or clamp or tie the gas line so that you will keep out air and begin to collect gas.

81. You can tell that the waste mixture in your simple biogas unit has begun to rot and make gas when the small drum begins to rise. This means that gas is being collected.



Gas collected

82. If you find that gas is leaking from the small drum after the biogas unit has begun to work, seal the leaks with tar, mastic or paint. If the gas is leaking around the gas outlet or valve, tighten the outlet or valve again and coat the joints with tar, mastic or paint.

83. A good way to check for leaks after the biogas unit has begun to work is to put soapy water on the small drum and on the joints of all the parts and lines. If you see bubbles anywhere, you will know that there is a leak. Seal the leaks as you were told in items 53 and 54.



Bubbles

Time

84. It may take up to three weeks or even a month for the waste in your biogas unit to start making gas. After that, gas will be made for about eight weeks.

85. During these eight weeks, half of the gas will be made in the first two or three weeks and the rest in the last five or six weeks.

86. If you find that not much gas is being made in the last weeks, empty the unit and start again.

Cold weather protection

87. If the temperature where you are often falls below 15°C, you will have to keep the waste mixture in your biogas unit warm.

88. If you put your biogas unit under the ground or partly under the ground, this will help to keep the waste warm.



Keep the waste warm

89. You can keep the waste mixture in your biogas unit warm by putting leaves, grass, straw or maize stalks around the large drum.



Keep the mixture warm

90. You can also keep it warm by adding a bucket or two of poultry drop, pigs mixed with other waste to the waste already in the large drum. Use one part of poultry droppings to three parts of other waste.



Use poultry droppings

Stirring the waste mixture

91. Sometimes a layer of scum may form on top of the waste mixture in your biogas unit. If this happens, less gas will be made and the small drum may not rise.



Layer of scum

92. If the waste is well mixed before it is put into the unit, there will be less chance for scum to form and your biogas unit will make gas well.

93. If you use plant materials, scum is more likely to form than if you use only animal manure. You will need to stir the waste mixture in your biogas unit from time to time.

94. You can break up a scum layer by stirring or shaking the waste mixture after it is in the unit. You must do this without opening the small drum and letting out the gas or letting in the air.



Shaking

95. During warm weather, the waste mixture in your biogas unit may become too thick and little gas will be made.

96. If this happens, add a bucket of water to the unit and stir the waste to thin it. If after a few days no

gas is being made and the waste is still too thick, add another half- bucket of water and try again.



Add water and stir or shake

97. If a lot of very hard scum forms on top of the waste mixture and no gas is being made, take out all the waste mixture, clean the unit and start again. Do not throw the waste mixture away, use it for fertilizer.

When the gas is made

98. Do not burn the first gas that is made. It may have air in it and could explode.

99. A few days after the small drum has begun to rise, open the valve or clamp or untie the gas line and let out all of the gas that has been collected.



open the valve

100. While you are letting the gas out, be very careful not to have fire near the biogas unit.

101. To let the gas out, push the small drum back down into the waste mixture in the large drum. This will force all gas and air out of your biogas unit. Then, close the valve or clamp or tie the gas line and your biogas unit will begin to collect gas again.



Push the small drum down

102. If you have done this carefully, the next gas that is made will have no air in it and it will be safe to burn. You can burn all the biogas that is made after this. Do not open the unit again until all the gas has been made.

103. After all the gas has been made, take the unit apart and empty out the fertilizer. Keep about 4 litres of the fertilizer to be used as a starter for the next time.



Take the unit apart



Keep fertilizer for starter

104. Clean the unit and check for leaks.



Clean and check for leaks

105. Now fill the unit with new waste material and add the starter. Close the unit tightly and it will begin to make gas again.



Fill with new waste material

106. Remember, every time you start again, do not burn the first gas that is made.

Using your biogas

107. The best way to use the biogas that you make with your small biogas unit is for cooking. When your unit is working well, it will make enough gas every day to cook your evening meal.

108. You can use biogas with almost any ordinary gas- burner, if you adjust the burner so that the right amount of air is mixed with the biogas.



Adjust air mix

109. If there is too much air, the flame will be blown out and the biogas will not burn. If there is not enough air, the flame will be yellow, the biogas will not burn well and will not give enough heat.

110. When there is the right amount of air and the biogas is burning well, it will burn with a blue flame. By letting more or less air into the burner, try to make the flame as blue as you can.

111. Sometimes the flame may begin to turn yellow after it has been burning well. This may mean that the burner has become full of a black material called soot.

112. If this happens, clean the burner very carefully and clean all the holes in the burner with soap and water. Dry the burner well. This may help your biogas



Clean burner

113. If the flame is not steady, or if it is weak when there is still gas in the unit, this may be because there is water in the burner or the gas line.

114. Shut off the gas at the small drum and take off the burner. Empty out any water that is in the gas line or in the burner. Then put the burner back, turn on the gas and light the burner again.



Shut off gas



Empty out water

Using the fertilizer

115. You have already learned that when all the gas has been made, the material that is left in your biogas unit is a very rich fertilizer.

116. It does not have a bad smell, and the parasites that were in the animal wastes and the weed seeds that were in the plant wastes are no longer harmful.

117. You can spread this new fertilizer on your fields to help your plants grow well.



Put fertilizer everywhere

118. Do not put the fertilizer all in one place. Put a little of it everywhere on your fields. In this way, all of your plants will grow better.

Taking care of your biogas unit

119. Always be very careful when you are near a biogas unit because gas may be leaking.

120. Never build a fire near the unit, smoke, or even light a match near the unit, because if gas is leaking it may explode.



Never build fire near the unit

121. If biogas is leaking and you breathe in too much of it can make you very sick.

122. Check your biogas unit and gas lines often to be sure that there are no leaks. Items 49 to 57 and items 82 and 83 have told you how to find and stop leaks.

123. After some time, rust will start to appear on the inside of your unit.

124. Once a year you should take the unit apart and clean and paint the metal gas holder and all other metal parts.



Clean and paint

125. You can use paint which is used to protect metal or coat the metal parts with tar.

Making more biogas

126. After you have made biogas a few times with your small biogas unit, and have used it for cooking, you may find that you could use more gas if you had it.

127. The easiest way for you to make more biogas is to build one or more biogas units just like your first one.

128. If you can get more oil drums, pipe, valves and gas lines, and if you have enough waste materials, you can build and run several small biogas units and get gas from all of them.

129. When you have several biogas units, you can connect them to your gas line by using T- pieces. The drawings show you a t- piece and how to connect several units to the same gas line.



T- piece

130. When you have several biogas units fill them with waste at different times so that when all of the gas in one unit has been made, you will still get gas from another unit which is working.

131. In this booklet you have learned how to build a small biogas unit and how to make your own biogas. You have also learned that you can make more biogas by building several small biogas units.

132. But there are still other ways to make more biogas. You can build an improved small unit or you can build a different kind of unit which is bigger and better and will give more biogas.

133. You will learn about these ways in a later booklet.

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