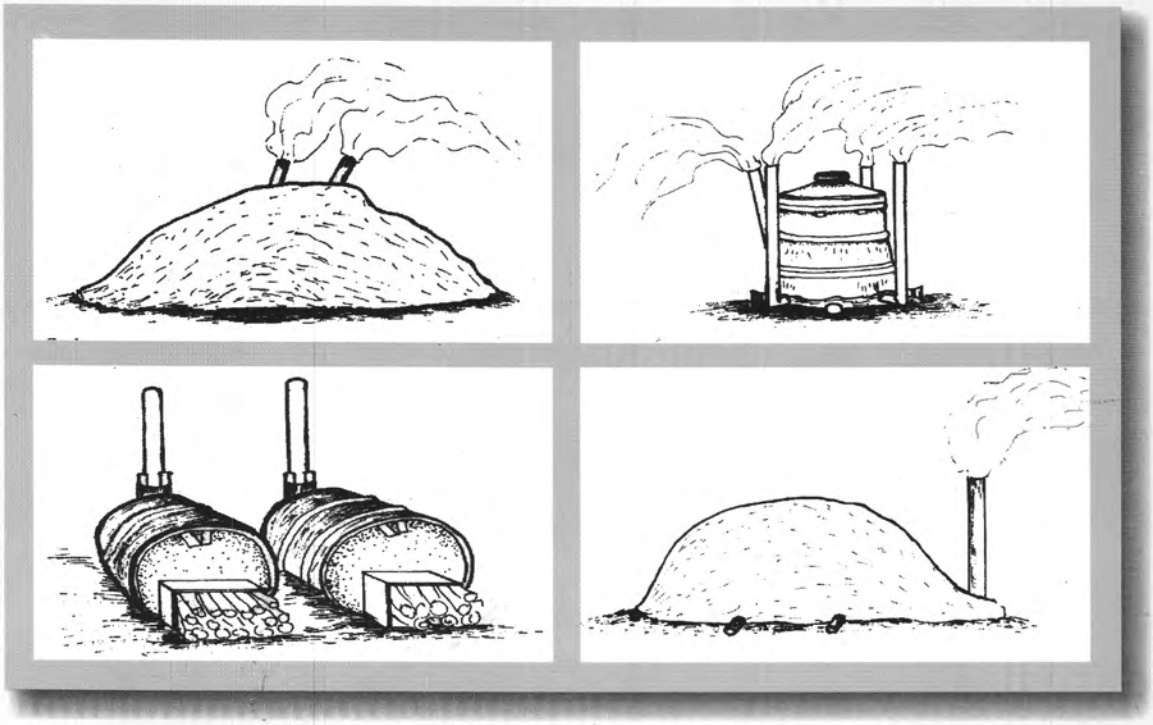
Charcoal Production using Improved Earth, Portable Metal, Drum and Casamance Kilns



Kenya Forestry Research Institute
Forest Products Research Centre - Karura

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Charcoal Production

Using

Improved Earth, Portable Metal, Drum and Casamance Kilns

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Illustrations on the cover page are
Top left: An improved earth kiln
Top right: A portable metal kiln
Bottom left: Two drum kilns
Bottom right: A casamance kiln

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1.0

Introduction

Charcoal is a residue of solid organic matter that results from incomplete carbonisation by heat in the absence of air at temperatures above 300°C. The essential requirement for wood carbonisation is a source of heat to raise the temperature to the necessary level and exclusion of oxygen. Various methods have been used in wood carbonisation (commonly referred as charcoal burning). Some of these methods are crude with low yield and very limited control of the quality of the charcoal produced while others are highly automated (eg. retorts). Higher charcoal conversion efficiency and quality can be achieved through proper control of the carbonisation process.

There are three most common methods of charcoal production today; earth kilns, masonry and metal kilns. The earth kilns are of various types but the most common are the traditional and improved earth kilns. The masonry kilns are represented by the beehive and half orange while the metal kilns by the drum kiln and Mark V.

This manual is intended to act as a guide to charcoal making in Kenya using technologies that have proved to be efficient and appropriate. They include; improved earth, drum, portable metal and the *casamance* kilns. The improved earth and *casamance* kilns have been modified by KEFRI through research while drum and metal kilns have been adopted from technologies developed elsewhere.

2.0

Improved Earth Kiln

The improved earth kiln is an improvement of the traditional earth kiln. It offers better carbonisation control resulting in higher yield (about 27%) and better charcoal quality. The construction and operation of the improved earth kiln, involves the following steps;

1. Cross-cut wood into workable pieces of 1-1.5 m in length immediately after felling for faster evaporation.
   - Stack the fuelwood to dry for about 6 weeks in the open where there is ample sunlight and wind to facilitate rapid drying to a moisture content of less than 20% before charcoaling (Figure 2.1). Stacking assists in estimating the volume of wood to be carbonised .
   - Assemble necessary tools; shovels, spades, jembes (hoes), match box, axes and sacks. Additionally, a wire mesh or light gauge iron sheet is required.

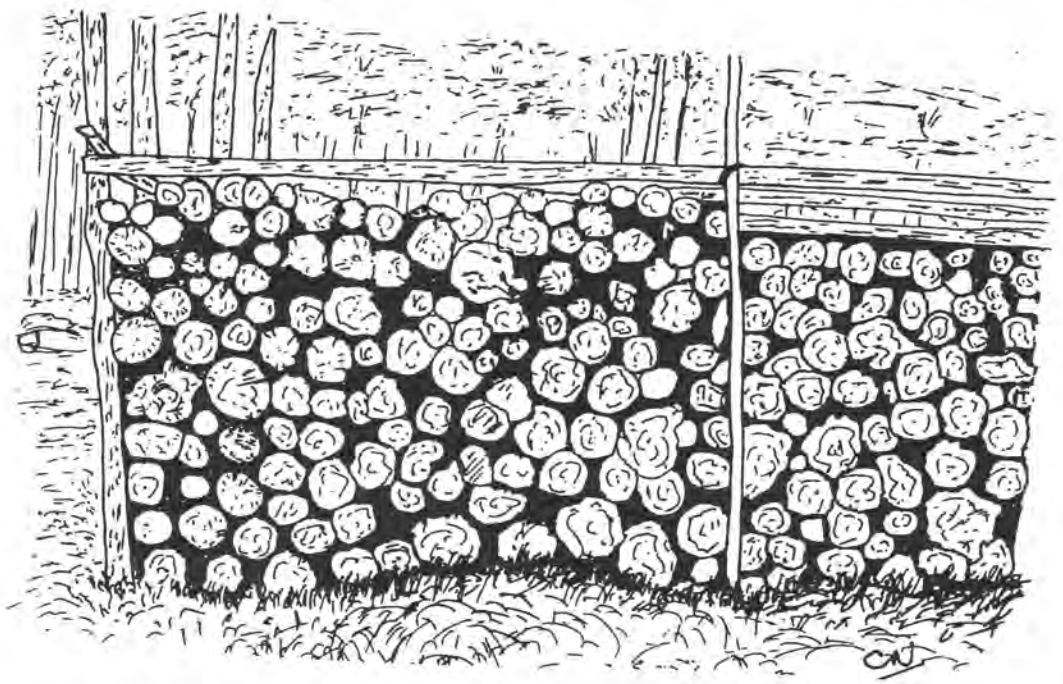

Figure 2.1: *A standard stack of 3m³ (1m high x 1.5m length of wood x 2m breadth of stack) to allow free air circulation*

2. Select the kiln site as close as possible to the wood supply where the vegetation is cleared and the ground is levelled (Figure 2.2).

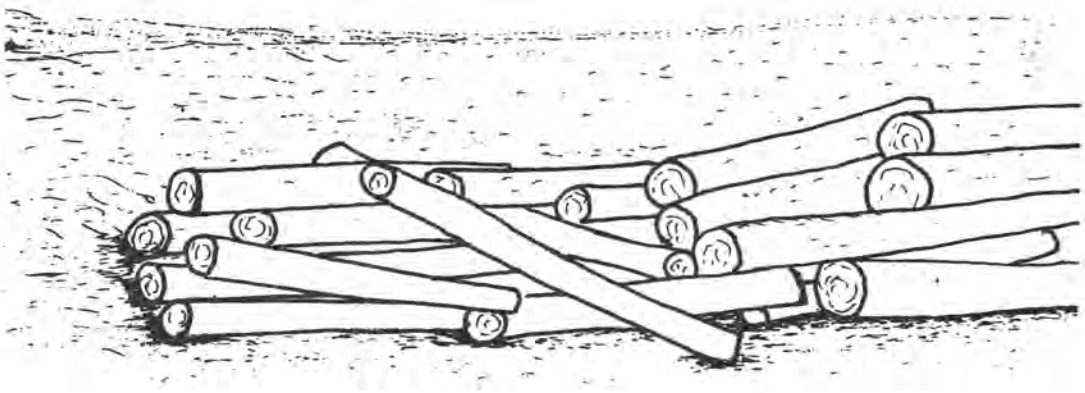

Figure 2.2: *The ground is cleared and levelled before stacking the wood*

3. Stack the fuelwood as tightly as possible in a horizontal position (Figure 2.3) and fill all gaps between the wood with smaller fuelwood pieces to allow for better heat transfer. At the lighting zone, (which is on the side opposite the chimneys) place small branches and twigs.

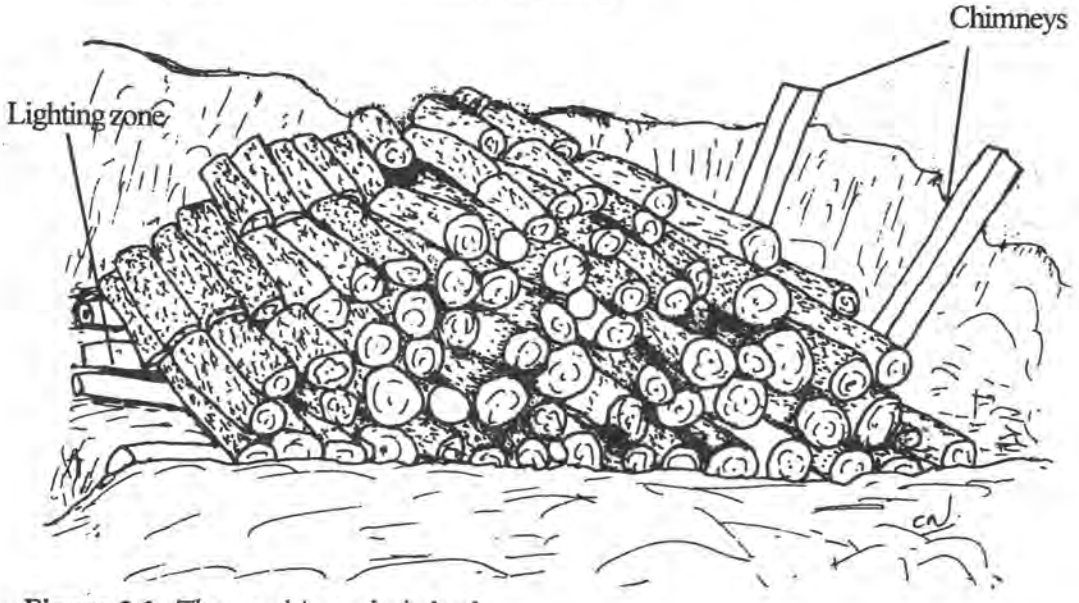

Figure 2.3: *The wood is stacked closely*

4. Cover the fuelwood with a wire mesh (or metal sheet) to reduce defilement and contamination of charcoal.
    - Place the two chimneys at the opposite side to the lighting place (Figure 2.4). The chimneys are made of gauge 26 galvanised iron sheet and are 180 cm long with either a diameter of 12 cm or cross-section area of 10.6 by 10.6 cm.
    - If the wire mesh is not available, leave this step out and cover the wood with loose thick layer of foliage.

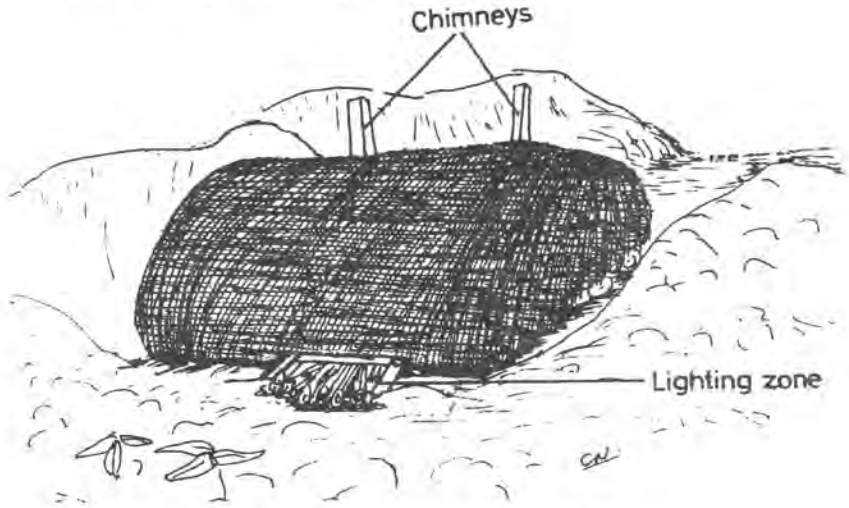

Figure 2.4: *The pile of wood is covered with the wire mesh*

5. Cover the wood with thick loose foliage (Figure 2.5), grass or light iron sheet except for the lighting point.

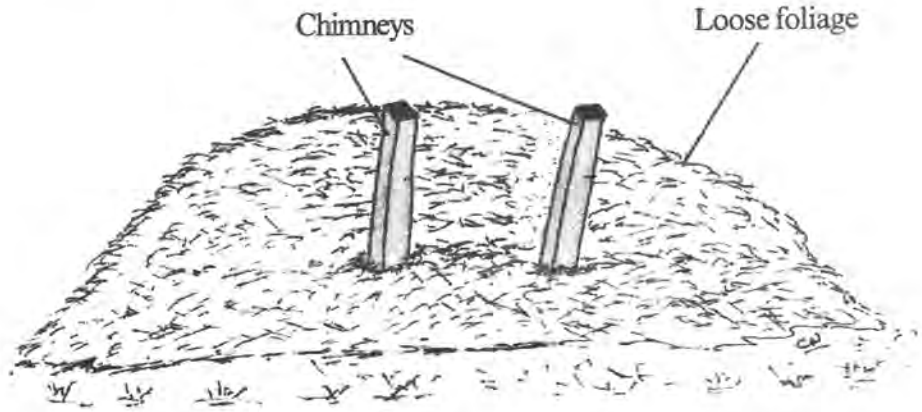

Figure 2.5: *The kiln is covered with thick loose foliage*

6. Apply a thick layer of soil on top of the loose foliage and grass layer (or metal sheet) to a depth of about 20 cm other than the lighting point (Figure 2.6). The thick layer of soil is necessary to prevent complete combustion.
    - Monitor the kiln frequently throughout the carbonisation cycle to ensure that the required soil thickness is maintained and no openings emerge.

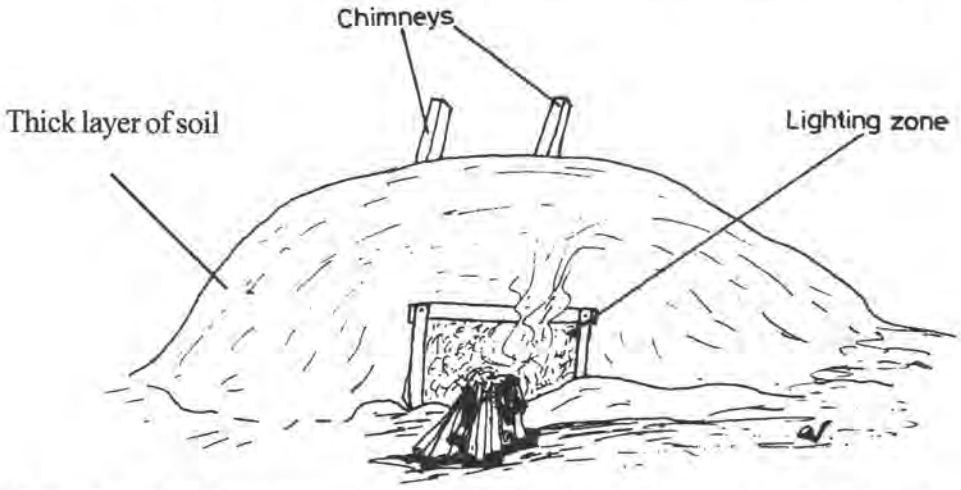

Figure 2.6: *The kiln is covered with a thick layer of soil except for the lighting point*

7. Make a small fire near the kiln and when well lit, place two or three shovels of burning wood at the kiln's lighting point where the small pieces of wood are fed to ensure a fierce blaze. Once lit, smoke starts to come out through the chimneys (Figure 2.7).
    - Seal off the lighting point with loose grass or vegetation and immediately cover with soil.

Figure 2.7: *Once lit, the kiln emits smoke from the chimneys*

8. The emission of dense white smoke emitted from the chimneys indicates carbonisation is progressing well (Figure 2.8). After 3 - 4 days, the kiln will sink to about a third of the original height and the smoke becomes thin and reduced. A light blue smoke colour indicates that the charcoal has been carbonised.

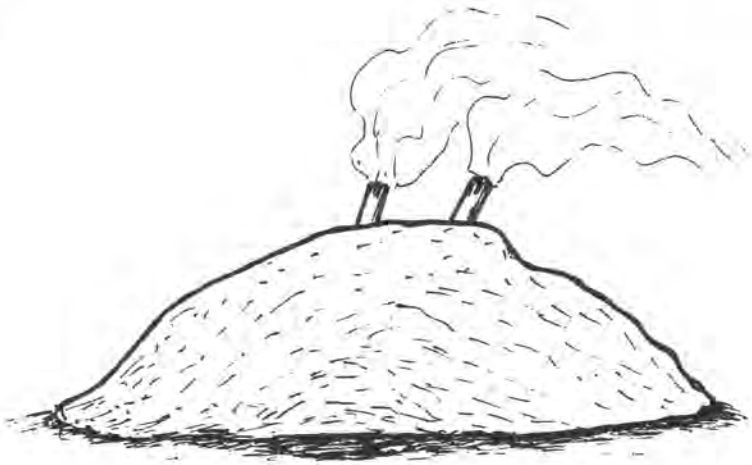

Figure 2.8: *Carbonisation progressing well evidenced by the thick smoke emitted from chimneys*

Put off the kiln by stepping on top of the earth mound and sealing the chimneys and all other ventilations (Figure 2.9). The cooling time of the kiln depends on its capacity or size, type of wood and weather. During cooling, the kiln is kept air tight to prevent charcoal inside from catching fire which would prolong the cooling and reduce the charcoal yield and quality

Figure 2.9: *The kiln is put off by stepping on top of the earth mound and sealing the chimneys and all other vents to keep the kiln air-tight*

9. Remove the soil, grass and wire mesh covering the kiln (Figure 2.10). If some pieces of the discharged charcoal start to smoke and burn, they are covered with soil to put them off.
   - DO NOT use water to cool the charcoal as it affects its quality. However, a bucket of water should be available for precaution incase of an emergency.
   - Each stack of 3 m^3 wood gives about 9-11 bags of charcoal. The kiln takes 4 - 7 days to achieve full carbonisation and has a recovery of about 27%.

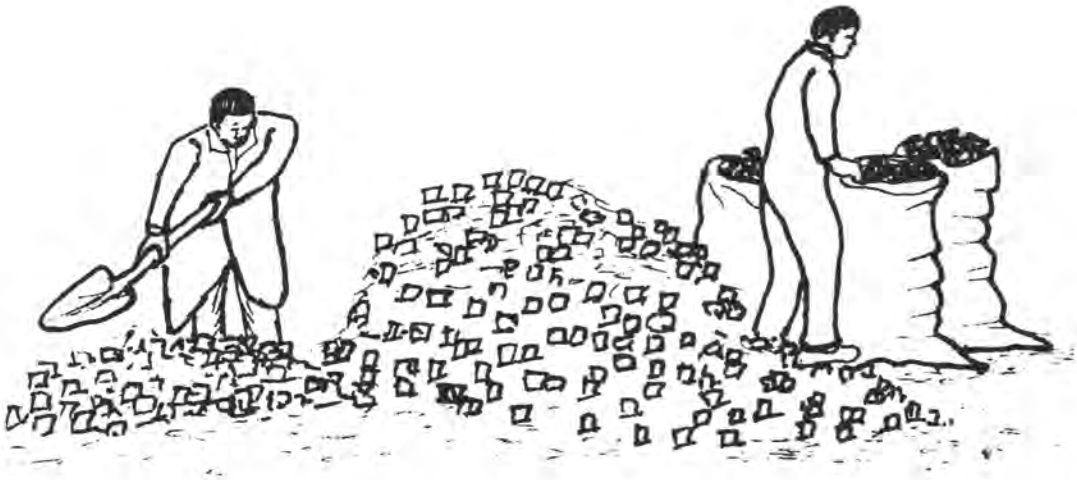

Figure 2.10: *The soil, grass and wire mesh covering the kiln are removed and the charcoal is put into gunny bags*

3.0

Portable Metal Kiln

Metal kilns are of various dimensions and have been designed to be easily transported. The key advantage of these kilns is their mobility to the source of fuelwood and its short production cycle (16-24 hours). However, they have a higher capital cost compared with an equal production capacity of either improved earth kiln or the masonry kilns. The cost of importing fully fabricated metal kilns is high but this can be reduced through local fabrication of the same kiln using basic workshop facilities. Therefore, where there is a need for this type of kiln, possibility of local fabrication should be considered.

There are several different makes of portable steel kilns. Majority operate on reverse draught principle (where carbonisation starts from top going downwards) with the aid of chimneys situated around the base of the kiln. They provide a better control and greater yield (about 30%) of charcoal. In KEFRI, there is a stainless steel kiln of 2mm thick sheet and consisting of three interlocking cylindrical sectors and conical cover. The bottom cylinder has eight air inlet/outlet channels arranged radially at the base (Figure 3.1). For its operation the following steps are taken.

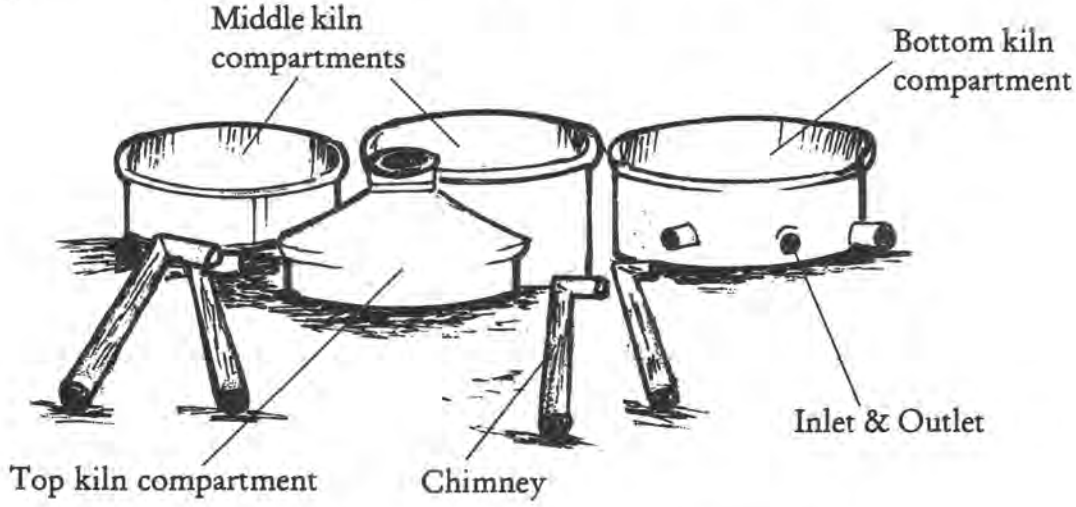

Figure 3.1: *Dismantled sectional metal kiln showing the four compartments*

1. Select a site free from stumps near the wood supply. Remove vegetation and level the ground .

2. Cross cut the wood to pieces between 45 - 60 cm long and a maximum diametre of 20 cm and stack it to dry upto 20% moisture content maximum.
   - Place the (hollow) bottom kiln compartment on the ground and arrange the wood pieces radially from circumference to centre of the cylinder. Ensure the ends of the inlet/outlet channels and the spaces between them are not blocked (Figure 3.2).

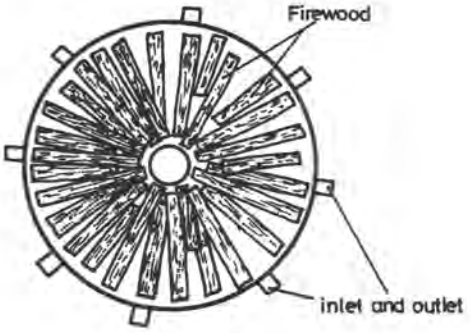

Figure 3.2: *Wood pieces arranged radially from the circumference of the lower section of portable metal kiln to the centre*

3. Place the round metal grill vertically at the centre of the kiln and arrange the wood parallel to it. The inner circle of the grill is filled with the light wood to facilitate carbonisation and heat transfer from the top where the kiln is lighted to the bottom.
   - Pack the wood closely (Figure 3.3) with the larger diameter pieces placed alongside the metal grill at the centre of the kiln to expose them to higher carbonisation temperature when the kiln is lit.

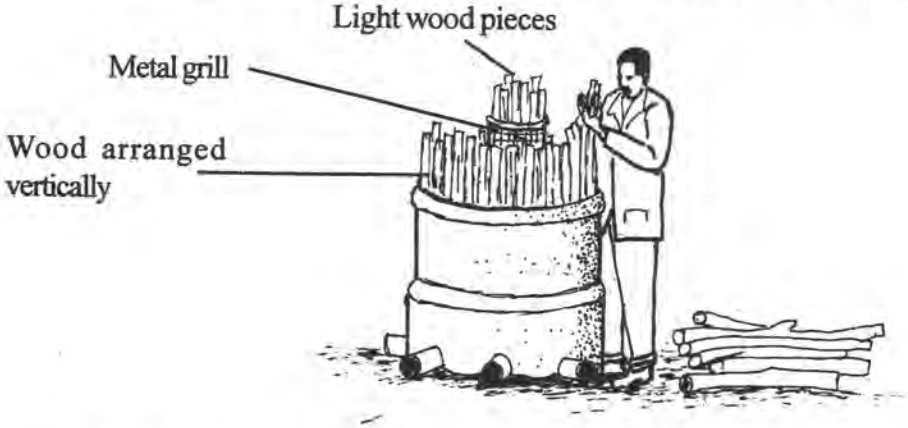

Figure 3.3: *Wood is closely charged into the compartments of the portable metal kiln in a vertical position*

4. After filling the bottom cylinder with firewood, place the second cylinder on top of it and continue filling the wood in the same way until all the three cylinders are filled.
   - Fill the hollow rim where the cylinders are interconnected with soil to make the kiln air tight.
   - Fill the metal grill at the centre with light pieces of wood to the top of the kiln (Figure 3.4)

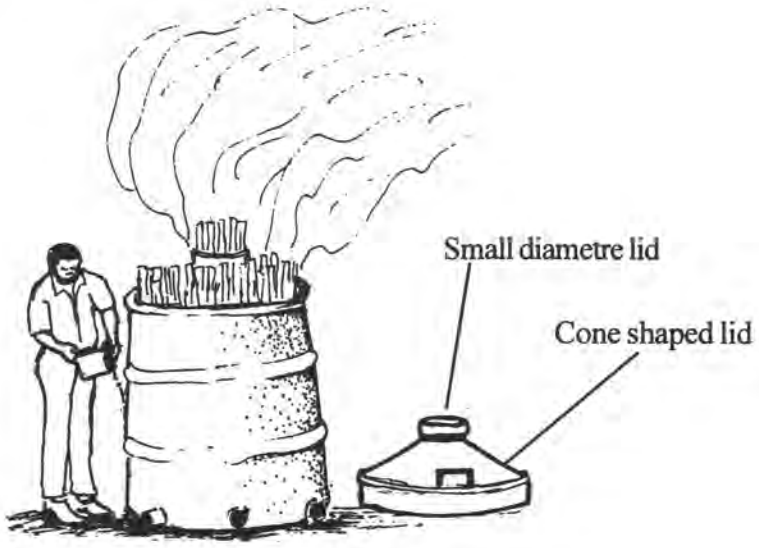

Figure 3.4: *Light pieces of fuelwood placed in the grill at the centre are lit and the joints where the compartments are intercon nected are filled with soil to make the kiln air tight*

5. Light the kiln from the top with the air inlets and outlets open.
   - Place the cone shaped cover lid on top leaving the top most small diameter lid at the centre open until the fire gets to the bottom of the kiln through metal grill at the centre.
   - Fit the chimneys on the outlets and cover the inlets with the lids (Figure 3.5)

6. As soon as the light blue smoke is released from a particular chimney, the operator removes and closes it completely to avoid further carbonisation. After this has been done to all the four chimneys, the kiln is left for about one day to allow cooling before discharge (Figure 3.6). The carbonisation process takes 24 hours with a recovery rate of 25-30%

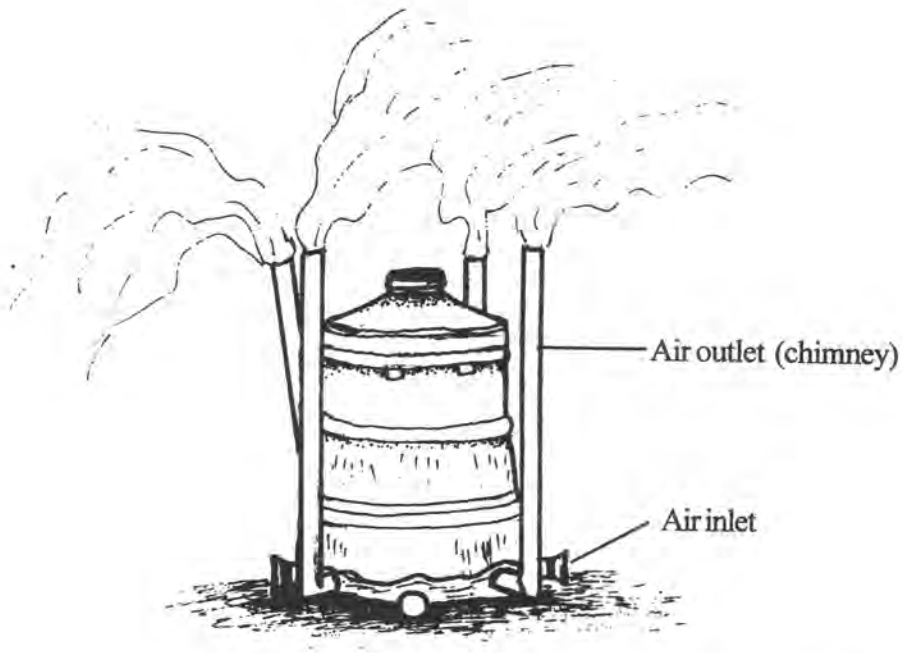

Figure 3.5: *Once the kiln has caught fire, the cone shaped top covering is fitted on top of the kiln and the chimneys (outlets) and lids for the air inlets fitted.*

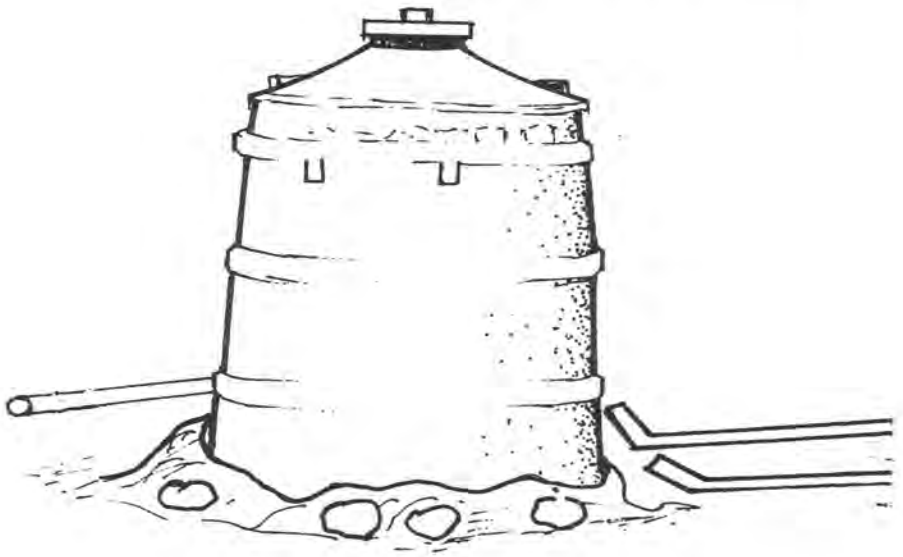

Figure 3.6: *After the full carbonisation of wood, the chimneys are removed and the airlets covered with lids which are then covered with soil to make them air tight and the kiln is left for a day to cool.*

7. Remove the charcoal from the kiln and put into bags once it has cooled (Figure 3.7)

Figure 3.7: *The charcoal is removed from the kiln and put into bags*

4.0

Drum Kiln

The drum kiln is a simple metal kiln that has been modified from the ordinary oil drum through simple technology. The drums have a removable lid and a metallic belt which joins the lid to the drum. The belt has adjustable screw which tightens the lid to the drum (Figure 4.1). This type of kiln is more suitable for the household domestic charcoal production using small diameter stems or tree branches (of not more than 10 cm)

The drum is modified by welding a chimney holder made of a short piece of metal pipe to fit a chimney of a diameter of 6 cm and a length of 1 m on the bottom side of the drum (Figure 4.2). A metal grill is made to prevent the wood from touching the bottom of the drum and to provide air circulation within the drum kiln. The firing door of 20 x 25 x 30 cm is welded on the metalic lid of the drum.

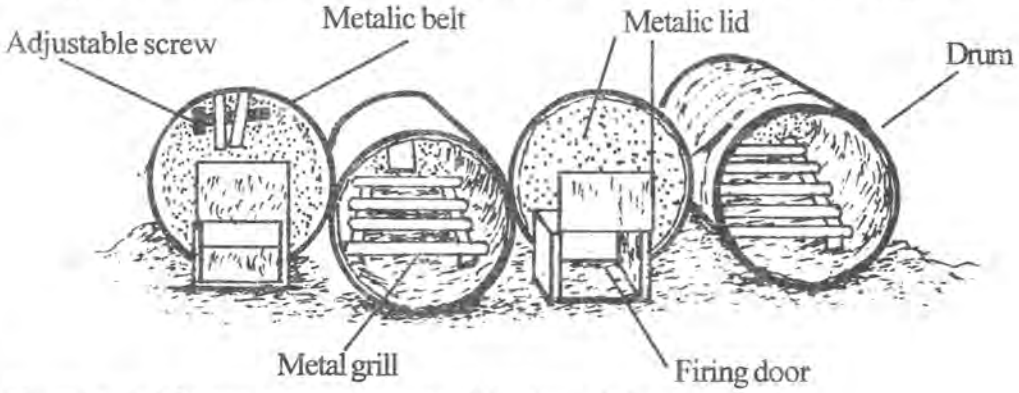

Figure 4.1: *The various components of the drum kiln*

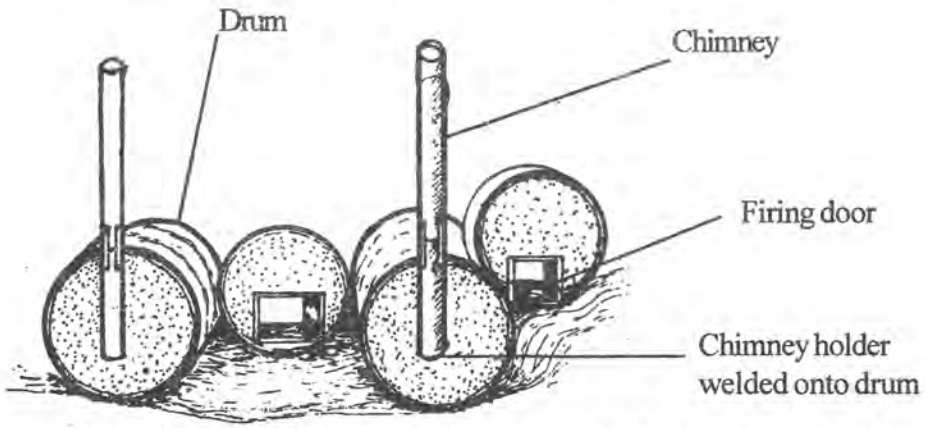

Figure 4.2: *The drum kiln is fitted with the chimney holder welded at the bottom of the drum*

The operation of the kiln involves the following steps

1. Cut the wood into pieces of 80 cm length and split the bigger diameter logs to give an average diameter of 6-10 cm.
   - Stack the wood to air dry for 6 weeks to attain a moisture content of about 20%.
   - Closely pack the seasoned/dried wood onto the metal grill in the drum (Figure 4.3) until it is fully loaded.
   - Close the loaded drum with the lid that is fitted with a firing door and stack small pieces of wood at the firing section (Figure 4.4) and light the kiln.

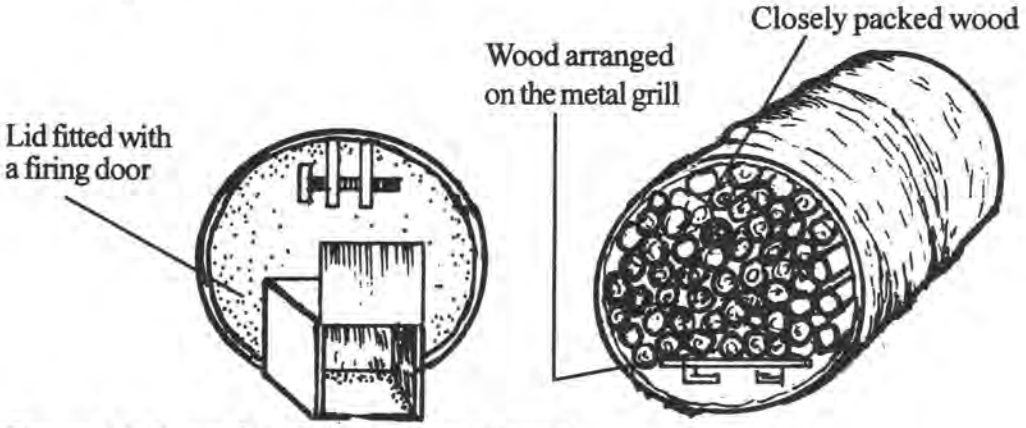

Figure 4.3: *Drum kiln fully stacked with wood*

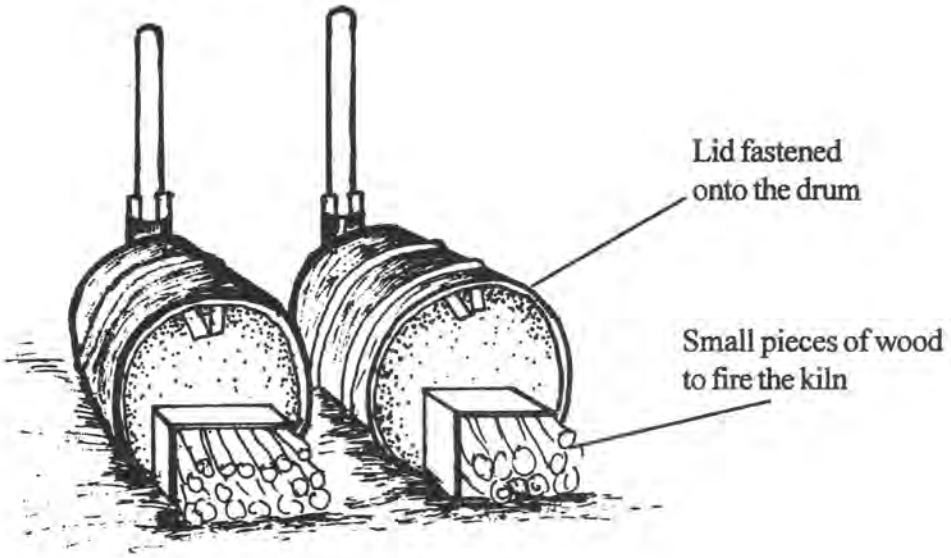

Figure 4.4: *Small pieces of wood placed at the firing section*

2. Allow the wood pieces at the lighting section to burn until the wood inside the drum catch fire and smoke starts coming out through the chimney.
   - Close the door of the firing section. Cover the kiln with soil to prevent heat loss during carbonisation (Figure 4.5). The entire drum is covered with soil.

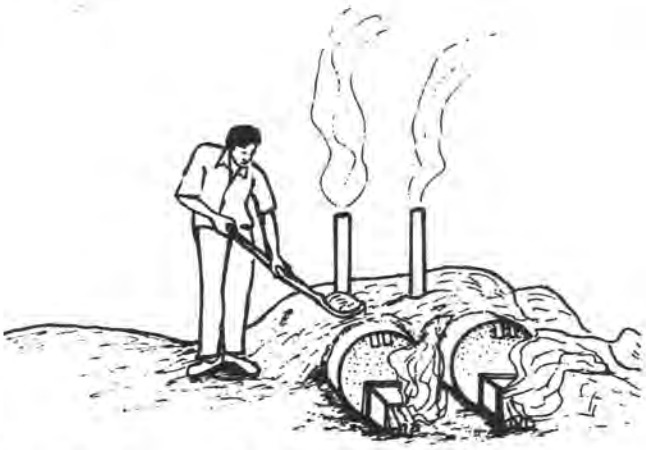

Figure 4.5: *The drum kilns are covered with soil*

3. Remove the chimneys when clear blue smoke is emitted thus indicating the wood is fully carbonised.
   - Seal the chimney holder with grass and soil and leave the drum to cool for 12-24 hours to cool before removing the charcoal.
   - Remove the soil covering the drum to hasten the cooling process (Figure 4.6).
   - The carbonisation takes 6-12 hours giving a charcoal recovery of 28- 30%. Each drum kiln has a capacity of about 0.4m^3 of wood and yields about 3/4 of a bag/sack.

Figure 4.6: *Cooling of the uncovered drum kiln*

5.0

Casamance Kiln

The *casamance* kiln is a modified earth kiln whose experiments initially carried out in Senegal has been adapted by KEFRI. The experiments in Senegal used oil drums as the chimney whilst the adaptation at KEFRI worked at using smaller diameter chimneys. The kiln gives better carbonisation control resulting in higher yield (26 - 30%). Its construction and mode of operation is as follows:

The kiln has one chimney and four air lets. The chimney, 180 cm long with a diameter of either 15 cm or 20 cm is made from gauge 26 galvanised iron sheet. The four air lets are made of the same material as the chimney and are 50 cm long wth diameter 6.25 cm or 5 cm. (NB: The 15 cm chimney size is used with the air let size of 6.25 cm and the 20 cm one with the 5 cm air let size)

1. Cut the wood into lengths of 0.5 m and stack it to dry for about 6 weeks.
   - Select the site close to the wood stacks on level ground with little vegetation.
2. Stack the dry wood in a circular way starting by making an 'air channel' of wood made across the circle. Place thin pieces of wood radially pointing towards the centre of circle leaving spaces between the wood pieces for air to flow easily (Figure 5.1). The base plays an important part for ensuring airflow in the kiln.

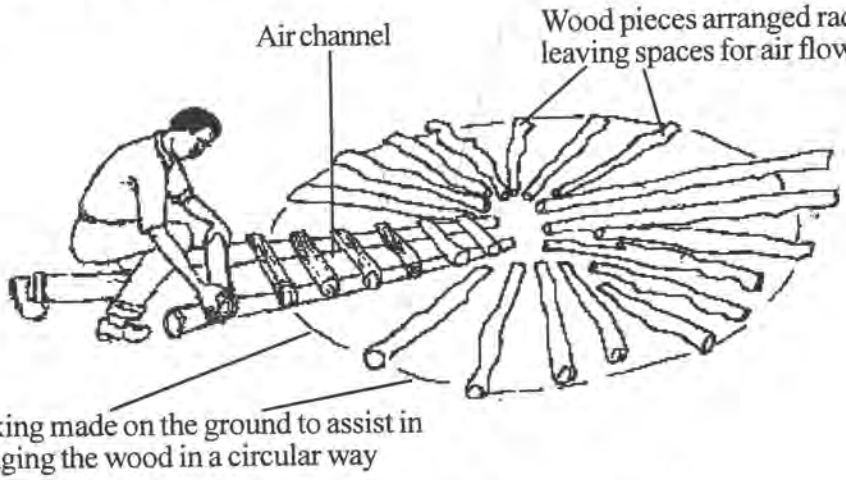

Figure 5.1: *The wood arrangement forming the base of the kiln*

3. Place the largest diamter pieces of wood in the centre standing upright and the medium- and small-sized pieces around them (Figure 5.2).

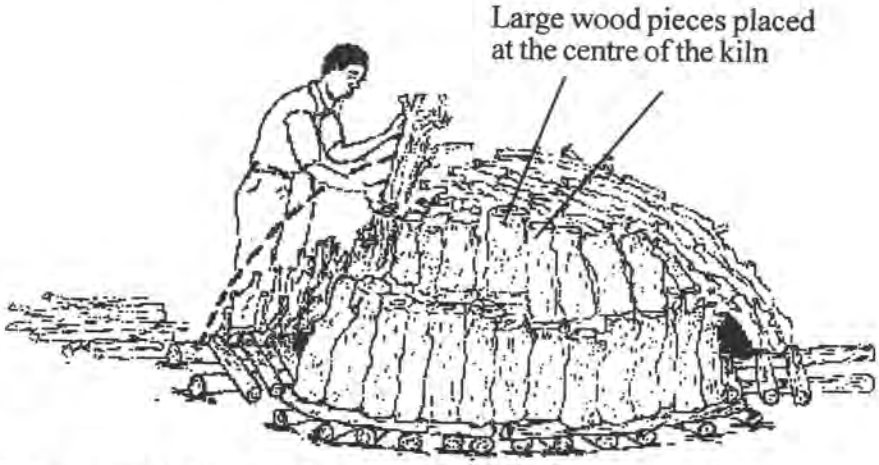

Figure 5.2: *Stack wood pieces closely starting with the large pieces of wood at the centre of the kiln and the medium and small-sized pieces around.*

4. Stack the wood as tightly as possible filling all gaps between the wood with smaller wood pieces to allow for better heat transfer (Figure 5.3).

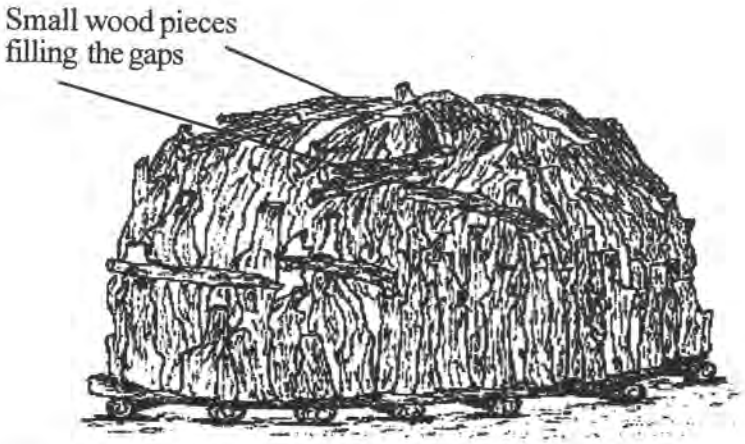

Figure 5.3: *A complete stacked Casamance kiln*

5. Cover the wood completely with grass or foliage first and then soil (Figure 5.4).

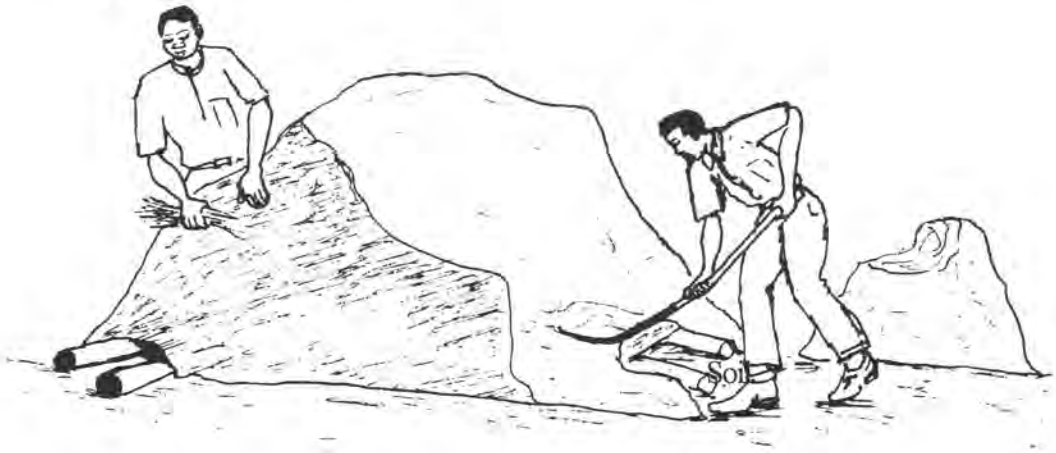

Figure 5.4: *Covering the wood completely with grass or foliage and then soil*

6. Place the chimney at one end of the the kiln. The chimney is angled at the bottom end to connect into the air channel (Figure 5.5). The angled extension is 1m long
   - The chimney improves air circulation, which reduces the amount of un-carbonised wood and speeds up the carbonisation.
   - Cover the angled extesion of the chimney with grass/foliage and then soil

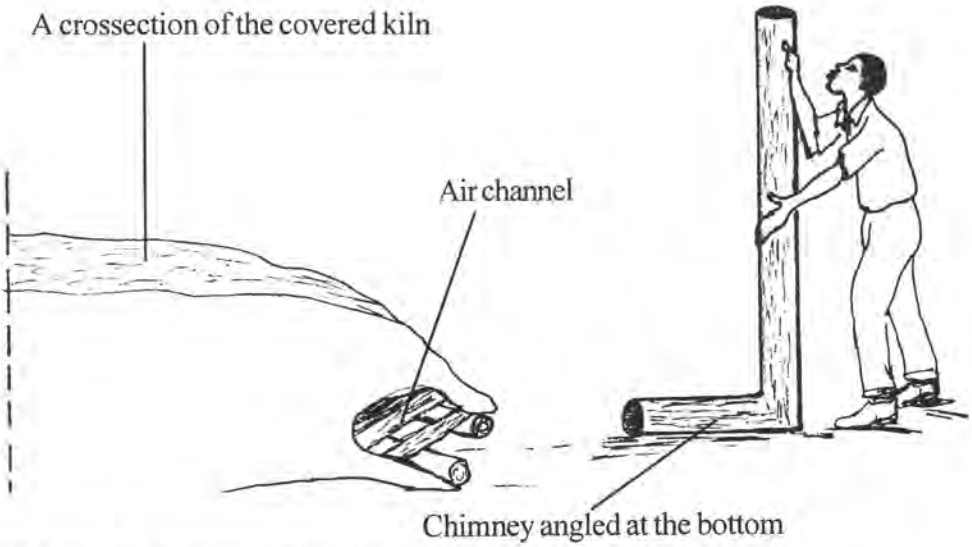

Figure 5.5: *The chimney is placed at one end of the air channel*

7. Place small dry twigs at the lighting zone which is at the side opposite the chimney - at the other end of the air channel.
   - Place the four air inlet pipes around the base of the kiln - two on either side of the chimney.
   - Light the kiln (Figure 5.6).

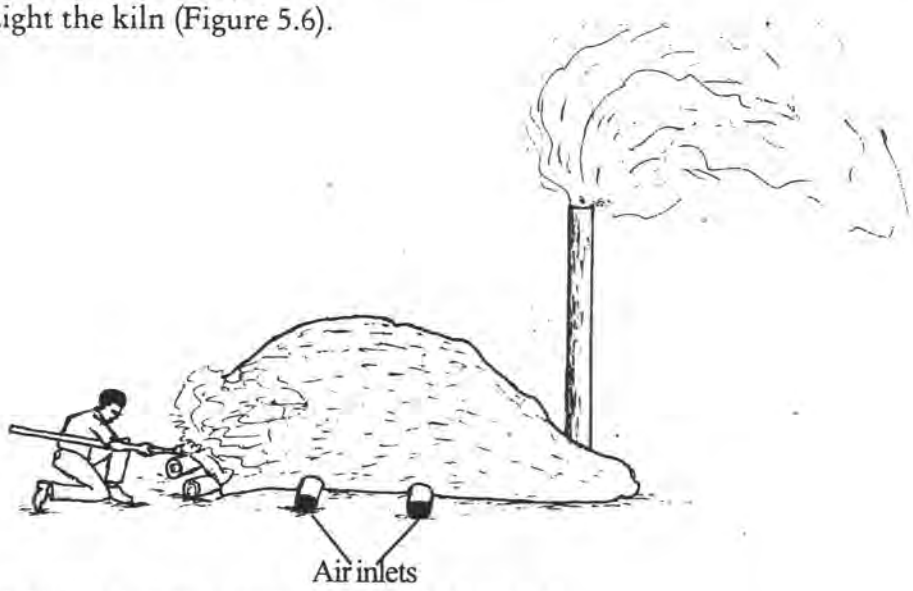

Figure 5.6: *The air lets are put in place and the kiln lit*

8. All the smoke should come out though the chimney and therefore any cracks within the mound are sealed with soil (Figure 5.7). Once the wood near the lighting point has caught fire the lighting point is sealed off with leafy twigs, grass and then soil.

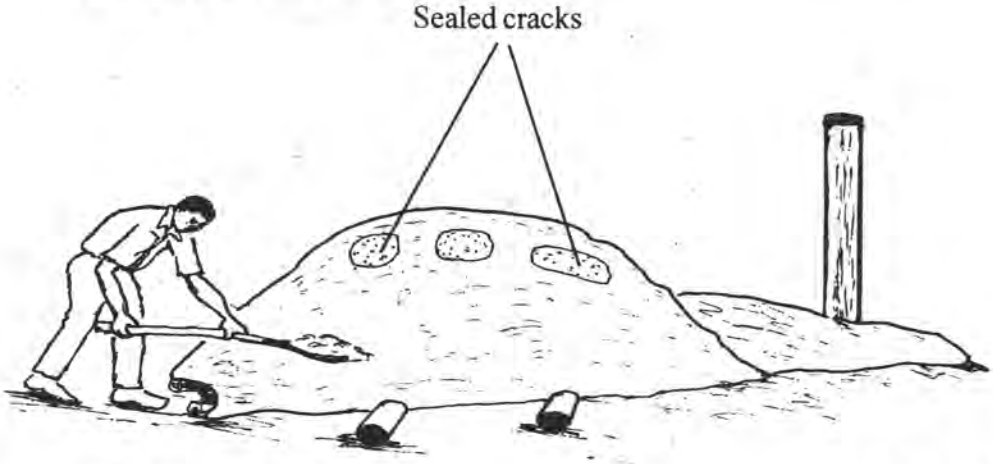

Figure 5.7 *Seal any cracks that appear in the mound with grass and soil. All the smoke should come out of the chimney*

9. Dense white smoke emitted from the chimney indicates that the carbonisation process is progressing well.
   - After 2-3 days the kiln should sink to about half of its original height and the smoke emitted is thin and reduced in amount. A light bluish coloured smoke indicates that the charcoal is carbonised.
   - Remove the chimney and the air inlets and allow the mound to cool for 12 hours.
   - Seal the mound completely

10. Prod the mound using a long pole to force soil into it. This is to aid cooling and to prevent burning of the charcoal.
   - Use a rake to remove the soil and grass covering the kiln. Cover the fresh charcoal from the mound with soil to prevent it catching fire. Do not use water to douse burning charcoal as this lowers the charcoal quality.
   - Once the charcoal has completely cooled, it is loaded into gunny bags.
   - Recovery rate is between 26-30%