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Using improved kilns to produce charcoal in Kenya: A practical guide

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Introduction

Charcoal is a type of woodfuel; it is a carbon-rich product processed through combustion of wood under limited supply of oxygen in a process known as carbonization (Demirbas et al. 2016; Koech et al. 2020; Njenga et al. in press). Charcoal is produced within a chamber commonly known as a kiln. There are different types of kilns which are broadly categorized into traditional and improved kilns, with low and high charcoal recovery rates, respectively. Improved kilns are made of various materials, ranging from mud, bricks and drums, among others. Currently, more than 90% of the charcoal producers in Baringo and other parts of Kenya

use traditional earth mould kiln (TEKs) (Ndegwa et al. in press), which has a low charcoal recovery rate (conversion of wood into charcoal) and produces low quality charcoal, leading to unnecessary tree cutting. Improving kilns presents an opportunity for producing more charcoal while reducing wood wastage and environmental pollution (Sola et al. 2020).

This document is a practical step-by-step guide to the production of charcoal using improved earth mould kilns (IEKs) and drum kilns (DKs) based on interventions in Baringo supported by the Governing Multifunctional Landscapes (GML) project in Kenya. Box 1 further provides a list of tools that are often used by charcoal producers in charcoal production.

Box 1. Tools for charcoal production

- Hoe/'Jembe' – for ground levelling
- Kiln – for converting wood to charcoal
- Shovel – for scooping up soil to cover the kiln, opening up the ground and charcoal harvesting
- Machete or power saw – for wood harvesting
- Matchbox – for lighting the kiln
- Rake – for opening up the kiln and spreading the charcoal
- Covering materials (grass or herbaceous vegetation) – for kiln covering
- Chimneys – for air outlets/emission
- Breathers – for allowing air into the kiln
- Sacks – for packing charcoal after harvesting
- Wire mesh or an iron sheet – may be used for covering the kiln instead of grass or herbaceous vegetation

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Stage 1

Wood harvesting and processing for carbonization

This stage includes preparations carried out before wood is placed into the kiln as described through the four steps below:

Step 1. Wood sourcing – harvest wood that is greater than 5 cm in diameter for the IEK and wood residues of less than 5 cm in diameter for the DK, either by thinning, selective cutting/harvesting or pruning, both from community land and/or private farms as shown in *Plate 1*.

Step 2. Kiln site identification – the site should be well-drained, accessible and located close to the source of wood, cleared of any vegetation and ground levelled.

Step 3. Wood preparation – cut the wood that is greater than 5 cm in diameter into pieces that are 100 cm long for IEK, and the wood that is less than 5 cm into pieces that are 80 cm long for DK.

Step 4. Wood drying – sun dry *Prosopis* wood for 2–6 weeks to dry it to less than 20% moisture content by piling up the sized pieces as shown in *Plate 2*. Check if wood has dried sufficiently well by splitting a piece – the wood should feel light in weight when dry.

Drying wood:

- Reduces the time spent on carbonization as wood is turned into charcoal fast.
- Reduces emissions of greenhouse gases (GHGs) as well as other particulate matter.
- Increases charcoal quality and recovery rate.



Plate 1. Wood sourcing/harvesting

Photo by Moses Kirimi/ICRAF, 2019



Plate 2. Piling up wood for sun drying

Photo by Moses Kirimi/ICRAF, 2019

Stage 2 Carbonization process

Stage 2.1. The improved earth mound kiln (IEK)

The improved earth mound kiln is an enhanced form of the traditional earth mound kiln (TEK); it is improved by fitting inlet pipes (breathers) and chimneys that control the air into and out of the kiln for efficient wood conversion into charcoal. The IEK has a recovery rate of about 27% of the total wood mass put into the kiln (Oduor et al. 2006) compared with the 8–15% recovery rate achieved in the TEK (Iiyama et al. 2014; Drigo et al. 2015; Njenga et al. in press). Wood carbonization using the IEK takes six steps as follows:

Step 1. Ground preparation and wood stacking for carbonization

1. Clear the ground of any vegetation and level it.
2. Lay two pieces of wood (parallel to each other) on the ground to protect the rest of the wood from coming into contact with the ground.
3. Stack the remaining pieces of wood across the two pieces on the ground, starting with the largest pieces, and stack them as close together as possible (see *Plate 3*). Fill the remaining air spaces with smaller pieces of wood for ease of heat transfer within the kiln.
4. Fill the lighting zone with light branches and twigs that catch fire (or ignite) easily.



Plate 3. Stacking wood for carbonization
Photo by Mary Njenga/ICRAF, 2019

Step 2. Cover the wood and fit the chimneys and breathers

1. Cover the stacked wood with a thin layer of herbaceous vegetation (at least 7 cm thick), leaving the lighting point open (*Plate 4*).



Plate 4. Covering stacked wood with grass and soil
Photo by Moses Kirimi/ICRAF, 2019

2. Fit two chimneys 66 cm apart (Njenga et al. in press) at the opposite side to the lighting point (*Plate 5*).



Plate 5. Improved earth mound kiln with two chimneys and six breathers in place, covered with a thick layer of soil (Bourne et al. 2020)
Photo by Moses Kirimi/ICRAF, 2019

3. Fit three air inlets/breathers at equal intervals on each of the longer sides (*Plate 5*). *Chimneys and breathers allow free airflow for continuous combustion* (Koech et al. 2020).
4. Apply a layer of soil about 14.5 cm thick on top of the layer of herbaceous vegetation all round, leaving the lighting point open (*Plate 5*). *The thick soil layer prevents uncontrolled air inflow which may otherwise cause burning of wood to ashes.*

Step 3. Lighting fire and covering the lighting point

1. Add small dry pieces of firewood at the lighting point on the windward end of the kiln and set fire.
2. Keep the lighting point burning until a few pieces of the stacked wood in the kiln catch fire and smoke emerges from the opposite chimneys.
3. Seal the lighting point by covering with herbaceous vegetation and a thick layer of soil (*Plate 6*).



Plate 6. Sealing the lighting point

Photo by Moses Kirimi/ICRAF, 2019

Note: Thick dense white smoke emitted from the chimneys indicates that carbonization is proceeding well.

Step 4. Kiln monitoring

Frequently monitor the process, ensuring that no air openings emerge in the soil cover until the carbonization process is complete. This process continues for about 4 days until the colour of the smoke changes to light blue and the kiln shrinks to about one-third of its original size.

Note: Light blue smoke indicates that the carbonization process is complete.

Step 5. Putting out the fire and cooling the charcoal

4. Put out the kiln by first removing the two chimneys and the six breathers/air inlets (*Plate 7*).



Plate 7. A cooling kiln with breathers and chimneys removed.

Photo by Moses Kirimi/ICRAF, 2019

5. Seal all the openings using soil to cut off the air supply into the kiln to enhance charcoal cooling. Cooling time depends on the size of the kiln and wood, and weather conditions and takes about 1.5 days.
6. Open the kiln and remove soil and covering materials with a soil rake and spade or any other convenient tool.
7. Spread the charcoal with the rake and check if all the charcoal is cool. Cover any hot charcoal with soil to cool it down.

Caution: Avoid cooling charcoal with water as this may affect its quality. Soil is highly recommended except in cases of emergency.

Step 6. Charcoal harvesting, grading and packaging

1. Sort and separate large pieces of charcoal with diameter 1.5 cm and above from charcoal dust and any unburned pieces of wood (*Plate 8*). Large pieces of charcoal can be sold or utilized for household use, while charcoal dust is recovered for use as biochar for soil amendment or for production of charcoal briquettes. Charcoal briquettes are used like charcoal and produce less emissions (Njenga et al. 2013).
2. Keep the large pieces of charcoal and charcoal dust outside for some hours to fully cool down before packing to avoid fire incidences.
3. Pack the large pieces of charcoal in bags, seal well and store in a cool dry place (*Plate 9*).



Plate 8. Harvesting and sorting charcoal
Photo by Moses Kirimi/ICRAF, 2019



Plate 9. Charcoal producers in Baringo, Kenya packaging charcoal for sale/use
Photo by Moses Kirimi/ICRAF, 2019

4. Also pack the recovered charcoal dust.
5. Unburned or wood remains can be used as firewood. They can also be carbonized further into charcoal but should not be mixed with fresh wood as the unburned wood burns fast and turns into ashes.

Stage 2.2. Drum kiln

The drum kiln (DK) is a modification of the normal oil (or any liquid) drum. The DK is suitable for smaller wood size which could otherwise burn to ashes when carbonized using the IEK (Njenga et al. 2019) and has a recovery rate of about 30% (Oduor et al. 2006; Njenga et al. in press). The modification of the drum into a kiln involves making a small door (opening) for kiln lighting, a lid for kiln covering, a chimney for smoke emission and air inlets at the base as shown in Plate 10. In addition, the chimney can be fitted with an elongated metallic pipe 2 metres long for purposes of wood vinegar collection as shown in Plate 11.



Plate 10. DK without elongated chimney is suitable for charcoal production only.

Photo by Mary Njenga/ICRAF, 2019

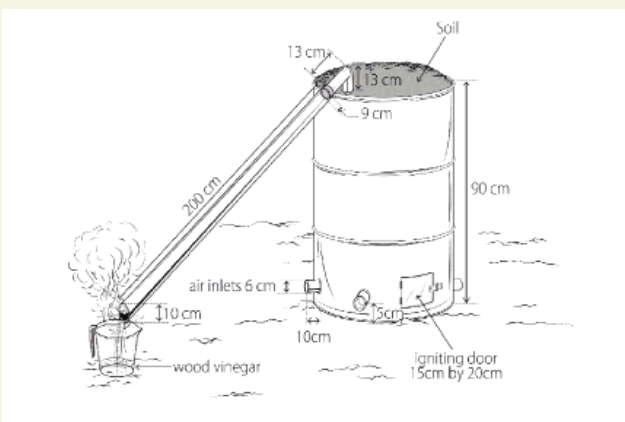


Plate 11. DK fitted with an elongated chimney is used for wood vinegar collection in addition to charcoal production.

Infographic by Fucha Media, Nairobi

Steps 1 and 2 listed in Stage 2.1 for the improved earth mound kiln also apply when using DK.

Step 1. Wood sourcing – harvest wood of above 5 cm in diameter for the IEK and wood residues of less than 5 cm in diameter for the DK either by thinning, selective cutting/harvesting or pruning from both community land and/or private farms (see *Plate 1*).

Step 2. Kiln site identification – the site should be well-drained, accessible and located close to the source of wood, cleared of any vegetation and ground levelled.

Step 3. Operating and managing the drum kiln

6. **Arranging wood** – Closely pack the dried wood into the drum until it is fully loaded (*Plate 12*).
7. **Covering the kiln** – Place a tight-fitting lid on the kiln and reinforce the covering with soil to ensure the kiln is air-tight while leaving the chimney open until the carbonization is complete (*Plate 13*).
8. **Lighting the kiln** – Light small pieces of wood through the door until the big pieces of wood inside the drum kiln catch fire and smoke starts coming out through the chimney as shown in *Plate 13*. Tightly close the door.



Plate 12. Wood stacked in a DK

Photo by Mary Njenga/ICRAF, 2019



Plate 13. Lighting stacked wood in a DK

Photo by Moses Kiriimi/ICRAF, 2019

9. **Monitoring the change in the colour of the smoke** – Smoke changes from deep and dense white smoke (during carbonization) to light blue smoke (when fully carbonized).
10. **Cooling the DK** – Close the air inlets and the chimney using herbaceous vegetation and soil to cut off oxygen. Monitor closely for any smoke venting point and stuff it with soil to ensure the kiln is fully choked for maximum and fast cooling.

Step 4. Unloading, grading and packaging charcoal

1. Once cooled, remove the lid (*Plate 14*), pour the charcoal on prepared ground, sort the charcoal, and separate lump charcoal from small pieces or charcoal dust as described for IEK in Stage 2.1, Step 6 (*Plate 15*).
2. Neatly pack the larger pieces of charcoal for household use or sale and then store.
3. Collect the small pieces or charcoal dust for use as biochar and/or for briquetting.



Plate 14. DK with lid removed

Photo by Moses Kiriimi/ICRAF, 2019



Plate 15. Sorting the charcoal for sale/use

Photo by Moses Kiriimi/ICRAF, 2019

Note: The carbonization in DK takes about 6–12 hours. Ensure the charcoal is fully cooled before packing. If one is interested in collecting wood vinegar, then fit an elongated chimney (200-cm-long metallic pipe) and set the wood vinegar collector in the right position (*Plate 11*). An elongated chimney enhances cooling of the smoke and therefore more wood vinegar is collected. Any uncarbonized wood can be used as firewood. It can also be carbonized further into charcoal but should not be mixed with fresh wood as it burns fast and turns into ashes.

The Dos and Don'ts of charcoal harvesting

Dos

- Use a piece of cloth to remove the kiln cover/lid
- Remove the chimney with a piece of cloth
- Use a piece of wood to push the kiln cover in case it is tight

Don'ts

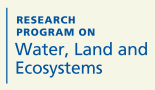
- Do not touch the kiln or chimney with bare hands
- Do not open the kiln lid when the carbonization is going on as you may get burned
- Do not touch the hot charcoal with bare hands

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World Agroforestry (ICRAF)

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