Young Engineers Award 2015

How can we promote the Moringa plant and the cactus for Household Water Treatment & Safe Storage in deprived communities?

Alexa Bruce, Anna Cesenni, Anokhee Shah
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Overview

Key Questions
- What dosage would be right, and how can it be managed by a household?
- Could it cause problems of user acceptability, and how to change this?
- Can it be adapted to backup filters or onto other simple water treatment techniques?

Sustainable solution for household water treatment and storage
- Support
- User confidence
- Simple to use
- Tested
- Affordable
- Improvement
- No ongoing costs
Key Questions

- What dosage would be right, and how can it be managed by a household?
- Could it cause problems of user acceptability, and how to change this?
- Can it be adapted to biosand filters or onto other simple water treatment techniques?
Liberia at a glance

Water supply and sanitation

WASH considerations

Water Treatment

Reasons for not treating the water
Water supply and sanitation

Access to improved water points within 1.5 miles

Water Sources in Rural Areas

Legend:
- Improved water source
- Surface water
- Open dug well
- Deep hand-dug well
- Protected spring
- Unprotected spring
- Protected hand pump
- Data not available
Access to improved water points within 1.5 miles

Legend
- County Boundaries
- Green: Areas of settlement with functional in-use point within 1.5 miles (76% of population)
- Black: Areas of settlement without such point within 1.5 miles (24% of population)
- Grey: Areas without settlements
Water Sources in Rural Areas

- Improved water sources
- Surface water
- Unprotected spring
- Open dug wells
- Unprotected hand pump
WASH considerations

Water Treatment
- No water treatment
- WT with chlorination

Reasons for not treating the water
- Water is Safe
- Do not know how to treat water
- They are used to using that water
- It is expensive
Sustainable solution for household water treatment and storage

- Support
- User confidence
- Simple to use
- Tested
- Affordable
- Improvement
- No ongoing costs
Moringa

The Miracle Tree

Moringa for Water Treatment

Household water treatment with Moringa

A simple process...
Figure 1: Overview of products stemming from the Moringa tree

Source: Own compilation
Moringa for Water Treatment

Natural Coagulant

Water Treatment Efficiency (40 tests)

Only slightly influenced by fluctuations of pH

Dosing - turbidity relationship

Optimum Dose

Excess dose required (mg/L)

Turbidity (NTU)

Maximum dose required
Natural Coagulant

Inner (Stern) layer (0.3-0.5 nm). Stern layer moves with the particle and is ‘specifically adsorbed’ by the colloidal particle – generally positive charge (+).

Colloidal particle, charge (-)

Outer (Diffuse) layer – much weaker than stern. Formed by electrical forces and thermal motion.
Only slightly influenced by fluctuations of PH
Dosing - turbidity relationship

![Graph showing the relationship between M. oleifera dose required (mg/l) and turbidity (NTU). The graph includes a line of best fit and a shaded area representing the optimum dosing zone. The R^2 value is 0.82.](image)

![Image of five bottles with color gradations from brown to white, indicating different doses of M. oleifera. The doses are labeled as 250, 100, 50, 25, and 10 mg/l.](image)
Household water treatment with Moringa

To purify 20 litres of water:
- De-hull and grind into a powder the seeds of moringa oleifera.
- Put two heaping spoonfuls of the powder into a small bottle containing clear water.
- Shake the bottle for 8 minutes.
- Filter the water through a cloth into the water to be purified.
- Stir the water rapidly for 2 minutes, then allow it slowly for 10 to 15 minutes.

AGADA - C.W.S.
S.P. 1000 Ziguinchor, Senegal

Let the bucket air undisturbed for an hour, or until the water is clear.
Impurities in the water will sink to the bottom.

Filter the water through a cloth.
For your family's health.
A simple process...

Or the recipe for a disaster??

- Correct Dosing
- Recontamination
- Residual Contaminants
- Secondary Infection

Risk to lose user's trust
Or the recipe for a disaster??

- Correct Dosing
- Recontamination
- Residual Contaminants
- Secondary Infection
Risk to lose user's trust
Pilot Plant

Plant Sizing
- Harvesting method: 100 trees/person

Water Treatment Targets
- Water treatment targets:
  - Runoff: 5 NTU
  - Average: 1 NTU

Plant layout

Daily Treatment Cycle

Turbidity Monitoring

Water treatment guidelines on turbidity:
- Minimum: 1 NTU
- Aim: 1 NTU
- Maximum: 10 NTU
Plant Sizing

Harvesting Moringa: 0.8 trees/person

...To the treatment
Assume drying 100% and demand 1.6% per day, Importation supplied.

From the tree...
1200 trees, 200 seeds/tree, 100% yield.
Seeds 0.2 kg/day, Seed kernels 0.13 kg/day, Seed husks 0.01 kg/day.

To the products...
M. seedcake 0.09 kg/day, M. oil 0.06 kg/day.
...To the treatment

Assume dosing: 100 mg/l

and demand: 6 lit/person/day

Population supplied: 150

900 l/day
From the tree...

120 trees

2000 seeds/tree/year

Seeds

0.2 kg/day

Seed kernels

0.15 kg/day

Seed husks

0.05 kg/day
To the products...

M. seedcake
0.09 kg/day

M. oil
0.06 kg/day
Water treatment targets:
WHO guidelines on turbidity

- Minimum < 5 NTU
- Aim < 1 NTU

>300 NTU → <10 NTU

<50 NTU → <1-5 NTU
## Water Treatment Targets

<table>
<thead>
<tr>
<th>Count per 100ml</th>
<th>Category, Colour, Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A: In conformity with WHO guidelines</td>
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<tr>
<td>1-10</td>
<td>B: Low risk</td>
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<tr>
<td>10-100</td>
<td>C: Intermediate risk</td>
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<tr>
<td>100-1000</td>
<td>D: High risk</td>
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<tr>
<td>&gt;1000</td>
<td>E: Very high risk</td>
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</tbody>
</table>

![Bar Chart](image)
Plant layout
1) Stir each drum for 10 minutes at ~ 20 RPM using bicycle

2) Leave water to stand for 1 hr to allow flocs to settle

3) Decant water into biosand filter

4) Water filters through biosand filter over 2 hr period
   Total residence time: minimum 6 hrs

Always standing water above the 'Smutzdecke'

Taps set at different levels for decanting at ~0.8 L / min

Flow diffuser mesh
Daily Treatment Cycle
<table>
<thead>
<tr>
<th>Activity</th>
<th>6am</th>
<th>7am</th>
<th>8am</th>
<th>9am</th>
<th>10am</th>
<th>11am</th>
<th>12pm</th>
<th>1pm</th>
<th>2pm</th>
<th>3pm</th>
<th>4pm</th>
<th>5pm</th>
<th>6pm</th>
<th>7pm-8am</th>
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</thead>
<tbody>
<tr>
<td>Water Collection and Filling Drums</td>
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<tr>
<td>Add Moringa and Stir in Drum</td>
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<td>Sedimentation (No Operator Action)</td>
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<td>Decanting (Operator Open Tap)</td>
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<td>Residence Time in Filter</td>
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<td>Emptying Filters into Containers for Users</td>
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<td>Users Water Collection</td>
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<td>Processing Moringa Seeds</td>
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<td>Lunch Break</td>
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<td>Water Quality Testing</td>
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</table>
Some ideas for household water treatment...

Flocculation and transport → Sedimentation → Flocculation and sedimentation

Pour remaining 20–30 litres including flocs

Pour 20 litres
Turbidity Monitoring

Homemade turbidity test

Pilot plant / Cooperative periodical test and advice on dosing
Homemade turbidity test

**Turbidity Tube Key Components**

1. Clear Tube
2. Tube Cap
3. Viewing Disc
4. Measuring Device

- **Images**: Bottles, plastic tubes, measuring device, and various tools.
Pilot plant / Cooperative periodical test and advice on dosing
Supply Chain Development

Financial model
- Start-up capital request
  + Operational costs
    - Raw materials to start
    - Tools: no additional maintenance costs
    - 25% of total
- Production
  - Achieved 450 t/year in test
  --'Plan to increase at least 500 t/year per year.
Oil of Ben market

[Map of the world with highlighted regions]

[Graph showing World Market with lines for palm kernel oil, groundnut oil, coconut oil, and exotic veg. oil]

[Diagram of chicken and egg with supply and demand cycle]

The chicken or the egg?
The chicken or the egg?
Start small and scale up

- Pilot plant
  - Neighbouring community
   - Cooperative
     - Neighbouring community
      - Cooperative
      - Neighbouring community
       - Cooperative
       - Cooperative

- Harvesting
  - Growing market
    - Central community water treatment
  - Cultivation
    - Developed market
      - Household water treatment
Harvesting
Growing market
Central community water treatment

Cultivation
Developed market
Household water treatment
Women's Empowerment

- 31% female headed households
Financial model

Start up capital required
- Estimated at £15,000

Operational Costs
- 2 plant operators on £50 a month
- £200/year ongoing maintenance costs
- TOTAL: £1,400

Breakeven
- Market price for Moringa Oil in West Africa is £50/litre.
- Plant would need to produce 28 litres per year in order to breakeven.
Watch its!

84% total dependency ratio

Quality Control

European Food Safety Authority

Land ownership
Next steps...

- Community **consultation**
- Establish the **proliferation of Moringa** in Liberia. Sustainable harvesting possible?
- Solidify the **business case** based on local information.
- Needs assessment to establish **community structures**.
- **Test the technology**, build/test/monitor (university collaboration?) Is it better than the bucket method?
- **Funding** opportunities
- **Implementation** on the ground
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