

60. Water clarification using *Moringa oleifera* seed coagulant

The removal of organic and inorganic material from raw water is essential before it can be disinfected for human consumption. In a water treatment works, this clarification stage is normally achieved by the application of chemical coagulants which change the water from a liquid to a semi-solid state. This is usually followed by flocculation, the process of gentle and continuous stirring of coagulated water, which encourages the formation of 'flocs' through the aggregation of the minute particles present in the water. Flocs can be easily removed by settling or filtration. For many communities in developing countries, however, the use of coagulation, flocculation and sedimentation is inappropriate because of the high cost and low availability of chemical coagulants, such as aluminium sulphate and ferric salts.

This Technical Brief gives an overview of the application of an indigenous, naturally derived coagulant, namely seed material from the multi-purpose tree *Moringa oleifera* Lam. (*M.oleifera*) which offers an alternative solution to the use of expensive chemical coagulants.

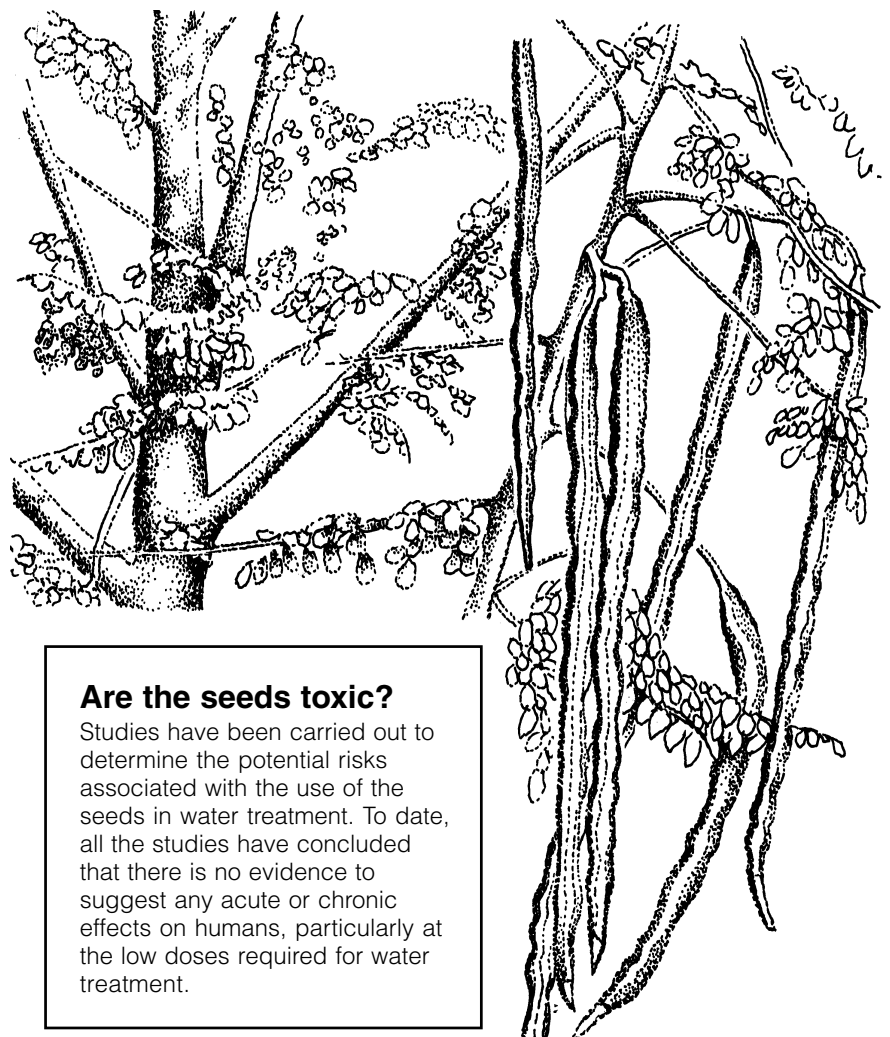
Background

How do the seeds work?

The seed kernels contain significant quantities of a series of low molecular-weight, water-soluble proteins which, in solution, carry an overall positive charge. The proteins are considered to act similarly to synthetic, positively charged polymer coagulants. When added to raw water the proteins bind to the predominantly negatively charged particulates that make raw waters turbid (silt, clay, bacteria etc.). Under proper agitation these bound particulates then grow in size to form the flocs, which may be left to settle by gravity or be removed by filtration.

Household water treatment

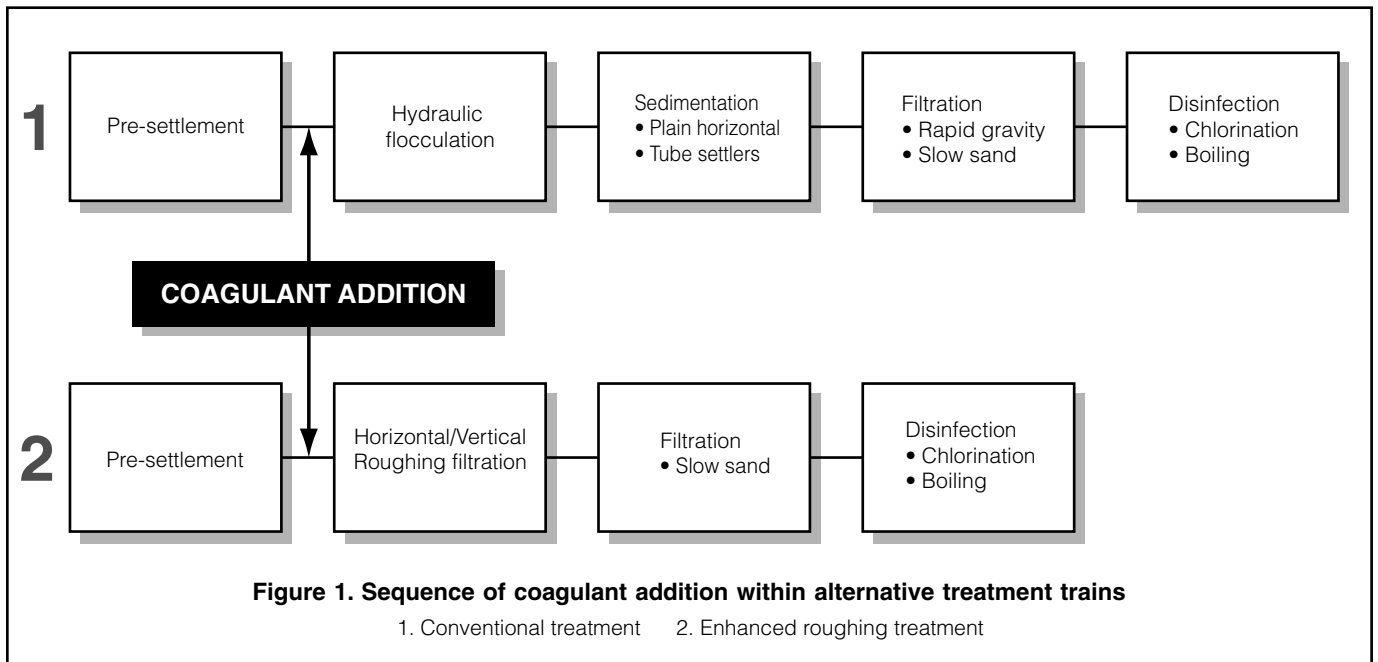
The traditional use of the *M.oleifera* seeds for domestic household water treatment is limited to rural areas in Sudan. Village women, collecting their water from the River Nile, place powdered seeds in a small cloth bag with a thread attached. This is then swirled around in the turbid water to promote coagulation and flocculation. The flocculated solids are allowed to settle and the treated water is removed before boiling and subsequent consumption.



Are the seeds toxic?

Studies have been carried out to determine the potential risks associated with the use of the seeds in water treatment. To date, all the studies have concluded that there is no evidence to suggest any acute or chronic effects on humans, particularly at the low doses required for water treatment.

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Community water treatment systems

For practical reasons of solution preparation, the use of powdered seed kernels is only recommended for treatment systems up to 10m³/hour.

As with all coagulants, the effectiveness of the seeds may vary from one raw water to another. Jar testing should be undertaken to determine their effectiveness on a particular water, and to establish preliminary dosing regimes depending on the season. The practical application of dosing solutions is exactly the same as for all other coagulants. Figure 1 (above) demonstrates the stage of application in two alternative treatment 'trains'.

Two further advantages of seed treatment are that:

- the effectiveness is, in general, independent of raw water pH; and
- the treatment does not affect the pH of the treated water.

Coagulant solution preparation

Seed solutions may be prepared from either seed kernels or the solid residue ('presscake') obtained following the extraction of seed oil.

Shelled whole seed

- (1) Seed pods are allowed to mature and dry naturally to a brown colour on the tree.
- (2) The seeds are removed from the harvested pods, and shelled.
- (3) The seed kernels are crushed and sieved (0.8mm mesh or similar). Traditional techniques used to produce maize flour have been found to be satisfactory.
- (4) The finely crushed seed powder is mixed with clean water to form a paste, and is then diluted to the required strength. Dosing solutions can be prepared from 0.5 to 5 per cent concentration (e.g. 0.5 to 5g/l).
- (5) Insoluble material is filtered out using either a fine mesh screen or muslin cloth.
- (6) The solution is ready for use.

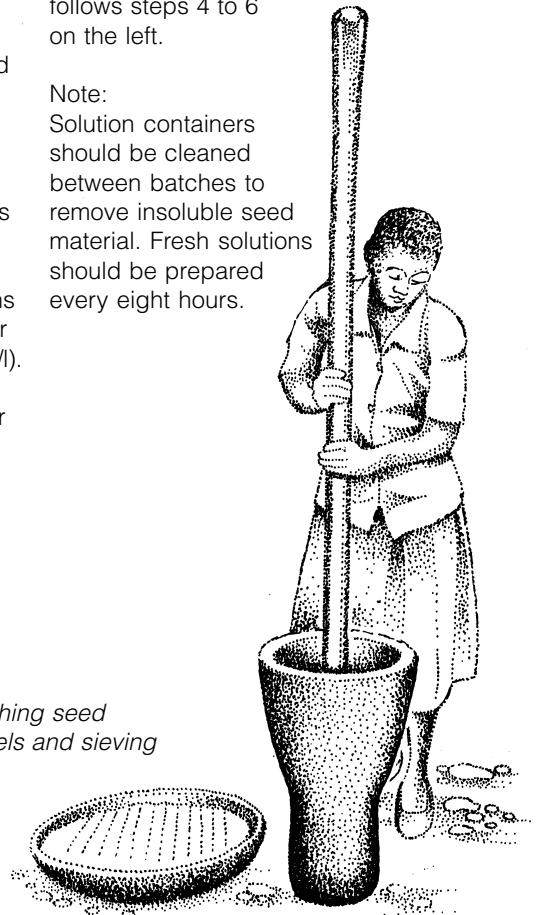


Presscake

Presscake should be ground to a fine powder and sieved (0.8mm mesh or similar). Solution preparation then follows steps 4 to 6 on the left.

Note:
Solution containers should be cleaned between batches to remove insoluble seed material. Fresh solutions should be prepared every eight hours.

Crushing seed kernels and sieving



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Coagulant dose requirement

As for all coagulants, the amount of seed required will vary depending on the raw water source and on the raw water quality. One advantage of seed use is that, in general, there is a wide dose range over which effective treatment may be achieved and maintained. The dose ranges shown in Table 1 are given as a guide only, and jar testing should be carried out to determine more specific dose requirements for the raw water in question. Dosages are given as equivalent weight of seed powder or presscake material required to make up the dosing solution.

| Raw water turbidity (NTU) | Dose range mg/l |
|---------------------------|-----------------|
| < 50 | 10 - 50 |
| 50 - 150 | 30 - 100 |
| >150 | 50 - 200 |

Table 1.
Dose requirements as a function of raw water turbidity

Seed requirement

The area under cultivation to produce the annual seed requirement depends on the size of the treatment works and raw water quality (as noted in Table 1). Assuming the average seed kernel yield for a mature tree is 3kg, then at an average seed dose of 100mg/l the harvest from a single tree will treat 30 000 litres of water. Using the same assumptions and a recommended tree spacing of 3m, the harvest from 1ha of mature trees (approx. 3000kg) would treat 30 000m³ of water. This equates to a small treatment works producing 10m³ per hour if operated eight hours a day for a full year.

Moringa oleifera (*M.oleifera*) General information

Description

A native of northern India, *M.oleifera* is now grown widely throughout the tropics. It is sometimes known as the 'drumstick' or 'horseradish' tree. Ranging in height from 5 to 12m with an open, umbrella-shaped crown, straight trunk and corky, whitish bark, the tree produces a tuberous tap root. The evergreen or deciduous foliage (depending on climate) has leaflets 1 to 2 cm in diameter; the flowers are white or cream coloured. The fruits (pods) are initially light green, slim and tender, eventually becoming dark green, firm and up to 120cm long, depending on the variety. Fully mature, dried seeds are round or triangular, the kernel being surrounded by a lightly wooded shell with three papery wings.

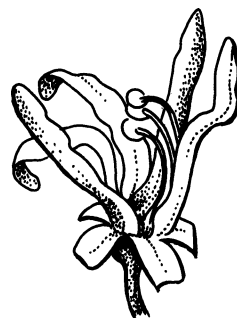
Climate and soil conditions

The *M. oleifera* prefers hot, semi-arid regions (annual rainfall 250-1500mm), although it has been found to adapt well to hot, humid, wet conditions with annual rainfall in excess of 3000mm. Considered to be suitable only for lowland cultivation at altitudes less than 600m, the adaptability of the tree was demonstrated by the discovery of natural strands at

altitudes of 1200m in Mexico. Although preferring well-drained sandy or loamy soils, heavier clay soils will be tolerated, although water logging should be avoided. The tree is reported to be tolerant of light frosts and can be established in slightly alkaline soils of up to pH9.

Cultivation

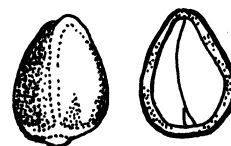
The tree grows rapidly from seeds or cuttings, and growth up to 4m in height; flowering and fruiting have been observed within 12 months of planting out. In areas where the climate permits, e.g. southern India, two harvests of pods are possible in a single year. Recent estimates suggest that, for a spacing of 3m, a likely annual seed yield is 3 to 5 tonnes per hectare.



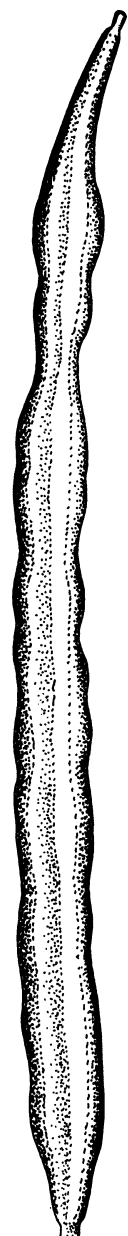
Moringa flower



Moringa, part of fruit cut vertically

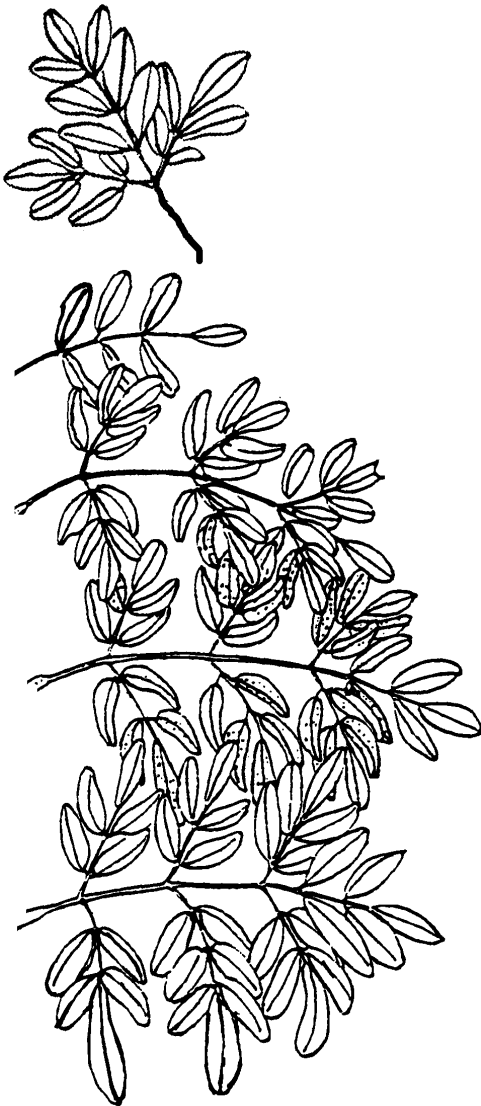


Seed: entire and cut vertically



Moringa fruit

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Additional products and uses of *M. oleifera*

Vegetable

- Green pods, fresh and dried leaves

Oil

- Seeds contain up to 40% of oil by weight
- Used for cooking, soap manufacture, cosmetic base and in lamps

Other uses

- All parts of the plant are used in a variety of traditional medicines
- Leaves are useful as animal fodder
- Presscake, obtained following oil extraction, is useful as a soil conditioner
- Grown as live fences and windbreaks
- Fuelwood source after coppicing (cutting back the main stem to encourage side shoots).
- As an intercrop with other crops
- Wood pulp may be used for paper-making.

The leaves have outstanding nutritional qualities, among the best of all perennial vegetables. The protein content is 27 per cent and there are also significant quantities of calcium, iron and phosphorus, as well as vitamins A, B and C. This nutritional value is particularly important in areas where food security can be threatened by periods of drought. *M.oleifera* leaves can be harvested (and dried)

during dry seasons when there are no other fresh vegetables available. The immature green pods are consumed by Asian populations world-wide and canned pods are exported from India. The seeds contain up to 40 per cent by weight of oil and the fatty acid profile of the oil shows it to be, on average, 73 per cent oleic acid. The oil approaches the high quality of olive oil. ■

Further reading

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