21st WEDC Conference Kampala, Uganda, 1995
SUSTAINABILITY OF WATER AND SANITATION SYSTEMS

Natural coagulants — a sustainable approach

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THE *M. OLEIFERA* TREE is a native of Northern India which now grows widely throughout the tropics. English vernacular names include 'drumstick' (shape of the pods) and 'horseradish' (taste of the roots). It may be propagated from seeds or cuttings, even in poor soils, requiring minimal horticultural attention and is able to survive long periods of drought. It grows rapidly - growth of up to 4 metres in height, flowering and fruiting were all observed within one year during trials near Nsanje, Southern Malawi. Extended and multiple harvests in a single year are evident in many parts of the world. The many products and numerous uses of the tree are given:

Vegetable

- Green pods, leaves, flowers and roasted seeds are highly nutritious.

Oil

- Seeds contain 40% vegetable oil by weight - may be used for cooking, soap manufacture, cosmetics base and as a lamp fuel.

Coagulant

- Seeds used traditionally for 'household treatment' in the Sudan and Kenya.
- Successfully used at pilot and full scale water treatment works in Malawi.
- Presscake remaining after oil extraction effective as a coagulant - bench scale testing.
- Potential for use as an aid to primary sedimentation in wastewater treatment - bench scale testing.

Other uses

- All parts of the plant are used in a variety of traditional medicines.
- Presscake as a soil conditioner / fertiliser and potentially as an animal / poultry feed supplement.
- Green leaves as a fertiliser - mulch.
- Powdered seed used in ointment to treat common bacterial skin infections.
- Grown as live fences and windbreaks.
- Fuelwood source following coppicing.
- Agroforestry within an intercropping system - also providing semi-shade.
- Wood pulp for paper making industry.
- Planted for specific protective and soil melioration functions.
- Planted as an attractive ornamental tree.

M. oleifera is a multipurpose tree of enormous potential. Multipurpose trees are cultivated and managed in such a way that they foster sustainable land use with more than one product and / or function. They are particularly significant in agroforestry systems, performing specific, protective and stabilising functions.

Water treatment

River water drawn for human consumption and general household use can be highly turbid particularly in the rainy season. River silt is churned into suspension and run off from fields and other surfaces carries solid material, bacteria and other micro-organisms into the river. It is of paramount importance to remove as much of this suspended matter as possible prior to a disinfection stage and subsequent consumption. This can generally only be achieved by the addition of coagulants to the raw water within a controlled treatment sequence. In many developing countries proprietary chemical coagulants, such as alum and synthetic polyelectrolytes are either not available locally or are imported using foreign exchange.

A viable alternative is the use of crushed seed of *M. oleifera* as a natural coagulant. The seed pods are allowed to dry naturally on the tree prior to harvesting. The seeds are easily shelled, crushed and sieved using traditional techniques employed for the production of maize flour. The crushed seed powder, when mixed with water, yields water soluble proteins that possess a net positive charge. Dosing solutions are generally prepared as 1-3% solutions. The solution acts as a natural cationic polyelectrolyte during treatment. (Sutherland et al, 1990)

River water treatment at pilot scale

It is now regarded as axiomatic that both water and wastewater technology for developing countries must be no more complex than strictly necessary, be robust and cheap to install and maintain. A prototype treatment works was designed founded on this philosophy. The pilot plant was constructed within the grounds of the Thyolo Water Treatment Works, the works being controlled by the Ministry of Works and Supplies Water Department of the Malawi Government. The system was successfully commissioned during the 1992 rainy season with the source river exhibiting turbidity levels in excess of 400 NTU throughout the study period. Solids removal within the plant was consistently above 90% following a gravel bed flocculation stage and plain horizontal flow sedimentation. Subsequent rapid gravity sand filtration

gave a final, treated water turbidity generally well below 5 NTU. *M. oleifera* seed dose ranged from 75-250mg/1 depending on the initial raw water turbidity. (Folkard et al,1993)

River water treatment at full scale

In February 1994, the main Thyolo works was operated using *M. oleifera* solution as coagulant. The works comprise upflow contact clarifiers followed by rapid gravity filters and chlorinator. The clarifiers are in a state of disrepair with the impeller drives and chemical feed pumps inoperative. Alum solution is introduced into the incoming flow of 60 cubic metres per hour by simple gravity feed. Comparable treatment performance with alum was achieved. Inlet turbidities of 270-380 NTU were consistently reduced to below 4 NTU. This was the first time that *M. oleifera* had been successfully used as a primary coagulant at such a scale with the treated water entering supply. (Sutherland et al, 1994)

M. oleifera seed for the full scale trials was purchased from enthusiastic villagers in the Nsanje region. The tree is widely cultivated in this area, being highly prized as a source of fresh, green vegetable.

Alum and soda ash (for final pH correction) for the Thyolo works were imported from South Africa at an annual imported equivalent cost of £26,000 (March 1993). It was estimated that if the water utility established and maintained a plantation of *M. oleifera* trees for oil production / presscake coagulant, a net operating profit would be achieved.

Treatment of eutrophic water

Treatment studies have recently been conducted at bench scale on a eutrophic lake water serving the main treatment works to Harare, Zimbabwe. (Sutherland et al, 1995) The impounded water contains much light organic matter in suspension due to high algal growth and exhibits relatively low turbidity throughout the year. As such, the water is problematic to treat consuming significant quantities of alum (as primary coagulant) and activated silica (as weighting agent). Alum floc carry over from the clarifiers causes “filter blinding” and the sludge from the clarifiers is voluminous , difficult to dewater and presents pollution problems on discharge to the receiving water. *M.oleifera* in combination with sodium bentonite as weighting agent produced a final water quality equivalent to that produced using the conventional chemical coagulants. The sludge was significantly more compact and represents a potentially useful output as a soil conditioner / fertiliser.

M.oleifera as vegetable/oil source

M.oleifera pods are an important commercial vegetable crop throughout India. They are also exported fresh under refrigeration and in cans to countries with sizeable Indian communities.

The leaves have outstanding nutritional qualities - amongst the best of all the perennial tropical vegetables. The protein content is 27% and significant quantities of calcium, iron, phosphorous and vitamins A and C are also present. A particular advantage to people nutritionally at risk is that leaves can be harvested during the dry season when no other fresh vegetables are available.

M. oleifera seed contains 40% by weight of oil. The fatty acid profile shows oleic acid at 73% confirming that the oil is similar to olive oil and thus of high quality and high market value. Laboratory tests at Leicester confirm that the presscake remaining after oil extraction still contains the active constituents effecting coagulation. Coagulant may be regarded as a by product of viable oil extraction. (Sutherland, 1993)

Edible oils are an essential component of human nutritional requirements. In developing countries, the production and marketing of edible oils is usually dominated by a few large scale urban-based companies. Rural supplies of the finished product are erratic with increased prices due to additional transport costs.

The Intermediate Technology Development Group (ITDG) in Zimbabwe have successfully introduced technology appropriate for small scale decentralised rural processing of edible oils. A recent evaluation of the 17 oil mills established to constitute this ITDG project concluded (Sunga and Whitby, 1995):

- the oil mills are commercially viable returning an average of 51% on investment with profits of 21% on sales
- a typical mill employs 10 permanent and 3 temporary workers
- ready cash markets for oil seed crops had been created
- lower cost oil of significantly higher quality is now available in the rural areas.
- alternative edible oil seeds such as soya, cotton seed and *moringa* should be investigated
- the market for and sales of presscake are important for the overall viability and profitability of the mills....new outlets are required

Conclusions

The products of the *Moringa oleifera* tree are underexploited resources. Realisation of their potential will contribute towards sustainability in the rural areas, addressing major issues of current concern:

- **water quality and health**
- **food and nutrition**
- **employment opportunities**
- **income generation**

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