

## WATER, ENVIRONMENT AND MANAGEMENT

### Natural coagulants at pilot scale

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#### ABSTRACT

Crushed seeds of the tree *Moringa oleifera* Lam. (*M.oleifera*) are a viable alternative to aluminium sulphate as a coagulant for water treatment applications in the developing world. Supporting cases, in both technical and economic terms are presented based on a recently completed field study in Malawi.

A pilot scale treatment works operating at a flow rate of  $16.5\text{l min}^{-1}$  reduced raw water turbidity from 1000 NTU to below 1 NTU (header/mixer tank, gravel bed flocculator, sedimentation tank and rapid gravity filter). The filter was operated as a contact flocculator - filter during periods of low raw water turbidity. 20 NTU inlet values were reduced to below 1 NTU with this treatment unit. Successful *M.oleifera* plantation trials are briefly reported as is an economic analysis of establishing *M.oleifera* as a 'coagulant crop' in the Malawi context.

#### INTRODUCTION

The Environmental Engineering Group at Leicester have been examining coagulants derived from natural materials to treat river waters since 1986. Efforts have been concentrated on crushed seed powder of the tree *Moringa oleifera* Lam. (*M.oleifera*). *M.oleifera* is a tree of the sub-himalayan tracts of N.W. India, Pakistan and Afghanistan. Introduced pantropically it is widely cultivated and naturalised across Africa, South America and Asia. English vernacular names for the tree are Horseradish and Drumstick and vernacular terms associated with some Asian countries include (Jahn, 1986);

Nepal	-	Sitachini
Pakistan	-	Saijan/Sohanjna
Indonesia	-	Kachang/Kelor/Kaifok
India	-	Danshamula/Mangnai/Saragavo
Malaysia	-	Emunggai/Gemunggai
Phillipines	-	Arunggai/Balungai/Kamalungai

The tree is a true multi-provider with seeds, pods, flowers and leaves used variously; vegetable, live fences and hedges, fuel wood, cattle fodder, edible and industrial oil, honey clarifier, ropes, pulp, fertilizer, medicinal and as a **natural coagulant for the provision of potable water** (Booth and Wickens, 1988). The crushed seed powder, when mixed with water, yields water soluble proteins that possess a net negative charge. The solution acts as a natural cationic polyelectrolyte during treatment (Sutherland, Folkard and Grant, 1990).

This paper reports on a practical pilot plant project conducted in southern Malawi over the period January to March 1992. The study was timed to coincide with the rainy season. However drought conditions prevailed over the whole region, described as the worst for over 100 years. Crop failures have been widely reported.

#### PILOT PLANT

The works is shown schematically in Figure 1. River water is pumped at  $16.5\text{l min}^{-1}$  ( $24\text{m}^3\text{d}^{-1}$ ) to a header/mixer tank where the *M.oleifera* seed solution is dosed. An 18 minute flocculation period is provided within the gravel packed columns prior to sedimentation. A rapid gravity filter removes residual floc carried over in the outlet flow from the sedimentation stage. All the units are fabricated in sheet steel of gauge SWG16.

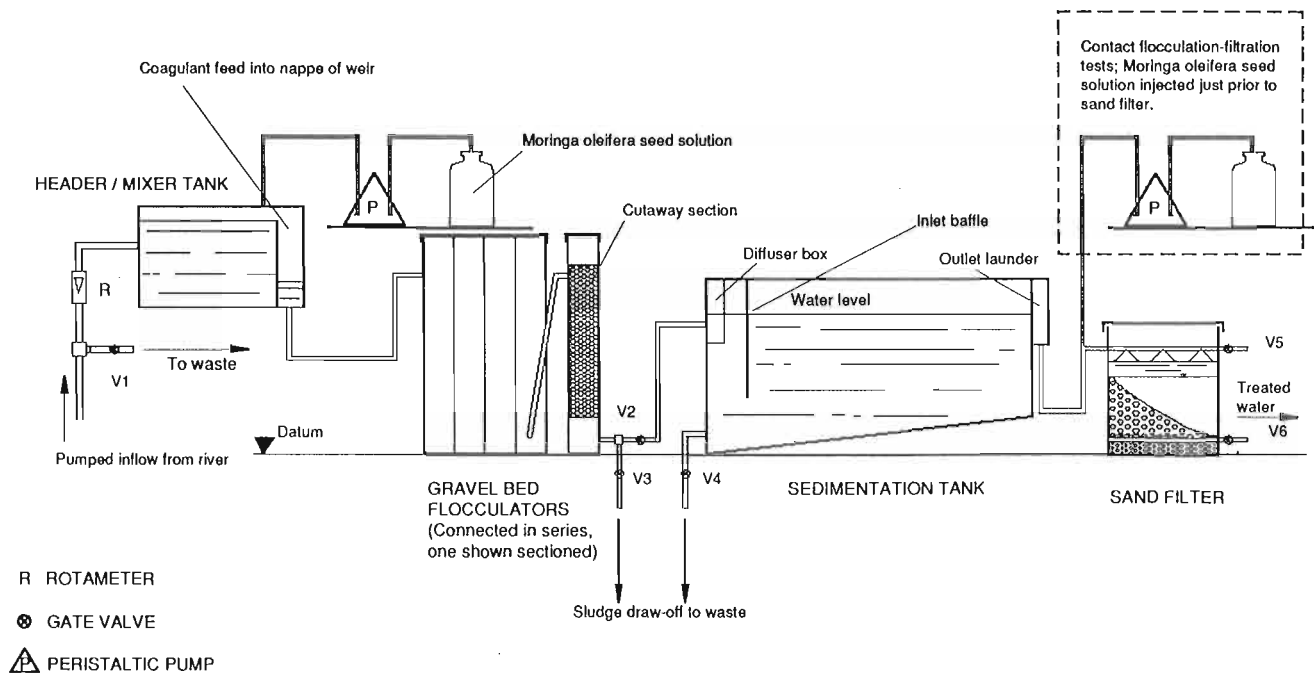


Figure 1 Schematic diagram of the pilot scale water treatment works

### High raw water turbidities

As previously noted, periods of high raw water turbidity were limited in number and duration. Figure 2 shows the results of one such test conducted over an 8 hour period with the full treatment sequence in operation. *M.oleifera* seed was dosed at  $200\text{mg l}^{-1}$ . Raw water turbidity of 1000 NTU (Nephelometric Turbidity Units) was reduced to below 10 NTU by coagulation/sedimentation. As the sand filter 'worked in' the final outlet turbidity was below 1 NTU and still improving. Presumptive coliform reductions were in the order of 96%.

### Low raw water turbidities

As prolonged periods of no rainfall were experienced a process known as contact flocculation-filtration (CFF) was evaluated in the field prior to scheduled laboratory work. After introducing seed solution to the flow, flocculation and deposition occur entirely within the sand bed (effective size  $0.62\text{mm}$ , uniformity coefficient 1.67). Figure 3 shows a dynamic dose response obtained with the raw water turbidity in the range 15-25 NTU over a 7 hour period. The mean hydraulic residence time in the filter is 20 minutes at a filtration rate of  $1.7\text{m hr}^{-1}$  (approx. 9 times the operating rate of conventional slow sand filters). Seed dosage was incrementally stepped up at intervals. Some removal is evident from the baseline control of no seed addition. Subsequent incremental additions up to  $25.5\text{mg l}^{-1}$  give concomitant improvements in turbidity removals. Approximately doubling this seed dose to  $49.5\text{mg l}^{-1}$  illustrates the fundamental robust nature of *M.oleifera* seed treatment - overdosing beyond the optimum value does not impair efficiency.

Turbidity (NTU)

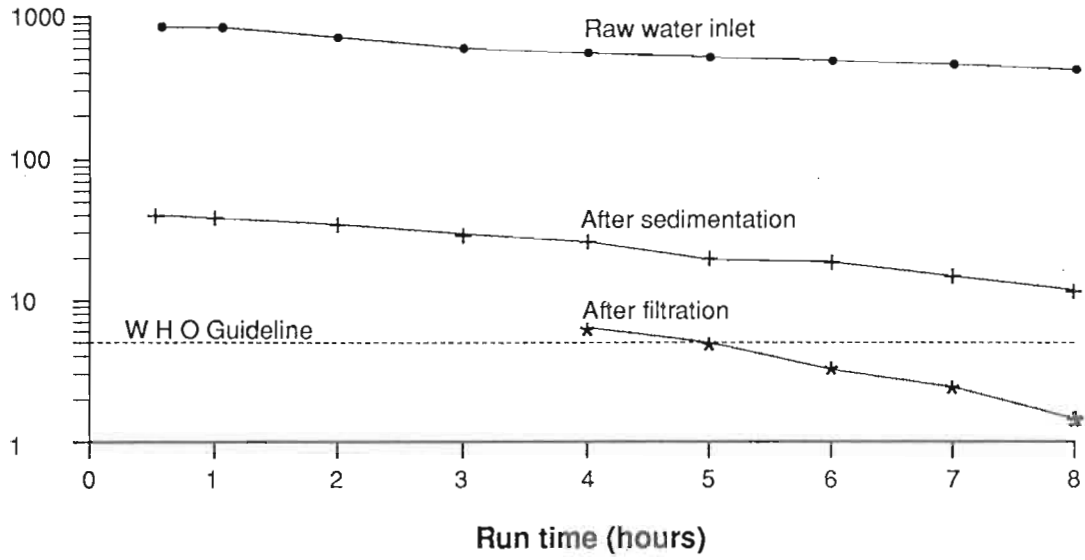


Figure 2 Pilot plant performance under conditions of high initial turbidity

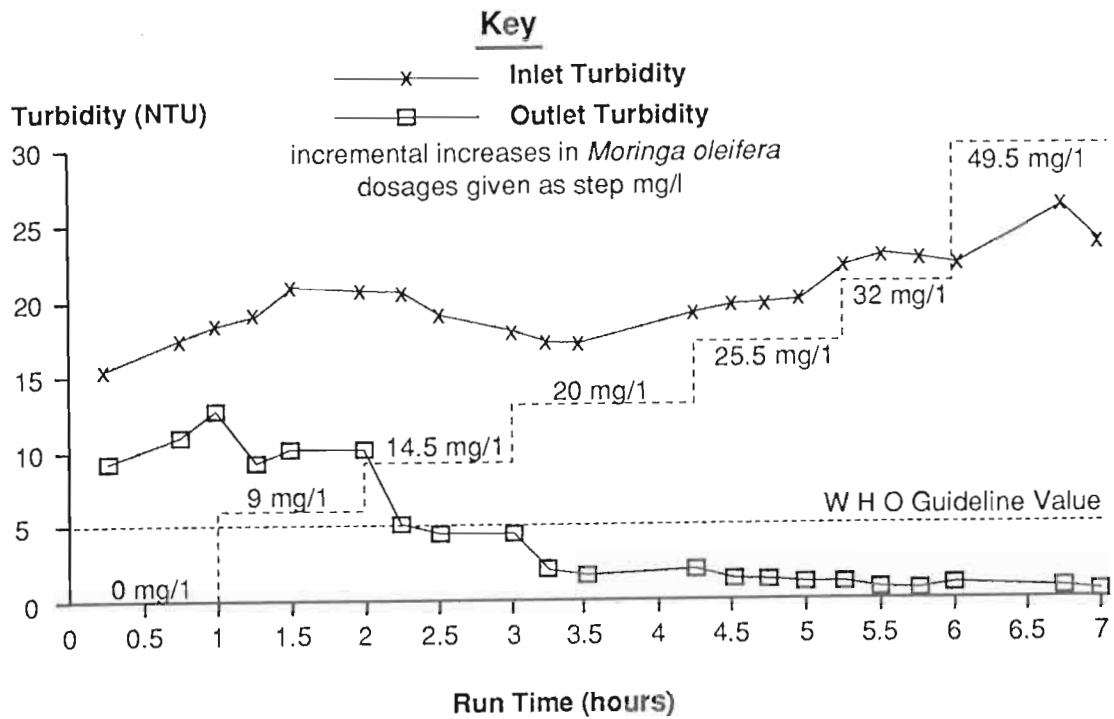


Figure 3 Contact flocculation - filtration - dynamic dose response

## CULTIVATION AND ECONOMICS

Trial plantations of *M.oleifera* have been established and maintained under the auspices of the Forestry Research Institute of Malawi. Seedlings of height 0.35 metre were field planted in February 1991. Within 12 months the majority have flowered and fruited within this period producing their first harvest of ripe, mature seed pods.

An economic assessment of replacing the use of aluminium sulphate (alum) by *M.oleifera* coagulant in the Malawi context was prepared in December 1990. Under optimum conditions, the natural coagulant was calculated to cost 18% that of alum. The 'worst' case scenario yielded a net saving of 33% in favour of *M.oleifera*.

## CONCLUSIONS

Small treatment works in the rural areas are generally attended by operators with limited technical skills. Thus for effective day to day operation the treatment units and protocols must be **simple, reliable and robust**. Treatment units developed, used in conjunction with *M.oleifera* seed coagulant, provide these essential requirements. The system is **sustainable** and does not rely on the importation and distribution of chemical coagulants such as aluminium sulphate. Based on treatment and cultivation studies to date, the treatment systems are considered to be **economically viable**.

The conventional treatment train of coagulation - flocculation - sedimentation - filtration should be used during periods of high raw water turbidity. Contact flocculation - filtration provides simple yet effective treatment in the dry season.

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