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# USE OF HERBAL COAGULANT FOR PRIMARY TREATMENT OF DAIRY WASTEWATER

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**Key words :** Moringa Oleifera, Herbal coagulant, Dairy wastewater, Coagulation-sedimentation, Wastewater treatment.

## ABSTRACT

***Moringa Oleifera*** **herbal coagulant is reported to be efficient in removal of turbidity from waters. Possibility of its use in the primary treatment of industrial wastewater was explored and the findings are reported in this paper. Dairy wastewater which was subjected to preliminary treatment - screens, oil and grease removal and equalization - aeration tank - was observed to contain white colloidal suspensions, mostly organic in nature. Coagulation-sedimentation studies were conducted on laboratory scale treatment units (Jar Test apparatus) using *Moringa oleifera*, a herbal coagulant, which is free of constraints viz. pH and alkalinity. The results of the studies are quite encouraging. Optimum dose of *Moringa oleifera* (60 mg/L) observed to reduce pollution parameters- initial $BOD_5$ and COD of Dairy wastewater- to the tune of 55% and 60% respectively. Using fullers earth as coagulant-aid (15 mg/L) these reductions were further increased by 5% and 6% respectively. Preliminary and primary treatment together reduce the initial $BOD_5$ and COD values respectively by 60 % and 66 % and residual $BOD_5$ remained below 500 mg/L (maximum limit allowed for discharge of treated effluent on land through irrigation)**

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## INTRODUCTION

Coagulation-flocculation followed by sedimentation, using chemical coagulant is a very common treatment method used mainly in water treatment practices. Recently there has been more interest, especially in developing countries, in possible application of **herbal coagulants**. Use of *Moringa oleifera* (Drumsticks seed) as **herbal coagulant** is reported to be quite effective and have many advantages over chemical coagulant like Alum. Recent studies have pointed out several serious drawbacks of using aluminium salts, such as Alzheimer's disease and similar health related problems associated with residual aluminium in treated waters (AWWA, 1990 and Miller *et al.* 1984), besides production of large sludge volumes. There is also the problem of reaction of alum with natural alkalinity present in the water leading to a reduction of pH and also low efficiencies in coagulation of cold waters (Werner, 1968). High cost of imported chemicals like alum for water and wastewater treatment is not affordable for many developing countries (Ndabigengesere, 1995).

Moringa is a tropical plant belonging to the family of *Moringaceae.* Earlier studies have found the plant to be non-toxic (Grabow *et al*. 1985), and recommended its use as coagulant in developing countries (Janh 1981, 86, 88)

Encouraged by the results of these studies, many developing countries have turned to using this plant as a viable coagulant in water treatment on a small scale (Karerwa, 1986 and Ndabigengesere, 1988). Moringa Oleifera has been reported to be free of constraints like pH and alkalinity. Sludge produced with Moringa Oleifera is reported to be four to five times compact than that produced with alum. Turbidity removal of 95 percent or more can be achieved with Moringa Oleifera, in water treatments (Muyibi *et al*.1995).

Jahn Samia A.A. (1998), has reported that Moringa is highly suitable for high turbidity i.e. 3000 NTU. It was also reported that this **herbal coagulant** is traditionally used in water purification in Sudan which is a developing country (Jahn, 1981).

Dairy industry is one of the big industries in India. A dairy needs large volumes of water for various purposes and the wastewater discharge from a dairy is also equally large in volume with highly variable pollution characteristics. Wastewaters from dairy plants consist of washings from cans, dairy equipments, floors etc. and therefore contain high organic solid concentrations particularly milk suspensions.

Present investigative studies were undertaken to explore the feasibility of **physico-chemical** processes, particularly coagulation with herbal coagulant-Moringa Oleifera for industrial wastewaters. Dairy wastewater from one of co-operative dairy plant, situated in Pune was collected and used during experimental investigative studies to explore the possibility of application of coagulation-sedimentation with Moringa Oleifera as coagulant for treatment of dairy wastewater to improve its characteristics and make it suitable for further treatment and disposal in environment. This paper is the report on investigative studies and its findings.



## MATERIALS AND METHODS

### *2.1 Coagulation-Sedimentation Studies*

Dairy wastewater after preliminary treatment was planned to be used for exploration of coagulation sedimentation studies for removal of fine colloidal suspensions imparting turbidity in range of 800-1200 NTU. *Moringa oleifera* coagulant was selected to be used as a **herbal coagulant** for the treatment of high turbidity dairy wastewater.

### *2.2 Preparation of M. oleifera suspension*

Dry seeds used for all experimental runs were procured from local market in Pune in Maharashtra state of India. After removing seed wings and coat the kernel was ground to a fine powder using the laboratory crusher. Fine colloidal suspension of this powder was prepared with distilled water. Proper doses of this suspension were given to raw water to achieve coagulant doses in the range of 30 mg/L to 90 mg/L. Every day fresh coagulant suspension was prepared to avoid any possible deterioration during storage. *Moringa oleifera* can be used in both shelled and non shelled forms. However, in the studies by Ndabigengesere *et al.* (1995) it is reported that the shelled seed is found to be more effective than non shelled seed. Therefore, in this study the plant was used in shelled form.

### *2.3 Coagulant-Aid*

Fullers earth was added to improve settlement of microflocs in dairy wastewater through providing nuclei for attracting these microflocs.

### *2.4 Experimental Setup*

#### *2.4.1 Jar Test Apparatus*

The jar test is a common laboratory procedure used to determine the optimum operating conditions for water or wastewater coagulation-sedimentation treatment (Kawamura, 1991 and Bratby, 1980). This method allows adjustment of pH, variation in coagulant or coagulant aid dose, alternating speeds, or testing of different coagulant or polymer types, on a laboratory scale coagulation sedimentation process units in order to predict the functioning of a large scale treatment operation. Jar test apparatus was selected to be used for coagulation-sedimentation studies. Time constraints followed in coagulation sedimentation studies are : Rapid mixing- 2 min (100 rpm), Slow mixing- 20 min (40 rpm) and Sedimentation- 45 min.

### *2.5 Characteristics of Katraj Dairy wastewater*

It is observed that wastewater generated from 9 to 11 am has high values of characteristics parameters because of washing of floors, cans and equipments. Twenty liters sample was collected just before the screens, and analyzed for various parameters following the procedure given in Standard Method (AWWA, APHA, 1987).

The result of average characteristics of wastewater (collected during 9 to 11 am on respective days) shows that Total Solids varies from 1280 to 3880 mg/L (average 2331 mg/L) and suspended solids (more than 1 micron size) varies from 240 to 607 mg/L (average 382 mg/L). Volatile solids (average 1434 mg/L) indicate solids imparting BOD which ranges between 960 and 2280 mg/L. COD/BOD ratio and TS/VS ratio vary in the range 1.63 to 2.12 and 1.14 to 1.75 respectively. Oil and grease is substantially high 276 mg/L on an average basis. The experimental studies were planned and conducted keeping in view the disposal of dairy wastewater on land through irrigation and alternative for further treatment for discharge in water bodies.

### *2.6 Preliminary Treatment*

The existing wastewater treatment plant has preliminary treatment of (a) Screening (b) Oil and grease trap and (c) Holding cum equalization tank. Therefore, laboratory studies include the studies on screens and oil & grease removal. Dairy wastewater is reported to have immediate oxygen demand, generally referred as four hours oxygen demand. If this demand is not satisfied, dairy wastewater produces very bad, disagreeable, obnoxious smell, probably due to formation of butyric acid, which pollutes ambient air. Therefore four hours of aeration is also included in present studies to satisfy immediate oxygen demand.

### *2.7 Effect of Preliminary Treatment of Dairy Wastewater*

Three preliminary treatments were planned for experimentation for coagulation-sedimentation studies on dairy wastewater viz. screening, oil and grease trap and four hours aeration cum holding tank. Screening process is expected to remove larger size material such as paper, plastics etc. Slow rate of small size air bubbles were provided through air diffuser located at the bottom of tank. Slow rising bubbles were expected and also found to get attached to oil and grease suspensions thereby helping oil and grease to rise upto wastewater surface due to increased buoyancy effect.

Four hours aeration is almost obligatory to avoid ambient air pollution and to satisfy immediate oxygen demand which continues upto four hours. This four hours retention of wastewater also amounts to holding wastewater for four hours thereby equalizing the flow characteristics as well as its discharge.

## RESULTS AND DISCUSSION

### *3.1 Experimental Runs For Coagulation Studies With Moringa oleifera (Coagulant)*

Preliminary treated dairy wastewater was used for coagulation studies with *Moringa oleifera* as coagulant. Main object of coagulation studies is to explore effectiveness of *Moringa oleifera* coagulant for reducing wastewater characteristics parameter concerned with environmental pollution i.e. $BOD_5$, COD through removal of organic colloidal suspensions. Characteristics of dairy wastewater indicate that COD/BOD ratio is almost constant having value of



1.6-1.7. Experimental runs were conducted using Jar Test apparatus. Quick mixing at 100 rpm for 2 minutes and slow mixing at 30-40 rpm for 20 minutes followed by 45 minutes settling was observed during experimental runs. Eight *Moringa oleifera* coagulant doses in range of 35 to 80 mg/L were applied to preliminary treated wastewater. COD of wastewater was determined at the beginning and at the end of each reactor run. The observations and results of the runs are displayed in Table -1. Col 3 indicates initial COD i.e. COD of dairy water after preliminary treatment (screening, oil and grease removal, and four hours of aeration /holding period).

At the end of reactor runs with various doses of Moringa Oleifera coagulant, COD was again monitored, which is referred as **residual COD** and reported in column 5**,** Table-1. Col 6 shows reduction in COD during the reactor runs. These results are also reported in Fig -1 and Fig -2.

The COD reduction varies from 15.47 to 63.49% and optimum reduction of 63.49 percent was observed at *Moringa oleifera* dose from 60 to 65 mg/L. Optimum dose was determined by **using curve fitting technique with regression analysis, by using 'Origin 6.1' software with standard deviation of 0.05.** Initial COD (that is of preliminary treated water) of 1260 mg/L was reduced to 460 mg/L, i.e. 63.49 percent during coagulation process. Studies on preliminary treatment (i.e. screening, oil and grease removal four hour aeration) indicate that dairy wastewater COD was found to be reduced by 25 percent during preliminary treatment. If preliminary treated wastewater indicates COD of 1260 mg/L, it can safely be presumed that dairy wastewater COD (before preliminary treatment) shall be 1260 x 100/75= 1680 mg/L. Therefore it can be concluded that wastewater COD of 1680 mg/L can be reduced to 460 mg/L i.e. 72.61 percent through preliminary treatment + coagulation with *Moringa oleifera* coagulant. $BOD_5$ of the same samples is bound to be less than 500 mg/L as BOD to COD ratio being 0.59 (as discussed earlier) and COD

**Table 1**
Experimental Runs for Coagulation Studies with MoringaSeed (Coagulant)

| Sr. No. | Experimental Runs | Initial COD* Mg/L | Moringa Coagulant Dose Mg/L | COD After Coagulation mg/L | COD Reduction Percentage |
|---|---|---|---|---|---|
| 01 | 02 | 03 | 04 | 05 | 06 |
| 01 | 01 | 1260 | 35 | 1065 | 15.47 |
| 02 | 02 | 1260 | 40 | 1095 | 13.09 |
| 03 | 03 | 1260 | 45 | 795 | 36.90 |
| 04 | 04 | 1260 | 60 | 460 | 63.49 |
| 05 | 05 | 1260 | 65 | 477 | 62.10 |
| 06 | 06 | 1260 | 70 | 544 | 56.84 |
| 07 | 07 | 1260 | 75 | 690 | 45.26 |
| 08 | 08 | 1260 | 80 | 955 | 24.21 |

Note: (1) * COD After four hours aeration, oil and grease removal
(2) Refer to Fig. 1 and Fig. 2
(3) Optimum Coagulant Dose = 60 mg/L
(4) Percentage Reduction at optimum dose = 63.49%

**Table 2**
Coagulation studies for determination of optimum dose of fuller earth (Coagulant Aid)
Wastewater : Dairy wastewater after preliminary treatment- screening, oil and grease removal, and four hours of holding/aeration tank.

| Sr. No. | Expt Runs | Initial COD* mg/L | Moringa Coagulant Dose mg/L | Fuller Earth Dose mg/L | COD After Coagulation mg/L | COD Reduction % |
|---|---|---|---|---|---|---|
| 01 | 02 | 03 | 04 | 05 | 06 | 07 |
| 01 | 01 | 1550 | 60 | 05 | 587 | 62.10 |
| 02 | | | 60 | 10 | 563 | 63.65 |
| 03 | | | 60 | 15 | 521 | 66.38 |
| 04 | | | 60 | 20 | 539 | 65.17 |
| 05 | | | 60 | 25 | 565 | 63.53 |
| 06 | | | 60 | 30 | 570 | 63.20 |
| 07 | 02 | 1835 | 60 | 05 | 705 | 61.57 |
| 08 | | | 60 | 10 | 651 | 64.50 |
| 09 | | | 60 | 15 | 617 | 66.33 |
| 10 | | | 60 | 20 | 648 | 64.65 |
| 11 | | | 60 | 25 | 675 | 63.20 |
| 12 | | | 60 | 30 | 691 | 62.34 |

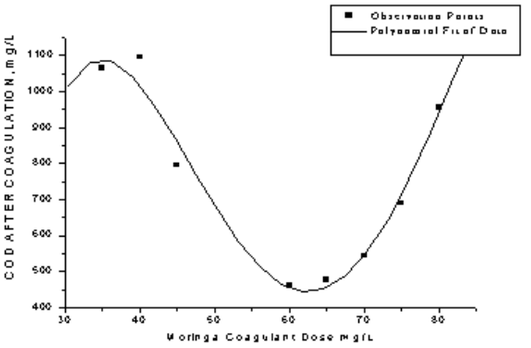
Notes : (1) Moringa Coagulant Dose = 60 mg/L Constant.
(2) Fuller Earth dose (Coagulant Aid) in range of 05 mg/L to 40 mg/L.
(3) Optimum fuller Earth dose is 15 mg/L (Refer Fig. 3 and 4)
(4) Maximum COD Reduction at Optimum dose = 66.3% (Average 64.03 %)

**Table 3**
Successive COD reduction in dairy wastewater during primary treatment using *Moringa oleifera* coagulant

| Sr. No. | Treatment With | Percent Reduction During Process Unit | Cumulative Percent Reduction |
|---|---|---|---|
| 01 | 02 | 03 | 04 |
| 1. | Screens | — | — |
| 2. | Oil and grease trap | 14 | 14 |
| 3. | Four hours of Aeration/ Holding | 13 | 27 |
| 4A | Coagulation-sedimentation with *Moringa oleifera* | 35 – 40 | 62 – 67 |
| 4B | Coagulation-sedimentation with *Moringa oleifera* seed + Fullers Earth | 40-45 | 67-72 |

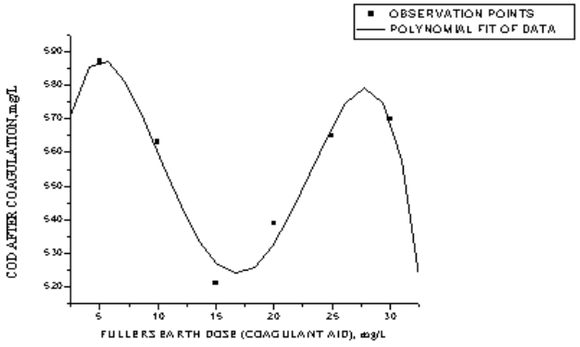
being less than 500 mg/L. $BOD_5$ of dairy wastewater is reported in the range 900-1500 mg/L therefore it can be safely assumed that through preliminary treatment + coagulation with MOC + fullers earth will be less than 500 mg/L, which is the maximum limit allowed for treated effluents to be discharged on land. (Effluent Standard IS 8682-1977: Guide for treatment of effluent of dairy industry).






Notes : (1) Optimum percent reduction = 63.49 %, (2) Optimum coagulant dose = 60 mg/L

**Fig. 1** Experimental runs for optimization coagulant dose with Moringa seed (Coagulant)

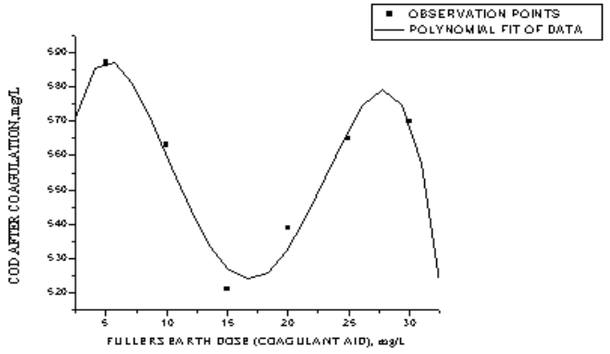



Notes : (1) Optimum percent reduction = 63.49 %, (2) Optimum coagulant dose = 60 mg/L

**Fig. 2** Coagulant dose Vs percent COD reduction with Moringa coagulant

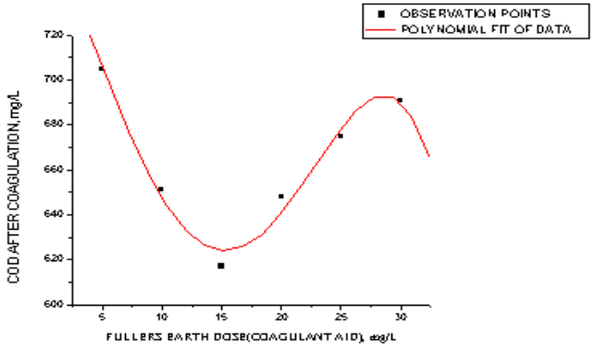
### *3.2 Experimental Runs For Coagulation Studies With Coagulant Moringa oleifera (Optimum Dose: 60 Mg/L) + Fullers Earth (Coagulant Aid)*

Dairy wastewater is observed to have micro-colloids in suspended form which needs to get settled, to yield colloids free wastewater. Coagulation aids like fullers earth, bentonite clays are reported to be used to enhance coagulation cum settling of micro-colloids/micro-flocs. Suspensions of these coagulation aids having suspension particle size greater than 1 micron are presumably effective as nuclei to quickly coagulate micro-flocs which also quickly settles. Suspensions of fullers earth were used along with *Moringa oleifera* coagulant to study the effect on coagulation and settling. Fullers earth suspension was prepared by adding 100 mg of fullers earth to 100 mL of distilled water followed by thorough mixing. Required quantity of fuller earth suspension was collected with pipette from continuously stirred fullers earth suspension solution.




Note : (1) Initial COD : 1550 mg/L, (2) Coagulant used : Moringa oleifera
(3) Otimum coagulant aid dose = 15 mg/L, (4) Standard deviation = ± 5%
(5) Residual cod = 521 mg/L

**Fig. 3** Coagulation Studies For Determination of optimum dose of fullers earth (Coagulant Aid) Set - I




Note : (1) Initial COD : 1835 mg/L, (2) Coagulant used : Moringa oleifera
(3) Optimum coagulant aid dose = 15 mg/L, (4) Standard deviation = ± 5%
(5) residual cod = 617 mg/L

Fig 4 Coagulation studies for determination of optimum dose of fullers earth (coagulant aid) Set - II

Experimental reactor runs were conducted with primarily treated (screening, oil and grease removal, four hours of aeration/holding period) dairy wastewater. Quick mixing at 100 rpm for 2 minutes and slow mixing at 30-40 rpm 20 minutes, followed by 45 minutes of settling was observed. **Twelve** Fullers Earth doses ranging between 05 mg/L to 30 mg/L were given along with **optimum dose 60 mg/L** of *Moringa oleifera* coagulant. COD of wastewater was monitored during the runs. The observations and results of the runs are displayed in the Table-2. Col 3 indicates initial COD i.e., COD of dairy wastewater after preliminary treatment (screening, oil and grease removal, four hours of aeration / holding period).



At the end of six reactors run with various fuller earth doses and optimum Moringa Oleifera coagulant dose (60mg/L), COD was monitored, which is referred as COD after coagulation, and displayed in Col 06. Result is also displayed in Fig. 3**.** The COD reduction varies from 62.10 % to 66.38 % during experimental runs. The residual COD is between 521 mg/L and 691 mg/L.

During this experimental run it is seen that maximum COD reduction was obtained with *Moringa oleifera* coagulant (optimum dose 60 mg/L) when fullers earth dose around 15 mg/L and COD reduction ranges from 62.10 to 66.38 % and optimum at 66.38%.

COD values were observed to be reduced successively during preliminary treatment + coagulation sedimentation with MOC + fullers earth as coagulant aid, which is displayed in Table -3.

## CONCLUSIONS

Dairy wastewater treatment units are observed to follow the biological treatment methods in addition to preliminary treatment. As the dairy industry being agro-oriented, located away from urban population, generally near to disposal site and in rural/agricultural area. Normally sufficient land is available for disposal of dairy wastewater. Simple and easiest method of disposal of this wastewater is on land through irrigation; as maximum $BOD_5$ of 500 mg/L is allowed to be disposed off through this method. Alternative simple method like **physico-chemical** treatment, if proved to reduce $BOD_5$ to or less than 500 mg/L, then dairy industry is bound to opt for such simple and cheaper treatment.

Dairy wastewaters are observed to have micro colloidal white suspensions of organic origin which contributes to major BOD and COD parameters of these wastewaters. If these suspensions are removed, indirectly BOD and COD will also be effectively reduced. *Moringa oleifera* is tropical plant, which is resistant to adverse environmental conditions, can be grown on the dairy wastewater if disposed off on land for irrigation. Thus *Moringa oleifera* seeds shall be cheaply and readily available resulting in its availability on regular basis.

## REFERENCES

American Public Health Association, American Water Works Association and Water Pollutional Control Federation (WPCF) (1989). *Standard Methods for the examination of Water and Wastewater*,17th Ed., APHA Pub.Office, Washington D.C.

Azaharia Samia Al Jahn 1998. Using Moringa seeds as coagulant in developing countries. *Journal of American Water Works Association*. pp 43 - 50.

Alagarswamy, S.R., Gandhirajan M., Govindraj, 1981. Treatment of Dairy wastes- A case study. *Indian Journal of Environmental Health*. 23 ( 2) : 107-17

Bhole, A.G. and Maloo, A.C. 1993. Performance studies of Bentonite as a coagulant and coagulant aid. *Journal of the IPHEI*. 2 : 43 - 46.

Bhole, A.G. 1987. Performance studies of a few natural coagulant. *Journal of Indian Water works Association*, XIX (3) : 205 -209.

Bulusu, K.R.,Theragaonkar V.P. and Kulkarni D.N. 1968. Natural polyelectrolyte as

coagulant aid. *Environmental Health.* (10) : 239-264

Datar, M.T. and Kale S.B. 1997. Performance of a Dairy Effluent Treatment Plant. *Indian Journal of Environmental Heath*. 39 (1) : 52- 60.

Howard, S. and Peavey, S., George Tchobanoglous 1995. *Environmental Engineering*.

IS: 8682-1977. *Guide for Treatment of Effluent of Dairy Industry*. B.I.S., New Delhi

IS: 2490-1982. *Indian Standard for Industrial and Sewage Effluent Discharge*. B.I.S.,N.Delhi

James, M. Montgomery 1985. *Water Treatment Principal and Design*. *John Wiley & Sons NY* .

Khurody, D.N. 1972. Disposal of wash from large dairies. *Indian Journal of Environmental Health*. 14 (3) : 259 -265.

Kawamura, S. 1991. Effectiveness of Natural Polyelectrolyte in water treatment. *J. Am. Wat. Wks. Association*. 83 : 88 - 91.

Li Guibai, John Gregory 1991. Flocculation and sedimentation of high turbid waters. *Water Research*. 25 (9) : 1137-1143.

Metcalf and Eddy, 2004. *Wastewater Engineering - Treatment Disposal and Reuse*' McGraw Hill, Fourth Edition.

Muyibi, A. and Evision L.M. 1996. Coagulation of turbid water and softening hard water with *Moringa oleifera* seeds. *Int. J. Environmental Studies.* 49 : 247-259.

Muyibi, S.A., Okuofu C.A. 1995. Coagulation of low turbidity surface water with Moringa Oleifera seeds. *Int. J. Environmental Studies*. 48 : 247-259.

Mohanrao, G.J. 1972. Dairy waste characteristics with reference to ISI standard. *Indian Journal of Environmental Heath*. 14 (3) : 246 -249.

Mohanrao, G.J. and Subramanian, P.V.R. 1972. Sources, flow and characteristics of dairy waste. *Indian Journal of Environmental Health.* 14 (3) : 207-217.

Ndabigengesere, K. and Subba Narasinh, 1998. Quality of water treated by coagulation using *Moringa oleifera* seeds. *Water Research*. 32 (3) : 781-791.

Ndabigengesere, A. and Narasiah K.S. 1996. Influence of operating parameter on turbidity removal by coagulation with *Moringa oleifera* seeds. *Environmental Tech*. 17 : 1103 -1112.

Ndabigengesere, K. Subba Narasinh 1995. Active agents and mechanism of coagulation of turbid waters using Moringa Oleifera. *Water Research*. 29 (2) : 703 -710.

Rajgopalan, S. 1972. Dairy Waste-Disposal on land. *Indian Journal of Environmental Health*. 14 (2) : 250 -258.

Suleman, A. Muyibi and Lilian, M. Evision 1995. Optimizing physical parameters affecting coagulation of turbid water with *Moringa oleifera* seeds. *Water Research*. 29 (12) : 2689-2695.

Suleman, A. Muyubi and Lilian M. Evision 1995. *Moringa oleifera* seeds for softening hard water. *Water Research.* 29 (4) : 1099 -1105.

Sen, A.K. and Bulusu, K.R. 1962. Effectiveness of Nirmali seeds as coagulant and coagulant aid. *Indian J. Environmental Health.* 4 : 232 -244.

Tetsuji Okuda, W. and Nishijima, M. Okuda 1999. Improvement of extraction method of coagulation active components from Moringa Oleifera seed. *Water Research.* 33 (15) : 3373 -3378.

Tetsuji Okuda, W. and Nishijima, Mitsumasa Okuda 2001. Isolation and characterization of coagulant extracted from Moringa Oleifera seed by salt solution. *Water Research*. 35 (2) : 405 - 410.

Tetsuji Okuda, W. and Nishijima, Mitusmasa Okuda 2001. Coagulation mechanism of salt solution-extracted active component in Moringa Oleifera seeds. *Water Research*. 35 (3) : 830 -834.