EXPLORING THE USE OF ORANGE PEEL AND NEEM LEAF POWDER AS ALTERNATIVE COAGULANT IN TREATMENT OF DAIRY WASTEWATER

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Abstract— *now a day's more interest has been concentrated on the identification of natural and alternative coagulant materials. Present study aimed to investigate the efficiency of orange peel and neem leaf powder on the treatment of dairy wastewater. Sample was collected from Attingal sub district and the wastewater characterization was made with standard methodologies. Orange peel and neem leaf powder were added in different doses (1g, 2g, 4g, 6g, 8g & 10g) as coagulants to assess the effectiveness and dosing level. Previous results using various natural products as coagulants showed measurable increase in the quality of wastewater with pilot and field studies. Present study also aimed to get maximum efficiency out of the selected two natural products and prove natural material have the potential of adsorption and removal of higher concentration of chemical constituents from the dairy industrial wastewater.*

Index Terms— Turbidity, pH, Total solids, Natural coagulants, Neem leaf powder, Orange peel powder, Chemical coagulant, Alum, Cost effective, Efficient , Reuse of waste water, Reduce chemical

1. INTRODUCTION

Water is the basis of life. About 75% of the body weight is made up of water. WHO estimates that about 85% of the rural populace lack potable drinking water. In developing countries 15 million infants die every year due to contaminated drinking water, poor hygiene and malnutrition. About 80% of illnesses in developing countries are directly connected with contaminated drinking water (WHO). The provision of water supply nearby for consumers and sufficient for their daily needs will help greatly in decreasing the incidence of skin diseases, eye infections and also reduce diarrhoea diseases as well as most worm infections, particularly if the water is of good quality bacteriologically[1]. However, major improvements in health conditions through provision of sufficient safe water can only be achieved through domestic hygiene practice and proper methods of water purification.

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In dairy industries, water is a key processing medium. Water is used throughout all processing steps of the dairy industry, including cleaning, sanitization, heating, cooling and cleaning of external areas -as a result, the water requirement is huge. Moreover, the liquid effluents generated through dairy product production exhibit high concentrations of organic matter, fats, suspended solids and nutrients. These are considered to be the main sources of pollution in this industry. Conventional treatment of these effluents normally includes a primary treatment to remove the suspended solids and fats and a secondary biological treatment; however, many problems have been reported during these processes. They are often related to the high production of foam, the low settle ability of the sludge, the low resistance to shock loads, the difficulty in removing nutrients, and the problems associated with the degradation of fats, oils, and other specific types of pollutants [2].

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. 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. 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 [3]. Present investigative studies were undertaken to explore the feasibility of physico-chemical processes, particularly coagulation with herbal coagulant for industrial wastewaters. Dairy wastewater from one of co-operative dairy plant, situated in Attingal was collected and used during experimental investigative studies to explore the possibility of application of coagulation-sedimentation with neem and orange peel powder 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 for the effectiveness of herbs as a coagulant.

2. OBJECTIVES

The objectives of this study were

1. To identify the most appropriate technique for removing contaminants from dairy wastewater
2. To test the efficiency of Orange peel powder and Neem leaf powder
3. To characterize physically and chemically the wastewater
4. To compared the most effective natural coagulant
5. To compare the results with one of the chemical coagulant.

3. MATERIALS AND METHODS

3.1 ALUM

Aluminium sulphate, a.k.a. "filter alum", is commonly used as a coagulant in water treatment systems and less frequently in waste treatment systems. In water treatment it is used primarily for the removal of tiny particles (called colloids, measured as total suspended solids) in the raw water which are too small to settle by gravity in a reasonable length of time. Another contributing factor as to why small particles are difficult to settle out is that very small particles commonly possess a negative surface charge. As a result, they will not adhere to each other if brought into contact since like charges repel. Such colloidal systems are termed "stable". The process of causing the colloidal particles to settle out is called "destabilization". "Coagulation" is defined as any process used to destabilize colloidal systems. There are two primary theories regarding the exact mechanism by which coagulants actually cause the removal of colloids in water (or wastewater). One theory involves neutralization of the surface charge on the particle so that they can adhere to each other forming particles large enough to settle by gravity in a reasonable time. This theory is rather complex and somewhat esoteric. It will not be covered here. The other mechanism, which we will we discuss, is often referred to as the "sweep floc" theory. This theory simply postulates that the coagulant(s) added form a precipitate (a solubility product is exceeded) which settles by gravity in a reasonable time. These coagulant floc particles then collide with and drag colloids down with them.

The term "alum" refers to aluminium sulphate $Al_2(S0_4)_3$. However the number of water molecules bound to the central molecule can vary substantially (3 to 24 waters). While this has no effect on the behaviour of the coagulant it is necessary to know in order how much bound water is present in order to compute the number of moles or equivalents of alum. The alum reacts with the bicarbonate molecule. In the reaction above bicarbonate is shown associated with Ca^{+2} in order to preserve charge neutrality. For most waters with a pH of 6-8 the

bicarbonate is measured as alkalinity. The reaction produces carbon dioxide, CO_2, as a gas. This CO_2 will then react with water producing carbonic acid H_2CO_3. The carbonic acid will partially dissociate producing bicarbonate, carbonate and H^+. Thus, the pH of water to which alum is added will drop, but not very greatly, since carbonic is a weak acid.

Fig 1: Alum

3.2 ORANGE PEEL POWDER

Orange peel was collected from local market and washed several times with tape water to remove the adhering dirt. Further the sample were dried under sunlight for four to six days and chopped by manual cutters into small pieces. Later on crushed to obtain small particle size powder and finally sieved with different mesh size ranging from 4 to 600um to 1200um and 3.0mm, 4.0mm and 5.0mm mesh size. Again washed with distilled water to remove any acidity or alkalinity, and oven dried at 80 degree Celsius for 24 hours. Oven drier was used for drying purpose.

Fig 2: orange peel powder

3.3 NEEM LEAF POWDER

Neem leaves was collected and washed with tape water to remove impurities and dirt present in it. The leaves are then dried under sun light for two to three days and it is then grinded to make fine neem leaf powder. If required neem leaf can also wash with acid or alkali to remove very fine dust particle present in the leaf.

Fig 3: Neem leaf powder

3.4 COAGULATION

Coagulation is an essential process in the treatment of both surface water and industrial wastewater. Its application includes removal of dissolved chemical species and turbidity from water via addition of conventional chemical-based coagulants, namely, alum ($AlCl_3$), ferric chloride ($FeCl_3$) and polyaluminium chloride (PAC).While the effectiveness of these chemicals as coagulants is well-recognized, there are, nonetheless, disadvantages associated with usage of these coagulants such as ineffectiveness in low-temperature water, relatively high procurement costs, detrimental effects on human health, production of large sludge volumes and the fact that they significantly affect pH of treated water. There is also strong evidence linking aluminium-based coagulants to the development of Alzheimer's disease in human beings. It is therefore desirable to replace these chemical coagulants with naturally obtained materials as coagulants to counteract the aforementioned drawbacks.

3.5 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.

Fig 4: JAR Test Apparatus

3.6 CHARACTERISTICS OF DAIRY WASTEWATER:

It is observed that wastewater generated has high values of characteristics parameters because of washing of floors, cans and equipments. Twenty litres sample was collected from Attingal milco industry, and analyzed for various parameters following the procedure given in Standard Method (AWWA, APHA, 1987). 142 Bhutada et al. The result of average characteristics of wastewater (collected during 9 to 11 am on respective days) shows that Total Solids in the range of 6000mg/l and the turbidity was in the range of 260NTU where the pH of waste water was about 5.5. 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.

4. RESULTS AND DISCUSSION

4.1 EXPERIMENTAL RUNS FOR COAGULATION STUDIES WITH NEEM LEAF POWDER (COAGULANT)

Dairy wastewater was used for coagulation studies with neem leaf powder as coagulant. Main object of coagulation studies is to explore effectiveness of neem leaf coagulant for reducing wastewater characteristics parameter such as turbidity and measuring the Ph, total solids through removal of organic colloidal suspensions. 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. Five neem leaf coagulant doses in range of 0.2 to 1g/l were applied to wastewater.

The turbidity was found to be reduced from 260NTU to 4NTU with the dosage of 0.2g, 0.4g, 0.6g, 0.8g, 1g.the corresponding values of turbidity and other parameters such as pH and total solids are given the table below. The result indicates a great reduction in the level of turbidity in the dairy waste.

4.2 EXPERIMENTAL RUNS FOR COAGULATION STUDIES WITH 0RANGE PEEL POWDER

Orange peel powder is applied in five doses in the range of 0.2g, 0.4g, 0.6g, 0.8g, 1g and the experiment was conducted in the same manner as stated above. There was a great decrease in turbidity using orange as coagulant but when compared with neem leaf powder its efficiency is slightly less. Following are the values obtained for turbidity, pH and total solids

4.3 EXPERIMENTAL RUNS FOR COAGULATION STUDIES WITH ALUM

The above experiment is further repeated with chemical coagulant such as alum. Five doses were used in the range of 0.2g to 1g. The table(3) below shows the corresponding value obtained.

- Using neem leaf as a coagulant turbidity was reduced about 98%.
- pH was in the range of 8 and above but less than 9.
- Using orange peel powder as coagulant turbidity was reduced to about 96%
- pH was less than 8 but greater than 7 around neutral pH.
- Using alum as coagulant turbidity was reduced to about 98.8%.
- pH was around less than 5 which is acidic in nature

The result of average characteristics of wastewater (collected during 9 to 11 am on respective days) shows that Total Solids in the range of 5000mg/l and the turbidity was in the range of 260NTU where the pH of waste water was about 5.5.In experimental run for coagulation studies with neem leaf powder as a coagulant with varying doses such as 0.2g, 0.4g, 0.6g, 0.8g, 1g. The turbidity was found to be reduced from 260NTU to 4NTU. The result indicates a great reduction in the level of turbidity in the dairy waste. The pH was in the range of 8 and above but less than 9. In experimental run for coagulation with orange peel powder as coagulant there was a great decrease in turbidity using orange as

coagulant but when compared with neem leaf powder its efficiency is slightly less , its turbidity was reduced to 8NTU and the pH was less than 8 but greater than 7 around neutral pH.In the experimental run with alum as a coagulant there was a rapid decrease in the turbidity and it reduced up to 3NTU and the pH was around less than 5 which is acidic in nature. On the whole comparision it can be stated that the effectiveness of neem and orange peel powder is better as its values of reduction is quite near to that of alum. The table below 1 ,2 and 3 represent the characteristics of dairy waste after coagulating with neem leaf powder , orange peel powder and alum respectively and corresponding graphs are given below.

Dosage (g)	0.2	0.4	0.6	0.8	1
Turbidity (NTU)	40	32	20	12	4
pH	8.11	8.02	8.52	8.63	8.6
Total solids (g)	2000	3000	2000	4000	2000

Table 1: characteristics of dairy waste treated with neem leaf powder

Dosage (g)	0.2	0.4	0.6	0.8	1
Turbidity (NTU)	53	45	30	19	8
pH	7.73	7.71	7.6	7.3	7.13
Total solids (g)	2000	2000	4000	4000	3000

Table 2: showing characteristics of dairy waste treated with orange peel powder

Dosage (g)	0.2	0.4	0.6	0.8	1
Turbidity (NTU)	29	18	12	7	3
pH	3.9	4.63	4.32	4.7	4.54
Total solids (g)	2000	2000	3000	4000	3000

Table 3: showing characteristics of dairy waste treated with alum

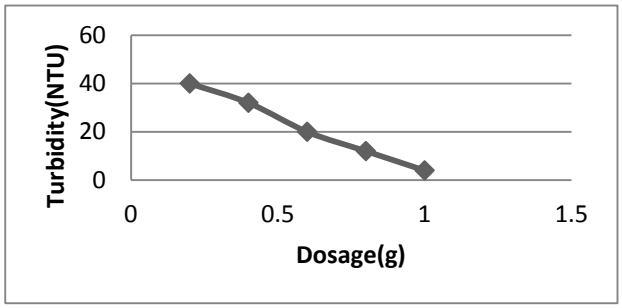

Fig 5: Graph shown the variation of turbidity for different dosage of neem leaf powder for a coagulation period of 30 min

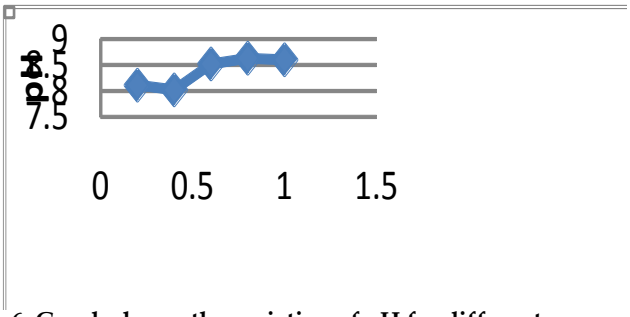

Fig 6: Graph shown the variation of pH for different dosage of neem leaf powder for a coagulation period of 30 min

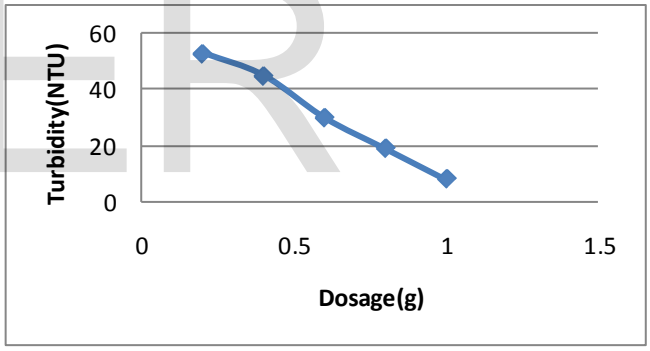

Fig 7: Graph shown the variation of turbidity for different dosage of orange peel powder for a coagulation period of 30 min.

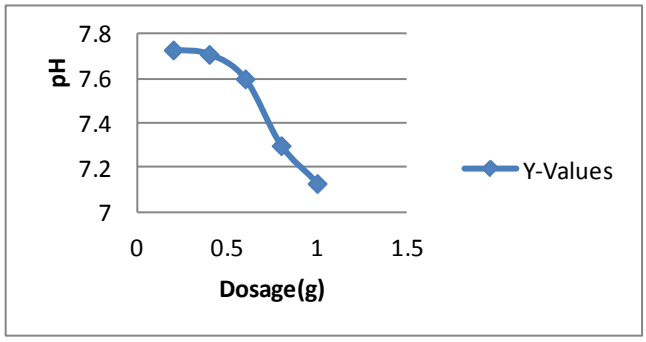

Fig 8: Graph shown the variation of pH for different dosage of orange peel powder for a coagulation period of 30 min

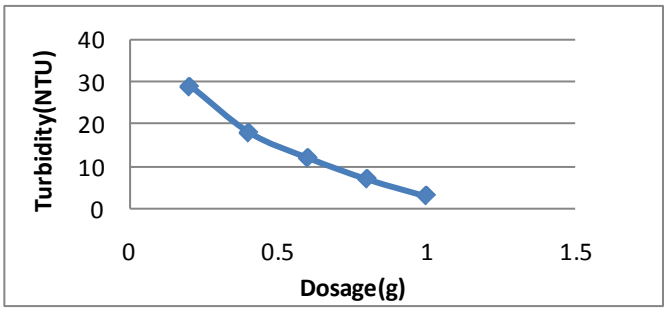

Fig 9: Graph shown the variation of turbidity for different dosage of alum for a coagulation period of 30 min.

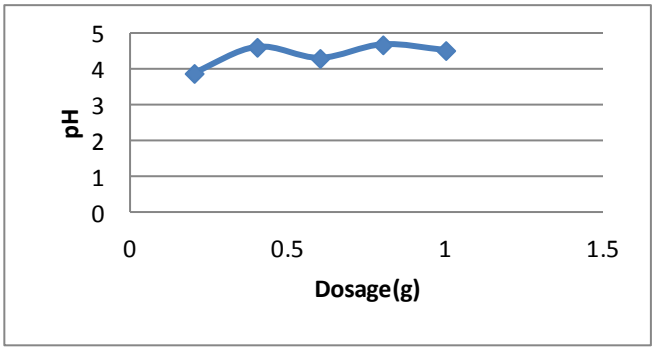

Fig 10: Graph shown the variation of pH for different dosage of alum for a coagulation period of 30 min.

6. CONCLUSION

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. This experiment was done to determine and compare the efficiency of natural coagulants such as neem leaf powder and orange peel powder as an effective coagulant in treating the dairy waste water and compare the result obtained with that of the chemical coagulant such as alum. From the result obtained it is clear that the both neem and orange can be used as an excellent coagulant in treating dairy waste water. The turbidity is reduced to about 4NTU by neem where as orange removed turbidity about 8NTU. The ph was alkaline on using neem but its alkalinity slightly decreased by the use of orange peel powder. By using alum the turbidity was reduced to about 3NTU also the ph became acidic. on an overall comparison it is clear that the effectiveness of neem and orange peel powder is near to that done with chemical coagulant (alum). Hence it can be concluded that it is coast effective to use natural products as coagulant thus reduce the use of chemicals and environmental pollution.

Water is the scarce resource for much of the World's population. Global warming, world population increases the water demand. It is estimated that by 2024 more than 40% of water will be used to meet the human needs. In industrialized countries water is used for non potable purposes such as industrial applications, toilet flushing and irrigation. Hence it is required to treat waste water to protect the natural water resources Reusing and recycling water conserves existing water resources, reduces need for new fresh water and it is no longer discharged to the environment which reduces contamination and degradation of freshwater resources

Recycled / reused wastewater used for activities like agriculture, aquifer recharge, aquaculture, fire fighting, flushing of toilets, snow melting, industrial cooling, parks and golf course watering, formation of wetlands for wildlife habitats, recreational impoundments, and essentially for several other non-potable requirements.

REFERENCES

[1]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.

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

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

[4] 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.

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

[6] Bulusu, K.R.,Theragaonkar V.P. and Kulkarni D.N. 1968. Natural polyelectrolyte as coagulant aid. Environmental Health. (10) : 239-264

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

[8] Howard, S. and Peavey, S., George Tchobanoglous 1995. Environmental Engineering.

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

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

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

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

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

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

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

[16] 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.

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

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

[19] 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.

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

[21] 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.

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

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

[24] 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.

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

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

[27] 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.