Preliminary Studies on the Effectiveness of Combined Treatment on Alleviating Contaminants of Wastewaters from Food Processing Plants Effluent

Khin Sein[1], Shwe Zin Mon[2], Swe Swe Hlaing[3]

Abstract

In the present research work, attempts were made to treat wastewater from food processing plant; Mohinga Plant by primary (sedimentation) and secondary (coagulation) treatments and Soy-Milk Plant by primary (sedimentation), secondary (coagulation) and biological treatments (aeration). Preliminary studies would be based on the standard wastewater treatment practice - primary (sedimentation), secondary (coagulation) and biological treatments were used singly or as a combined system. The effectiveness of individual or combined treatment systems were measured in terms of physical parameters (turbidity, color, suspended solids) and chemical parameters (pH, total solids, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand).In the treatment of wastewaters, alum was used as coagulant and most sediment were removed by the settling column. It was found that suspended solids was gradually reduced by sedimentation, (79.23) % for Mohinga Plant and (92.12) % for Soy-Milk Plant. The sedimentation also moderately removed the odor and color of Soy-Milk Plant Effluent, whereas for Mohinga Plant Effluent, removal of odor and color was not observed. In secondary treatment (coagulation), the most effective coagulant dosage were (80) mg/l for Mohinga Plant and (60) mg/l for Soy-Milk Plant. For Mohinga Plant, removal efficiencies were (24.55)% for total solid (TS), (95.61)% for suspended solid (SS) and (43.75)% for chemical oxygen demand (COD) whereas for Soy-Milk Plant, removal efficiencies were (35.6)% for total solid (TS), (99.69)% for suspended solid (SS) and (46.67)% for chemical oxygen demand (COD) . Biological treatment (aeration) was conducted for Soy-Milk Plant Effluent sample. It was also found that an aeration time of 2 days was most effective for reduction of BOD (97.04) % and COD (96.28) % for Soy-Milk Plant Effluent. Aeration time of 3 days was most effective for turbidity, color and suspended solid removal percentage and they were (98.98) %, (98.82) % and (99.35) % for Soy-Milk Plant Effluent.

Introduction

Industrial effluents destroy the recreational value of a stream, making the waters unfit for swimming usually not because of disease bacteria but because chemicals in the water are irritants to eyes and skin. The presence of industrial pollutants, especially of dissolved salts, may render a water supply totally unfit for industrial process use even after elaborate treatment, and may necessitate seeking another source of water or perhaps even another location for the industry. This is especially true in paper mills, textile plants, food-processing plants, and many chemical factories, where traces of iron or other contaminants can cause irreparable damage to the product.

Extensive pollution may make a river unfit for commercial fisheries or irrigation, or may introduce hazards and nuisances if it is so used. Even minor pollution impairs the stream for livestock, because animals either refuse to drink or they do drink and become poisoned.

Wastewater collected from cities and towns must ultimately be returned to receiving waters or to the land. The ultimate goal – wastewater management – is the protection of the environment in a manner commensurate with economic, social, and political concerns.

[1] Associate Professor (Retd.), Department of Industrial Chemistry, West Yangon University

[2] Demonstrator, Dr., Department of Industrial Chemistry, West Yangon University

[3] Demonstrator, Department of Industrial Chemistry, West Yangon University

Methods of treatment in which the application of physical forces predominate are known as unit operations. Methods of treatment in which the removal of contaminants is brought about by chemical or biological reactions are known as unit processes. Unit operations and processes are grouped together to provide what is known as primary, secondary, and tertiary (or advanced) treatment. In primary treatment, physical operations, such as screening and sedimentation, are used to remove the floating and settleable solids found in wastewater. In secondary treatment, biological and chemical processes are used to remove most of the organic matter. In tertiary treatment, additional combinations of unit operations and processes are used to remove other constituents which are not removed by secondary treatment. The objectives of this research are (1) to analyse the physical and chemical parameters of wastewater from Mohinga Plant and Soy-Milk Plant effluent (2) to treat wastewater from Mohinga Plant by primary (sedimentation) and secondary (coagulation) treatments and (3) to treat wastewater from Soy-Milk Plant by primary (sedimentation), secondary (coagulation) and biological (aeration) treatments and (4) to anlyse the physical and chemical parameters of treated wastewater.

Materials and Methods

Sampling and Analysis

In this research, effluent samples from Mohinga Plant and Soy-Milk Plant were analysed with respect to their physical parameters (turbidity, color, suspended solids) and chemical parameters (pH, total solids, dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand) and their respective results are shown in Table (1).

Treatment Methods

Sedimentation

The effluent sample from Mohinga Plant was filled in a laboratory settling column (5 in diameter, 7 feet height and taps were mounted at 2 feet depth intervals) as shown in Figure (1). A uniform concentration of the suspended solids was obtained when air was sparged into the bottom of the column for a few minutes at the beginning of the test. Suspended solids were determined on samples drawn off from (2) feet depth tap at selected time intervals up to (120) minutes and the results obtained were expressed in terms of percent removal of suspended solids at (2) feet depth and respective time intervals as shown in Table (2).

The same test was carried out with another effluent sample from the Soy-Milk Plant and the results are shown in Table (6).

Coagulation (with 1% Alum Solution)

Jar Test Procedure

A measured volume of effluent sample from Mohinga Plant, (200) ml, was taken in a (250) ml beaker and its pH reduced from 6.7 to 6.0 by dropwise additions of 1% H_2SO_4 and 1% NaOH solution, singly or combined. At this point, coagulant (1% alum solution) was added dropwise while the sample was thoroughly mixed (1-minute rapid mix followed by a 3-minutes slow mix) by a magnetic stirrer and visible flocs formed and the added volume was then noted and tabulated in Table (3).

The calculated dosage would then be used as a basis for further tests of the samples for pH determination employing Jar Test I.

Jar Test I

A measured volume of the same effluent sample, (500) ml, was placed in one of the beaker and equal volumes measured and added individually to the other beakers and a previously calculated dosage of 1% alum solution (i.e. 30 mg/l) was added to each beaker. The pH of the effluent sample in the first beaker was adjusted to 4.0, the second to 5.0, third to 6.0, fourth to 7.0, fifth to 8.0 and sixth to 9.0, respectively, with appropriate volumes of 1% H_2SO_4 and 1% NaOH solution- the digital pH meter was employed during each pH adjustment. Individual beakers were stirred simultaneously with a series stirrer shown in Figure (2), the mixing mode being rapid mix for (3) minutes at (80) rpm, followed by slow mix at (30) rpm for (12) minutes, and switched off, and left to stand for a further (30) minutes. The supernatant liquid of each beaker was withdrawn and its turbidity and color were determined and their results as shown in Table (3) and their relevant graphs were drawn in Figures (4) and (5).

From the above measured results, a tentative optimum pH was chosen, pH (5.0), for measuring coagulant dosage of the sample under consideration by Jar Test II. The procedure of Jar Test II was the same as Jar Test I, except coagulant dosages were varied instead of pH, and the data collected were tabulated in Table (4) and their relevant graphs as shown in Figures (6), (7) and (8).

The same procedure was repeated for the effluent sample from the Soy-Milk Plant and the results so obtained were recorded in Tables (7), (8) and the graphs shown in Figures (4),(5), (6), (7), and (8).

Physico-chemical Treatment

In the conventional treatment of wastewaters, the primary stage normally involved physical separation process and as such it was employed first for the Mohinga Plant effluent.

Prior to sedimentation operation, (500) ml of Mohinga Plant effluent was taken in a beaker and its characteristics, such as turbidity, color, odor, suspended solids, pH, total solids, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were determined and the measured results were shown in Table (12) and flowsheet in Figure (9). Next, the sedimentation operation was conducted by allowing the sample (1) liter to stand for (2) hours and the supernatant liquid withdrawn and its characteristics again determined and recorded in Table (12). Another portion of supernatant, (500) ml was taken in another beaker and a predetermined optimum dosage of 1% alum solution (6) ml was added to it and the pH was adjusted to 5.0 by using 1% H_2SO_4 and 1% NaOH solution. The content was mixed by means of a stirrer for (30) minutes and the beaker was held quiescently for (30) minutes. The supernatant liquid so formed was withdrawn and the parameters were again determined and recorded as shown in Table (12). Based on these results the removal percentage of pollutants was next calculated and their results tabulated in Table (5).

The same procedure was again repeated for Soy-Milk Plant effluent and their results were tabulated in Table (9).

Biological Treatment

Prior to sedimentation operation, (500) ml of Soy-Milk Plant effluent was taken in a 600 ml beaker and its characteristics, such as turbidity, color, odor, suspended solids, pH, total solids, DO, BOD and COD were determined .

Next the sedimentation operation was conducted by allowing the sample, (5) liters, to stand for (2) hours – phase (A) - in a glass container, the supernatant portion was withdrawn and the pollutional parameters were again determined, Figure (3). Then it is allowed to flow (by gravity) into the aeration chamber, and aerated continuously for a number of days by passing compressed air through a pipe fitted with a porous stone diffuser as shown in Figure (3).

The first measurement was taken on the first day at (24) hours, second measurement on the second day at (48) hours, third measurement on the third day at (72) hours, fourth measurement on the fourth day at (96) hours and the fifth measurement on the fifth day at (120) hours. The data of these consecutive measurements were recorded in Table (12) and shown together with the flow diagram as in Figure (9). The removal and remaining percentage of each stage was tabulated in Table (11).

Results and Discussion

In this research, food processing plant (effluents) from Soy-Milk Plant was treated by primary, secondary and biological treatments and Mohinga Plant by the primary and secondary treatments. The physical aspect involved sedimentation as primary treatment which remove a portion of suspended solids from the wastewater by settling. Secondary treatment involved further treatment of the effluent from the primary stage in which dissolved organic matter and the residual suspended material were removed by chemical coagulation.

It is generally accepted that the effluents from food processing plant has a relatively high organic matter when discharged into any receiving water contribute pollution effects, as it acted as nutrient supply to the microorganisms in the receiving water. The level of pollution / contamination, food processing plant (effluents) from Soy-Milk and Mohinga Plants was determined based on their physical and chemical characteristics as shown in Table (1).

Mohinga processing involved rice flour-composing mainly of carbohydrate and small amounts of fats and protein and the bacterial action through the course of processing exhibited an acidic pH (pH = 3.7) as shown in Table (1). Acidic nature of Mohinga wastewater was caused by the organic acids resulting from the biological degradation of organic constituents.

In this research work, laboratory settling column as shown in Figure (1) was used in the determination of suspended solids removal by sedimentation. Suspended solids were determined on samples drawn off at selected time intervals up to 120 minutes. The results of sedimentation on effluent samples from Mohinga and Soy-Milk Plants, Table (2) and (6), quite clearly demonstrated that the amount of suspended solids decreased as detention time increased. From the continuous readings, selected intervals were at 10, 20, 30, 60, 90 and 120 minutes. The suspended solids that settled was found to be gradually reduced for relatively longer periods of sedimentation; (92.12) % for Soy-Milk Plant and (79.23) % for Mohinga Plant. The sedimentation also moderately removed the odor and color of Soy-Milk Plant effluent, whereas, for Mohinga Plant effluent, removal of odor and color was not observed.

Coagulation was used for the clarification of industrial wastes that contained colloidal and suspended solids. Clarification involved the addition of chemical coagulants, coagulant aids, and pH adjustment to form a stable, rapid-settling floc which is then separated from the water by sedimentation. Two important factors that influenced coagulation were pH and coagulant dosage.

In the present research work, optimum pH determined by Jar-Test 1, and pH 5 was found to be the most effective for both effluent samples from Soy-Milk and Mohinga Plants as shown by their respective curves in Figure (4)-pH versus turbidity and in Figure (5), pH

versus color. This pH value also fall within the accepted pH range of 5-8 for treatment of industrial wastewaters with alum.

Based on this optimum pH 5 condition, the most effective coagulant dosage was determined by Jar-Test II and was found to be (60) mg/l for effluent sample from Soy-Milk Plant, and (80) mg/l for Mohinga Plant effluent, since removal/reduction efficiencies (percentage) were highest for total solids (TS), suspended solids (SS), and chemical oxygen demand (COD) for both samples. For Soy-Milk Plant, it was (35.6)% for total solid (TS), (99.69)% for suspended solid (SS) and (46.67)% for chemical oxygen demand (COD), whereas, for Mohinga Plant, it was (24.55)% for total solid (TS), (95.61)% for suspended solid (SS) and (43.75)% for chemical oxygen demand (COD) as plotted and calculated from respective Figures, (6) , (7) and (8).

In this research work, the primary treatment (sedimentation) and secondary treatment (physico-chemical) were conducted for effluent samples from Soy-Milk and Mohinga Plants. Referring to the data in Tables (5), (9), and (12) , there from it was obvious that in both samples, alum coagulant, further removed some of the suspended solids which could not be settled by normal sedimentation process, an increment of 16.7% for Soy Milk Plant sample and 8.56% for Mohinga Plant sample. At the same time, turbidity and color were also reduced, 9.26% and 11.35% for Soy Milk Plant and 1.18% and 20% for Mohinga Plant samples. Also, both biochemical oxygen demand (BOD) and chemical oxygen demand (COD) values were reduced to an increment of 13.34% and 25.71% for Soy-Milk Plant and 21.88% for Mohinga Plant samples.

In this research work, combined treatment was performed for effluent samples from Soy-Milk Plant (SMP) (primary treatment, sedimentation, and secondary treatment, coagulation) were conducted, and these treatment processes normally involved handling most of the nontoxic wastewaters.

With proper analysis and environmental control, almost all wastewater can be treated biologically. The objectives of the biological treatment of wastewater were coagulation and removal of the nonsettleable colloidal solids and stabilized the organic matter. For industrial wastewater, the objective was the removal or reduction of the concentration of organic and inorganic compounds as many of these compounds were toxic to microorganisms (especially bacteria), that pretreatment was required.

Based on these concepts/ideas, biological treatment was conducted for Soy Milk Plant effluent sample to be observed and understand the capability of employing aeration (biological process) directly to selected industrial effluent sample after the primary stage. This treatment in a way could provide some information related to the effectiveness of chemical treatment with coagulants for the sample.

Thus, the experimental data in Table (11), illustrated that an aeration time of (2) days was the most effective for reduction of BOD and COD values (as percentages). The BOD and COD reduction percentage were (97.04) % and (96.28)% for Soy-Milk Plant effluent.

Another aspect of aeration produced changes in physical characteristics, turbidity, color and suspended solids removal percentage was found to be the most effective at an aeration time of (3) days. Turbidity, color and suspended solids removal percentage were (98.98) %, (98.82) % and (99.35)% for Soy Milk Plant effluent.

The BOD and COD values of the Soy-Milk Plant effluents was systematically measured employing the biological treatment, since the contamination level by biodegradable organic matter was measured by BOD, whereas non-biodegradable organic matter was measured by COD. These BOD and COD values were widely regarded as parameters responsible for the discharge limits being employed for safe disposal of industrial effluents to receiving waters. As a matter of interest the present data was compared with the data obtained from the Administration General de Obras Sanitarias (AGOS, 1990) showing that BOD discharge limits for sewage collector, surface water and open sea were 200 mg/l, 50 mg/l and 150 mg/l and COD discharge limits were 700 mg/l, 250 mg/l and 400 mg/l respectively. This comparative study positively indicated that the treatment was effective as expected.

Table (1) Contaminants of Wastewaters

Parameters	Unit	Soy-Milk Plant	Mohinga Plant
Physical Characteristics			
Turbidity	FTU	4625	12500
Color	Pt-Cobalt Unit	14000	1750
Total Suspended Solids	mg/l	9950	2162
Chemical Characteristics			
pH		6.4	3.7
Total Solids	mg/l	11484	6431
Total Dissolved Solids	mg/l	1534	4269
Metals – Lead (Pb)	ppm	0.060	0.014
Iron (Fe)	ppm	0.291	0.020
Zinc (Zn)	ppm	0.054	0.017
Dissolved Oxygen (DO)	mg/l	3.5	0.04
Biochemical Oxygen Demand (BOD)	mg/l	6750	1470
Chemical Oxygen Demand (COD)	mg/l	1120	5120

Table (2) Sedimentation Performance Test of Mohinhga Plant Effluent by Flocculant Settling Technique

Parameter	Sampling Time, (minutes)						
	0	10	20	30	60	90	120
Suspended Solids (mg/l)	2162	69.6	1084.5	1332.7	1629.3	1662.4	1712.9
Removal (% w/w)	0	3.22	50.16	61.64	75.36	76.89	79.23

Table (3) Jar-Test I for Mohinga Plant Effluent

Characteristics	Jar Test Number					
	1	2	3	4	5	6
pH	4	5	6	7	8	9
1% Alum Dosage (mg/l)	30	30	30	30	30	30
Turbidity (FTU)	50	13	58	90	118	128
Color (Pt-Cobalt Unit)	185	50	210	330	410	415

Table (4) Jar-Test II for Mohinga Plant Effluent

Jar Test	1% Alum Dosage		pH	TS	SS	COD	Removal %		
	(ml/jar)	(mg/l)		(mg/l)	(mg/l)	(mg/l)	TS	SS	COD
Raw	-	-	3.7	6431	2162	5120	-	-	-
1	2	20	5	5572	205	3520	13.36	90.52	31.25
2	4	40	5	5296	130	3360	17.65	93.99	34.38
3	6	60	5	5031	120	3200	21.77	94.45	37.5
4	8	80	5	4852	95	2880	24.55	95.61	43.75
5	10	100	5	4993	118	2880	22.36	94.54	43.75
6	12	120	5	5179	140	2880	19.47	93.52	43.75

Table (5) Effect of Physico-chemical Treatment on Physical and Chemical Parameters of Mohinga Plant Effluent

Parameters	Effluent	Removal % of Pollutants	
		Sedimentation	Chemical Coagulation
Physical			
Turbidity (FTU)	12500	98.8	99.98
Color (Pt-Cobalt Unit)	1750	80.0	100.00
SS (mg/l)	2162	86.12	94.68
Chemical			
TS (mg/l)	6431	46.57	93.50
BOD (mg/l)	1470	44.44	70.00
COD (mg/l)	5210	43.75	65.63

Table (6) Sedimentation Performance Test of Soy-Milk Plant Effluent by Flocculent Settling Technique

Parameter	Sampling Time, (minutes)						
	0	10	20	30	60	90	120
Suspended Solids (mg/l)	9950	436.8	7094.4	8425.7	9092.3	9113.2	9165.9
Removal (% w/w)	0	4.39	71.30	84.68	91.38	91.59	92.12

Table (7) Jar-Test I for Soy-Milk Plant Effluent

Characteristic	Jar Test Number					
	1	2	3	4	5	6
pH	4	5	6	7	8	9
1% Alum Dosage (mg/l)	30	30	30	30	30	30
Turbidity (FTU)	60	16	950	920	880	850
Color (Pt-Cobalt Unit)	250	60	3350	3350	3150	3150

Table (8) Jar-Test II for Soy-Milk Plant Effluent Sample

Jar Test	1% Alum Dosage		pH	TS	SS	COD	Removal %		
	(ml/jar)	(mg/l)		(mg/l)	(mg/l)	(mg/l)	TS	SS	COD
Raw	-	-	6.8	11484	9950	11200	-	-	-
1	2	20	5	7659.83	122.38	6720	33.30	98.77	40
2	4	40	5	7516.28	76.62	6347.08	34.55	99.23	43.33
3	6	60	5	7395.69	30.84	5972.96	35.60	99.69	46.67
4	8	80	5	7527.76	152.24	5972.96	34.45	98.47	46.67
5	10	100	5	7582.88	213.92	5972.96	33.97	97.85	46.67
6	12	120	5	7758.59	320.39	5972.96	32.44	96.78	46.67

Table (9) Effect of Physico-chemical Treatment on Physical and Chemical Parameters of Soy-Milk Plant Effluent

Parameters	Effluent	Removal % of Pollutants	
		Sedimentation	Chemical Coagulation
Physical			
Turbidity (FTU)	4625	89.73	99.01
Color (Pt-Cobalt Unit)	14000	87.5	98.86
Suspended Solid (mg/l)	9950	82.52	99.22
Chemical			
TS (mg/l)	11484	53.04	55.90
BOD (mg/l)	6750	62.96	76.30
COD (mg/l)	11200	42.86	68.57

Table (10) Variation on Physical and Chemical Parameters of Soy-Milk Plant Effluent by Aeration Time

Parameters	Effluent	Sedimentation	Aeration				
			(1) day	(2) day	(3) day	(4) day	(5) day
Physical							
Turbidity (FTU)	4625	475	90	55	47	47	40
Color (Pt-Cobalt Unit)	14000	1750	325	200	165	160	145
SS (mg/l)	9950	1739	160	121	64	62	62
Chemical							
TS (mg/l)	11484	5393	-	-	-	-	1967
BOD (mg/l)	6750	2500	460	200	180	105	90
COD (mg/l)	11200	6400	960	416	384	256	192

Table (11) Effect of Biological Treatment on Physical and Chemical Parameters of Soy-Milk Plant Effluent

Parameters	Effluent	Removal % of Pollutants from each treatment					
		Sedimentation	Aeration				
			(1) day	(2) day	(3) day	(4) day	(5) day
Physical							
Turbidity (FTU)	4625	89.73	98.05	98.00	98.98	98.98	99.13
Color (Pt-Cobalt Unit)	14000	87.5	97.68	98.81	98.82	98.86	98.96
SS (mg/l)	9950	82.52	98.39	98.57	99.35	99.35	99.35
Chemical							
TS (mg/l)	11484	53.04	-	-	-	-	82.87
BOD (mg/l)	6750	62.96	93.18	97.04	97.33	98.44	98.67
COD (mg/l)	11200	42.86	91.43	96.28	96.57	97.71	98.28

Table (12) Physical and Chemical Water-Quality Parameters of Soy-Milk Plant Effluent after Biological Treatment

Physical Water-Quality Parameters				
Characteristics	Before Sedimentation	After Sedimentation	After Coagulation	After Aeration (5 days)
Turbidity (FTU)	4625	475	46	40
Color (Pt-Cobalt Unit)	14000	1750	160	145
SS (mg/l)	9950	1739	78	62
Chemical Water-Quality Parameters				
Characteristics	Before Sedimentation	After Sedimentation	After Coagulation	After Aeration (5 days)
pH	6.4	5.6	5	-
TS (mg/l)	11484	5393	5065	1967
BOD (mg/l)	6750	2500	1600	90
COD (mg/l)	11200	6400	3520	192

Figure (1) Laboratory Settling Column

Figure (2) Jar – Test Apparatus

Figure (3) Biological Treatment (Aeration)

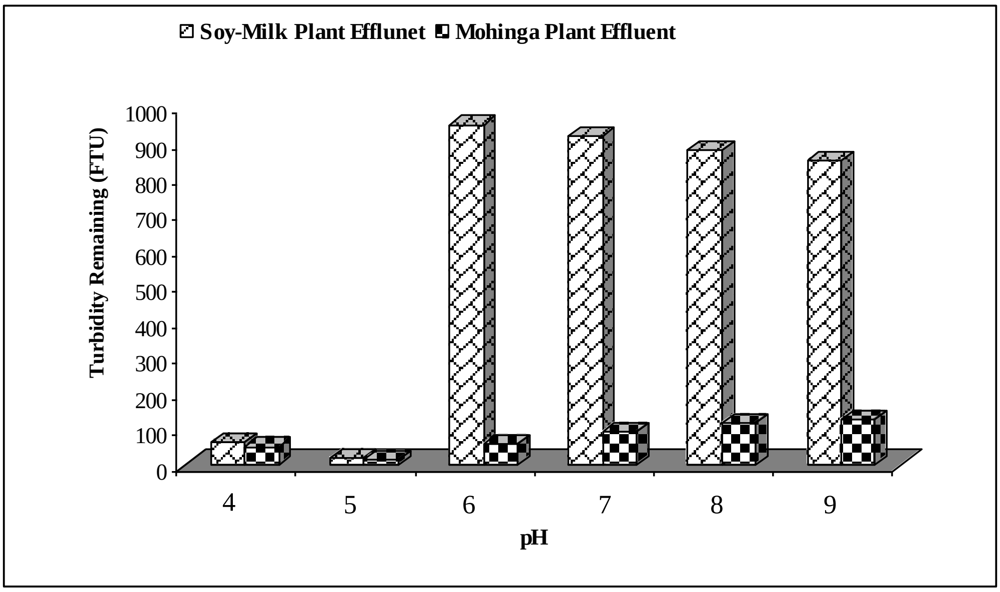

Figure (4) Characteristic Plots of Jar-Test Analysis

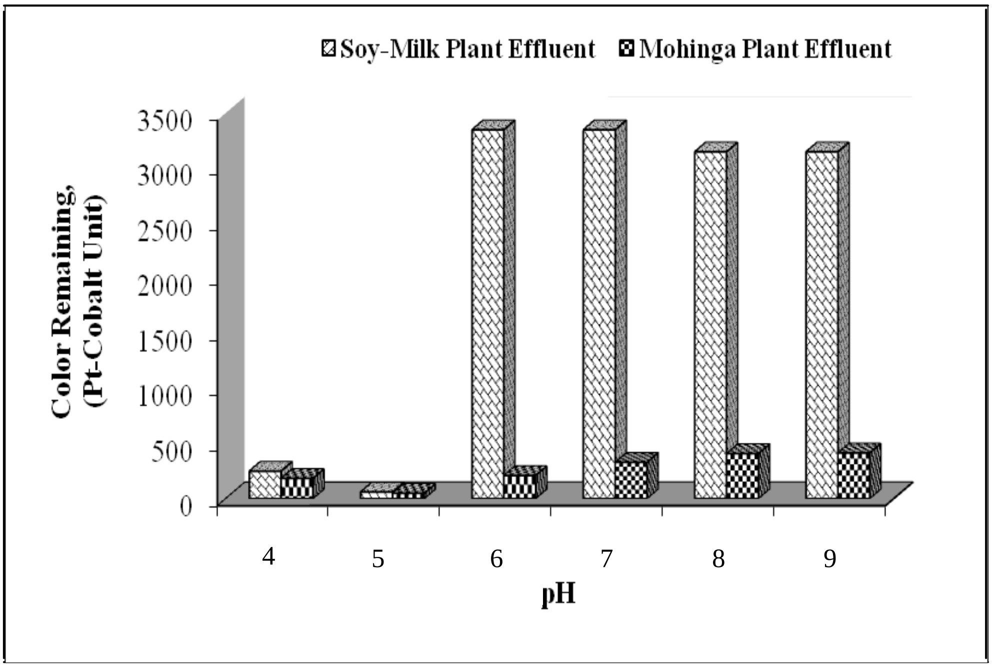

Figure (5) Results of Jar-Test Analysis

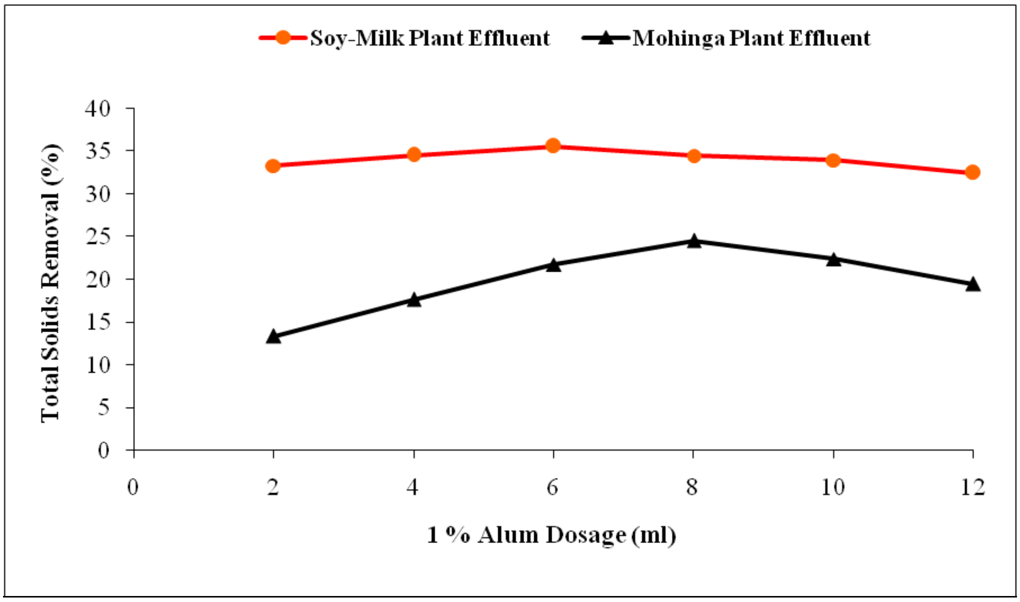

Figure (6) Results of Jar-Test (Optimum pH 5)

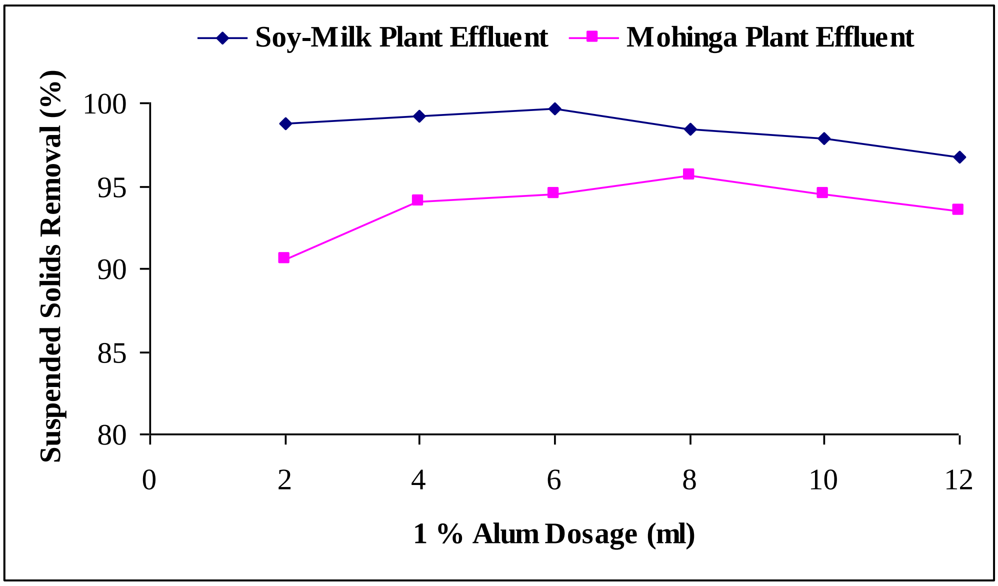

Figure (7) Results of Jar-Test (Optimum pH 5)

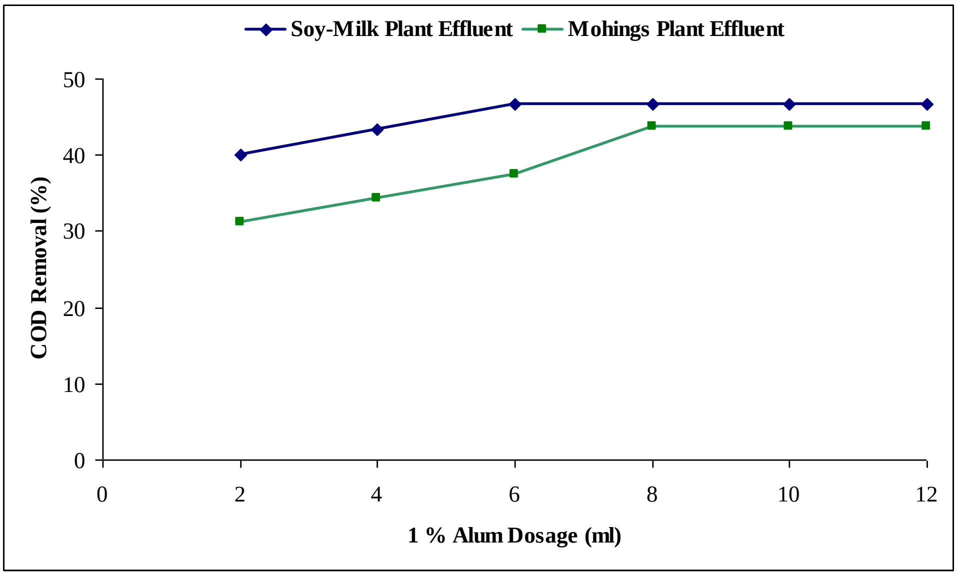

Figure (8) Results of Jar-Test (Optimum pH 5)

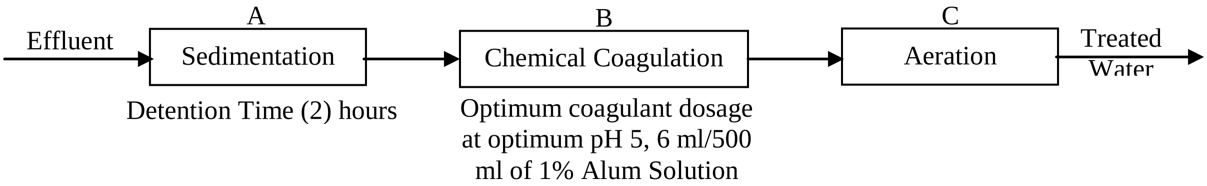

Figure (9) Process Flowsheet of Biological Treatment on Soy-Milk Plant Effluent

Conclusion

Most water pollution problems are caused by human activities-sewage from municipalities, chemicals from industrial wastes, agricultural runoff, and even air pollutants in rainwater. These pollution loads can make water unfit to drink, kill fish, accelerate eutrophication and cause other harm to ecosystem. Thus, waste-waters were treated by two methods (Physico-chemical treatment and Physico-biological treatment) to reduce biochemical oxygen demand (BOD).

It was found that suspended solid was gradually reduced by sedimentation, (79.23) % for effluent of Mohinga Plant and (92.12) % for effluent of Soy-Milk Plant. The most effective coagulant dosage for Mohinga Plant effluent was (60) mg/l and removal efficiencies were (24.55) % for total solid (TS), (95.61) % for suspended solid (SS) and (43.75) % for chemical oxygen demand (COD). For Soy-Milk Plant effluent, the most effective coagulant dosage was (80) mg/l and removal efficiencies were (35.6) % for total solid (TS), (99.69) % for suspended solid (SS) and (46.67) % for chemical oxygen demand (COD).Soy-Milk Plant effluent was treated by biological treatment and aeration time of 2 days was most effective in reduction of BOD and COD and they were (97.04) % and (96.28) %. Aeration Time of 3 days was most effective for turbidity, color and suspended solid removal percentage and they were (98.98) %, (98.82) % and (99.35) % for Soy-Milk Plant effluent. The reduced BOD and COD values were widely regarded as parameters responsible for the discharge limits being employed for safe disposal of industrial effluents to receiving waters. Thus, this operation is appropriate for the protection of environment and aquatic life of receiving water (ponds, streams, lakes, rivers, etc).

Acknowledgements

We would like to thank the Department of Higher Education (Lower Myanmar), Ministry of Education, Yangon for giving the opportunity to launch this research programme.

We wish to acknowledge our gratitude to Rector Dr. Aung Aung Min, West Yangon University for giving permission to carry out this research work.

Deepest gratitude and profound regards are extended to Dr. Khin Htwe Nyunt, Professor and Head of Department of Industrial Chemistry, not only for her meticulous comments but also for her suggestions to improve this work and for editing the manuscript.

We are also indebted to U Saw Thale, Civil Engineering Department of Yangon Technologically University for his unstinting help during this research.

Finally, we would like to thank our colleagues of the Department of Industrial Chemistry, West Yangon University for giving us all the necessary assistance during this research.

References

AGOS(Administration General de Obras Sanitarias), 1990. Province of Buenos Aires, Argentina, Rule No. 287, April 9th, 1990.

APHA (American Public Health Association), 1989. Standard Methods for the Examination of Water and Wastewater, 17th Ed.

Eckenfelder, W. Wesley.; 2000. Industrial Water Pollution Control.

Fair and Geyer; 1954. Water Supply and Wastewater Disposal.

Fred Gurnham, C.; 1955. Principles of Industrial Waste Treatment.

Hammer, Mark J.; 1986. Water and Wastewater Technology.

Holden, W.S.; 1970. Water Treatment and Examination.

Kumar, U and Bhanu Kakrani; 2000. Water Environment and Pollution.

Metcalf and Eddy Inc; 1979. Wastewater Engineering: Treatment, disposal, reuse.

Ohnmar: Preliminary Studies on the Effectiveness of Combined Treatment System, Primary, Secondary and Biological on Alleviating Contaminants of Wastewaters, M.Res (Thesis), Industrial Chemistry Department, University of Yangon, June, 2001.