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A COMPARATIVE STUDY OF THE EFFECTS OF NATURAL AND CHEMICAL COAGULANTS ON THE TREATMENT OF DOMESTIC EFFLUENTS

Ground dried seeds of *Moringa oleifera* and *Jatropha curcas* have been shown to have good coagulatory properties. They reduced the turbidity, biological oxygen demand (BOD), colour, odour and microbial load of domestic effluents. The results obtained using these natural coagulants were comparable to those obtained using the conventional chemical coagulant–aluminium sulphate (alum). The effectiveness of these natural coagulants with respect to turbidity, BOD, odour and microbial load is not only of good economic importance, but could be the most cost-effective alternative to prevent pollution.

1. INTRODUCTION

In the review of Progress of the International Water Supply and Sanitation in the decade 1981–1990, the World Health Organisation estimated that 1130 million people are currently without access to safe drinking water (WHO, 1988). Of this total, 80% live in relatively small rural communities, often relying on rivers as their only source of water. Such sources of water can occasionally exhibit bacterial concentrations that would normally be associated with weak, raw sewage (FREACHEM [2]). For such communities household water treatment and low capacity treatment works can make a significant impact on drinking water quality.

More recently, the problem of effluent from processing operations and their disposal has gained public recognition. In many areas of the world, especially in the developing countries, the environmental issues are the same, i.e., how to select wastewater treatment alternatives in order to provide environmental protection at an affordable price. Effluent water quality criteria are no longer matters of local agreements between regional regulatory agencies and representatives of industry, but they are established by state and federal status. In effluent treatment, certain processes are usually applied to the initial waste to remove or to alter its objectionable constituents. This process may be classified as preliminary treatment, primary treatment and secondary or complete treatment. Each wastewater has its unique quality and character-

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istics, which then suggest the type of treatment required. The two types of wastewater, namely domestic and industrial effluents, have different make-ups and often require various treatment processes. Wastewater resulting from industrial fermentation contains water-soluble colloidal and suspended waste and in this respect it somewhat resembles municipal sewage waste in its treatment requirements.

In such a treatment, coagulation and flocculation are employed to separate suspended soils from water whenever their natural subsidence rates are too slow to provide effective clarification. It is also the process by which finally divided suspended and colloidal matter in water is made to agglomerate and form blocks (SINGLEY [7]). This enables their removal by sedimentation or filtration. The substances that are frequently removed by coagulation and flocculation are those that cause turbidity and colours.

The effect of coagulant dose on the clarification and decolouration of water is such that for good coagulation the optimal dose of coagulant should be fed into the water and properly mixed with it (SINGLEY [7]).

Generally, the processes of domestic effluent treatment involving the use of chemicals are not suitable for small community water supplies. They should be avoided whenever possible and should be used only when the needed treatment result cannot be achieved (JAHN [6]).

The use of coagulants derived from natural sources such as indigenous plants was reported by SUTHERLAND in 1989 [9] as a viable alternative which offers significant technical, economic and environmental advantages. The use of seeds of the tree *Strychnos potatarium* to clarify muddy river waters was traced back to 400 years (TRIPATHI et al. [10] and AUDISLEY [1]). Seed kernel material of the trees *Moringa oleifera* and *Jatropha curcas* are used in this work to compare their coagulating properties to those of aluminium sulphate. The aim of this paper is to stimulate interest in the use of alternative coagulants of natural origin which are quite effective, cheap and available in the treatment of domestic and industrial effluents.

2. MATERIALS AND METHODS

Domestic effluent used for this study was household effluent, which included those from cassava, tomato and pepper processing collected from effluent discharge points at Ikenegbu Layout, Oparanozie and Royce Roads, all in Owerri, Imo State, Nigeria. They were collected in 2 dm^3 plastic bottles and were analysed within 6-hours of collection. The natural coagulants used are the seeds of *Moringa oleifera* and *Jatropha curcas*. The mature seeds were harvested and dried using a Fisher Econotemp laboratory oven model 30, at a temperature of 40 °C for 3 hours daily for 3 days after which the dried seeds were blended using a National Model Kitchen electric blender to fine power. A set of laboratory sieves (300–400 μm) were used to sieve the ground powder. Aluminium sulphate ($Al_2(SO_4)_3 \cdot nH_2O$), a chemical coagulant, was kindly supplied by Imo State Water Cooperation. The operation time of sedimentation process after coagulation amounted to 18–24 hours.

A Leeds and Northlip, Model 7413, pH-meter was used for measuring the pH of the effluent, while an ultraspec11 spectrophotometer, model 95, was used to measure the turbidity of the various effluent samples before and after treatment. A HACN Model 2173 BOD measurement apparatus was used for measuring the biological oxygen demand of the effluent. Various concentrations of the powdered seeds of *Moringa oleifera* and *Jatropha curcas* and aluminium sulphate (20, 30, 40, 50, 60, 80, 100 and 120 mg/dm^3) were added to the respective effluents, shaken vigorously for 5 min and left to stand for 18–24 hours. Turbidity was measured at 360 nm wavelength.

The microbial load of the effluent was determined before and after treatment with the coagulants by the pour plate method using both plate count agar and nutrient agar. The plates were incubated at 37 °C for 24 hours. The colonies were counted using a colony counter and reported as colony forming units (CFU/cm^3). All results were statistically analysed.

3. RESULTS

The effect of the various coagulants on the turbidity of domestic effluent is shown in table 1. The results showed a reduction in turbidity in the range of 66–92%. The powdered seeds of *Moringa oleifera* appeared to be more effective as an effluent coagulant than both

Table 1

Effect of coagulant on the turbidity of domestic effluent, pH 6.60

Aluminium sulphate				*Moringa oleifera*				*Jatropha curcas*			
Dose (mg/dm^3)	Initial turbidity	Final turbidity	Reduction (%)	Dose (mg/dm^3)	Initial turbidity	Final turbidity	Reduction (%)	Dose (mg/dm^3)	Initial turbidity	Final turbidity	Reduction (%)
20	1.86	0.37	80.11	20	1.86	0.47	74.71	20	1.86	0.46	75.26
40	1.86	0.16	91.40	40	1.86	0.21	88.71	40	1.86	0.29	84.40
60	1.86	0.15	91.94	60	1.86	0.14	92.47	60	1.86	0.28	84.94
80	1.86	0.13	93.01	80	1.86	0.14	92.47	80	1.86	0.28	84.94
100	1.86	0.13	93.01	100	1.86	0.14	92.47	100	1.86	0.28	84.94
120	1.86	0.13	93.01	120	1.86	0.14	92.47	120	1.86	0.28	84.94
Optimum dose = 80 mg/dm^3				Optimum dose = 60 mg/dm^3				Optimum dose = 60 mg/dm^3			

aluminium sulphate and the seeds of *Jatropha curcas*, reducing domestic effluent turbidity in the range of 74–92%, while *Jatropha curcas* and aluminium sulphate were in the ranges of 75–85% and 66–84%, respectively (table 1). In all the trials, as the dose of coagulant increased so did the degree of clarification until the maximum dose had been given, after which there was no further decrease in turbidity. The optimum dose varied slightly for the three coagulants – 80 mg/dm^3 for aluminium sulphate, while that of *Jatropha curcas* and *Moringa oleifera* was 60 mg/dm^3.

Table 2

Effect of coagulant on the turbidity of domestic effluent

Aluminium sulphate				*Moringa oleifera*				*Jatropha curcas*			
Dose (mg/dm^3)	Initial BOD	Final BOD	Reduction (%)	Dose (mg/dm^3)	Initial BOD	Final BOD	Reduction (%)	Dose (mg/dm^3)	Initial BOD	Final BOD	Reduction (%)
20	72	35.30	50.92	20	72	39.60	45.00	20	72	42.10	41.52
50	72	28.40	60.56	50	72	32.60	54.72	50	72	40.00	44.44
100	72	20.20	71.94	100	72	37.60	37.60	100	72	37.60	47.78
120	72	15.00	79.16	120	72	20.30	20.30	120	72	32.00	55.56

The effect of the coagulants on the biological oxygen demand (BOD) of the effluent is shown in table 2. The three coagulants, i.e. aluminium sulphate, seeds of *Moringa oleifera* and seeds of *Jatropha curcas*, reduced the BOD of the effluent from 72 mg/dm^3 to 15 mg/dm^3, 20.3 mg/dm^3 and 32 mg/dm^3, respectively. In general, the BOD of the effluent was reduced to levels acceptable for discharge into rivers and other bodies of water. *Moringa oleifera* was also effective in the reduction of the objectionable odour associated with domestic effluents. *Jatropha* removed some of the

Table 3

Effect of coagulant on the microbial load of domestic effluent

Sample	Coagulant	Initial microbial count	Final microbial count	Reduction (%)
A	*Moringa oleifera*	$4.2 \cdot 10^5$	$1.2 \cdot 10^2$	99.97
	Jatropha curcas	$4.2 \cdot 10^5$	$1.3 \cdot 10^2$	99.96
	Aluminium sulphate	$4.5 \cdot 10^5$	$0.6 \cdot 10^2$	99.98
B	*Moringa oleifera*	$3.4 \cdot 10^7$	$1.2 \cdot 10^3$	99.99
	Jatropha curcas	$3.4 \cdot 10^7$	$3.2 \cdot 10^4$	99.90
	Aluminium sulphate	$3.4 \cdot 10^7$	$1.9 \cdot 10^2$	99.99

A and B represent two different domestic effluents.
Sample A, pH = 6.60, OD, 1.86.
Sample B, pH = 6.30, OD, 1.56.

odour, while aluminium sulphate removed most of it. The antimicrobial effect of the coagulants is shown in table 3. The results indicate a reduction in the microbial load of the effluent by as much as 99%. *Jatropha curcas*, which did not remove much of the objectionable odour of the effluent, exhibited a high antimicrobial activity, reducing the microbial load by 99.96%, while *Moringa oleifera* and aluminium sulphate reduced the load by 99.97 and 99.98%, respectively.

4. DISCUSSION

Moringa oleifera and *Jatropha curcas* seeds have demonstrated a high degree of turbidity reduction (table 1). This reduction in turbidity was comparable to those achieved by chemical coagulants like aluminium sulphate (table 1). The reduction in turbidity depended on the application of ground seeds of *Moringa oleifera* and those of *Jatropha curcas* to turbid domestic effluent and was different from the settling of particulate and suspended matter observed in the control experiments. Turbidity reduction due to *Moringa* seeds was in the order of 72.8–92.4%, that of *Jatropha* in the order of 75.2–84.7%, while that of aluminium sulphate was in the order of 66.0–84.3%. These three coagulants compared favourably in turbidity reduction with a standard deviation of a 0.04. A similar observation was made by SUTHERLAND et al. [8] and JAHN [5], working on *Moringa oleifera* and muddy river water. Aluminium sulphate is employed as a chemical coagulant in domestic and industrial water treatment facilities. The use of natural coagulants in the treatment of muddy river water was noted by JAHN [3], [4]. The usefulness of these natural coagulants in small-scale effluent treatment or remediation before discharge is greatly desired.

Moringa oleifera and *Jatropha curcas* seeds reduced the BOD of domestic effluent from 72 mg/dm^3 to 20, 30 and 32 mg/dm^3, respectively, and alum reduced it to 15 mg/dm^3 (table 2). This is encouraging since the allowable discharge level for domestic effluent is 15.80–39 mg/dm^3 (WHO [11]). The ability of these seeds to reduce turbidity and BOD of domestic effluent are important properties to be considered in small- and large-scale domestic effluent management. The problem of domestic effluent management centers on its objectionable odour and high BOD. The two natural coagulants were able to reduce BOD and to control the objectionable odour.

Biological treatment of domestic effluents and wastes is increasingly gaining acceptance. The use of natural coagulants to treat domestic effluents and wastes before discharge could be the most cost-effective alternative to prevent pollution by involving environmentally-friendlier methods of production. In principle, biological remediation technology is preferable instead of chemical remediation where possible.

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PORÓWNANIE EFEKTYWNOŚCI NATURALNYCH I CHEMICZNYCH KOAGULANTÓW UŻYTYCH DO OCZYSZCZANIA ŚCIEKÓW GOSPODARSKICH

Wysuszone i zmielone nasiona *Moringa oleifera* i *Jatropha curcas* są dobrymi koagulantami. Zmniejszają one mętność, a także BZT, ilość bakterii w ściekach gospodarskich, intensywność zabarwienia tych ścieków oraz łagodzą ich woń. Wyniki otrzymane po użyciu tych naturalnych koagulantów są porównywalne z tymi, które uzyskano, stosując typowy koagulant chemiczny – siarczan glinu. Efektywność naturalnych koagulantów w odniesieniu do mętności, BZT, zapachu i ilości bakterii nie tylko ma wymierne znaczenie ekonomiczne, ale może również stanowić najbardziej opłacalną alternatywę przeciwdziałania zanieczyszczeniu środowiska.