Environment Protection Engineering

Vol. 28 2002 No. 3–4

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INDUSTRIAL EFFLUENT REMEDIATION USING NATURAL COAGULANTS (SEEDS OF *JATROPHA CURCAS*)

Jatropha curcas, a member of the *Euphorbiaceae* family, is not only of considerable economic importance, but also has great potential for environmental pollution and control. Ground seeds of *Jatropha curcas* reduced the turbidity and the biological oxygen demand (BOD) of industrial effluent by 73.45 and 52.94%, respectively, while enhancing the chemical oxygen demand (COD) by more than fourfold (280%). These reactions of ground seeds of *Jatropha curcas* increased the rate of biodegradation of industrial effluent and its subsequent remediation.

1. INTRODUCTION

Wastewater refers to liquid discharged from residences, business premises, small- and large-scale industries and institutions. In general, wastewater can be characterized based on its bulk or organic contents, physical characteristics and specific contaminants. Each wastewater has its unique quality and characteristics which determine the type of the treatment required. The disposal of effluent from industrial operations pose a source of worry to most developing nations due to the high cost of Western technology, as such alternatives that will provide environmental protection at affordable price need be selected [3]. The four classes of effluent treatment technologies: physical, chemical, thermal and biological are fast and controllable but require high energy and are cost prohibitive. Basic biological treatment or bioremediation is preferred over and above the other three methods because remediation techniques are cheap. Chemical treatment should be avoided whenever possible and should be used only when the needed treatment result cannot be achieved [4]. The use of coagulants derived from natural sources such as indigenous plants was reported by SUTHERLAND [7] as a viable alternative which offers significant technical, economic and environmental advantages.

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Interest has grown on the use of natural coagulants and a variety of materials have been examined with respect to their coagulatory properties. Preliminary studies have implicated seed suspensions of *Moringa oleifera* and *Jatropha curcas* [5], [1]. *Jatropha curcas* is a member of the *Euphorbiaceae* (spurge) family. The *Euphorbiaceae* are monoecious or occasionally dioecious herbs, shrubs or trees often with milky juice, sometimes fleshy and cactus like. The *Euphorbiaceae* are of considerable economic importance since products of the family include rubber, tung oil, castor oil, cassava and tapioca. The aim of this investigation is to stimulate interest on the use of alternative coagulants of natural origin, *Jatropha curcas* ground seeds, which are quite effective, cheap and readily available in the treatment of industrial effluent.

2. MATERIALS AND METHODS

The industrial effluent used for this study was collected from Nigerian Breweries Plc Aba, Abia State. The composition of the effluent was the following: water, insoluble barley grains, husks of barley, traces of hop resins and hops oil, spent products (such as beer and soft drinks) wort, traces of microorganisms such as yeast and bacteria. *Jatropha curcas* seed was harvested upon maturity. The seeds were sun dried but further dried in a gallen kamp hot box oven size one model at 40 °C, 3 hours per day for three days. After drying, the seeds were blended, using a national model kitchen electric blender, to fine powder. A set of laboratory sieves (300–425 μm) were used to sieve the ground powder. A Toledo Mettler (Model MP 220) pH-meter was used in measuring the pH of the effluent before and after treatment with the coagulant, while a Unicam 8625 model spectrophotometer was used to measure the turbidity of the effluent at a wavelength of 340 nm. A Hach model 2173 BOD measurement apparatus was used in measuring the biological oxygen demand (BOD_5), and the chemical oxygen demand was determined by the titrimetric method using ferrous ammonium sulfate $(NH4)_2SO_4{\cdot}FeSO_4{\cdot}6H_2O$.

The microbial load of the effluent was determined before and after treatment with the coagulant by the pour plate method using plate count and nutrient agar plates. The plates were incubated at 37 °C for 24 hours. The colonies were counted and reported as colony-forming units (CFU/cm^3). Various concentrations of *Jatropha curcas*, i.e. 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mg/cm^3, were added to the effluent, respectively, shaken vigorously for 3 mins and allowed to stand for 4 hours. All results were analysed statistically.

3. RESULTS

The effect of various concentrations of ground seeds of *Jatropha curcas* and ferric chloride on the turbidity of industrial effluent is shown in table 1. Both substances

reduced the turbidity of industrial effluent – *Jatropha curcas* in the range of 62.80–73.45% and ferric chloride in the range of 71.78–98.32%. In all the trials as the dose of the substance increased so did the degree of clarification of the effluent until the maximum dose is reached, after which there was no further decrease in turbidity. The optimum dose varied for the two substances, 1.5 g/dm^3 for *Jatropha curcas* and 0.5 g/dm^3 for ferric chloride.

Table 1

Effect of coagulant on turbidity of industrial effluent

Dose of coagulant (mg/cm^3)	Initial turbidity (EBU units)	Final turbidity	Reduction (%)	Final turbidity (EBU units)	Reduction (%)	Final turbidity (EBU units)	Reduction (%)
0.5	15.54	4.56	70.60	0.28	98.32	1.98	87.24
1.0	15.54	4.38	71.78	2.68	82.73	0.52	96.65
1.5	15.54	4.12	73.45	3.24	79.12	0.51	96.75
2.0	15.54	5.41	65.14	3.68	76.29	0.53	96.58
2.5	15.54	5.48	64.69	3.68	76.29	0.55	96.46
3.0	15.54	5.75	62.95	4.34	72.04	0.55	96.46
3.5	15.54	5.52	62.82	4.38	71.78	0.57	96.33
Jatropha curcas				Ferric chloride		Aluminium sulphate	

The effect of the coagulants on the biological oxygen demand (BOD) and the chemical oxygen demand (COD) of the effluent is shown in table 2. Both substances reduced the BOD and increased the COD of the effluent. The BOD of the effluent was reduced by as much as 52.94% by *Jatropha curcas*, while the COD was increased from 488 to 1859, representing an increase of 280% (almost fourfold enhancement). Ferric chloride did reduce the BOD, but increased the COD by only 38.37%.

Table 2

Effect of coagulant on the BOD and COD of industrial effluent

Initial BOD	Final BOD	Reduction (%)	Initial COD	Final COD	Increase (%)	Initial COD	Final COD	Increase (%)	Initial BOD	Final BOD	Reduction (%)
68	42.1	38.23	488	1632	234	456	616	35.08	72	30.00	58.33
68	40.0	41.18	488	1856	280	456	631	38.37	72	26.40	65.33
68	37.6	45.58	488	1859	281	456	630	38.15	72	18.40	74.44
68	32.0	52.92	488	1402	187	456	607	32.23	72	12.66	82.50
Jatropha curcas						Ferric chloride					

The antimicrobial effect of the two substances is shown in table 3. The results indicate a reduction in the microbial load of industrial effluent after treatment with both coagulants. *Jatropha curcas* reduced the microbial load by as much as 99.99%, while

Table 3

Effect of coagulant on the microbial load of industrial effluent

S/No.	Microbial load before treatment (CFU/cm^3)	Microbial load after treatment (CFU/cm^3)	Reduction (%)	Microbial load before treatment (CFU/cm^3)	Microbial load after treatment (CFU/cm^3)	Reduction (%)
1	4.74×10^7	1.02×10^3	99.99	1.02×10^4	9.8×10^2	90.40
2	3.64×10^6	1.92×10^2	99.99	1.02×10^4	3.5×10^2	96.56
3	1.81×10^5	0.48×10^2	99.97	2.3×10^4	9.8×10^2	95.75
4	2.70×10^5	0.19×10^2	99.99	4.8×10^4	2.4×10^2	99.50
Jatropha curcas				Ferric chloride		

Table 4

Effect of coagulant on the temperature and pH of industrial effluent

Coagulant	Initial temperature (°C)	Final temperature (°C)	Initial pH	Final pH
Jatropha curcas	28.1	28.1	5.88	5.98
Ferric chloride	28.1	28.2	5.88	2.86
Jatropha curcas	26.4	26.5	4.34	4.44
Ferric chloride	26.4	26.2	4.34	2.64
Jatropha curcas	26.4	26.4	5.46	5.51
Ferric chloride	26.4	26.1	5.46	2.36
Jatropha curcas	24.4	23.5	5.88	6.25
Ferric chloride	24.4	23.5	5.88	2.13

Temperature of the effluent was monitored over a 24 hours period.

ferric chloride reduced the same microbial load by 99.56%. Cell viability studies on the effluent after treatment confirmed that there was general cell death. The addition of ground seeds of *Jatropha curcas* to industrial effluent increased the pH slightly, from 5.88 to 8.25, making it more alkaline, table 4. The temperature of the effluent was not reasonably affected by the addition of the coagulants.

4. DISCUSSION

In conventional industrial effluent treatment, the techniques commonly applied are coagulation and flocculation using lime or sodium, aluminium sulphate or ferric/ferrous salts, respectively. However, some plant products have shown considerable coagulatory properties. In 1989, SUTHERLAND [7] demonstrated the effective use of plant products such as seeds of *Moringa oleifera* in clarifying muddy water. This has stimulated an interest in alternative ways of achieving effective and low cost technology in industrial

effluent treatment. *Jatropha curcas* seeds used in this work have demonstrated a high degree of turbidity reduction (table 1) comparable to those achieved by synthetic coagulants like ferric chloride and aluminium sulphate. The reduction in turbidity achieved by adding ground seeds of *Jatropha curcas* was in the range of 62.80–73.45%. A higher range of turbidity reduction, i.e. 75.25–84.94% was achieved earlier by ARIRIATU et. al. [1] for the same material used for domestic effluent.

The ground seeds of *Jatropha curcas* reduced the BOD of industrial effluent by as much as 55.56%, while enhancing the COD by as much as fourfold (table 2). The enhancement of COD is important because nearly all organic compounds are oxidised in COD test. The implication is that with the addition of ground seeds of *Jatropha curcas* almost all organic compounds in the wastewater are oxidised. However, some hazardous substances are preferably degraded anaerobically. Because nearly all organics are oxidized in the COD test and only some are decomposed in BOD test, COD values are always higher than BOD values [9].

The effect of ground seeds of *Jatropha curcas* on the temperature and pH of industrial effluent is mostly moderating since the effluent became slightly alkaline and the temperature did not change significantly (table 4).

Slightly alkaline reaction of a medium leads to a higher number of microorganisms that enhance biodegradation. This confirms the findings of VANLOOCKE et al. [8] that there is evidence that overall hydrocarbon biodegradation is higher in slightly alkaline than in acidic media. This could also explain the relatively low COD values achieved with ferric chloride treatment, which made the effluent more acidic in character. In general slightly alkaline reaction (pH from 6 to 8) is regarded as a favourable chemical factor affecting bioremediation [6]. The antimicrobial effect of ground seeds of *Jatropha curcas* is worth noting since the reduction in microbial load is broad based. Moreover, biomass (dead microorganisms) or small populations in the absence of food pose no contamination risk [2]. Microbes will live as long as optimal conditions exist. Once these conditions no longer exist, they die off and leave behind fatty acids that other living organisms can consume or can be used to enrich the environment. Eventually a new microbial population will develop to suit the new environmental conditions.

5. CONCLUSIONS

The use of coagulants derived from natural sources such as plants, as a viable alternative to chemical coagulants is advocated based on the results of this study. Natural coagulants offer significant technical, economical and environmental advantage. They are quite effective, cheap and readily available in many geographical locations. Therefore available biological remediation is preferred to chemical remediation.

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ZMNIEJSZENIE SZKODLIWOŚCI ŚCIEKÓW PRZEMYSŁOWYCH PRZEZ UŻYCIE NATURALNYCH KOAGULANTÓW (NASION *Jatropha curcas*)

Jatropha curcas, należąca do rodziny wilczomleczowatych (*Euphorbiaceae*), ma nie tylko znaczenie gospodarcze, ale może być również użyta do zwalczania skażenia środowiska. Zmielone nasiona tej rośliny zmniejszają mętność ścieków przemysłowych o 73,45% i biologiczne zapotrzebowanie tlenu (BZT) o 52,94%, a jednocześnie ponadczterokrotnie (280%) zwiększają chemiczne zapotrzebowanie tlenu (ChZT). Te właściwości zmielonych nasion *Jatropha curcas* pozwalają zwiększyć szybkość biodegradacji ścieków przemysłowych, a więc zmniejszyć ich szkodliwość.