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Investigating the Efficiency of Locally Available Mucilage Plant Extract for Reducing Hydrocarbon Materials in Water

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Abstract

The study aimed to examine plant extract prepared from three species including Leucaena seeds, Conocarpus leaves and Moringa seeds, those compared alum as natural coagulants for reducing chemical oxygen demand (COD) of domestic sewage water. Pure clay material was added gradually to the sewage water then mixed continually to obtain a final form of turbid sewage water. The experiment's work was carried out using a jar test device, each plant extract was used to reduce COD in sewage water which comprised five doses (10, 25, 50, 75 and 100) ppm with five levels of pH 3, 5, 7, 9 and 11. Results revealed that there was the highest decrease of COD percentages through the experiment process using three plant extracts compared alum which was (65, 66, 64, and 55)% at concentrations of (50, 50, 75 and 25) ppm for three natural coagulants and alum respectively, at Ph 9, also indicated acceptable changing pH and EC using natural coagulant application.

1. Introduction

There are many countries worked to find alternative methods of traditional technology for water treatment such as using plant extract at the initial stage of the water treatment process due to it is friendly for keeping the environment safe [1], its chemical compund includes a complex of carbohydrates and proteins which have ionic groups involve positive, negative and non-ionic charges called natural coagulant [2]. The studies confirmed that there are 40 species of plants used for water treatment technology, comprising 42% of trees, 35% of herbs, 17.5% of shrubs and 5% of climbers [3], some of these plant sources are easy to obtain from the local environment and characterized of high efficiency for reducing pollutants alone or combined chemical coagulants[4], as well as the residual sediment can be biodegradable, also it has high density and resistance to shear forces due to forming bridges to bind organic pollutants like covalent or hydrogen bonds that they are difficult to break by physical methods compared bonds that formed using inorganic coagulants like alum [3, 5]. The application of plant extract as a coagulant using several methods for removing water pollutants depends on its chemical components that are produced according to the method of extraction like water extraction using heat or without heat, as well as filtration or pressure and lyophilization, most studies showed that the coagulants application are the best for reducing organic pollutants in wastewater compared other methods such as membrane osmosis, ion exchange and filtration due to they are easier and lower cost to apply [6]. Wastewater is one of the most polluted water sources because it contains a high concentration of COD, which has a huge role to evaluate the quality and quantity of industrial and agricultural wastewater [7].

The plant extract of *Moringa oleifera* is used as a coagulant to neutralize electric charges of suspended particles and organic substances, as it can remove pollutants at high percentage may be reached 85% of suspended solid materials (TSS), more than 60% of COD, and 90% of color, most of them could be used at a little dose in water treatment [8]. The mention of [9] included that the Moringa seed extract has been used commercially in water treatment due to its content of organic compounds that give high efficiency for reducing chemical, physical and biological pollutants in wastewater, as shown by [10] about using leaves of *Leucaena leucocephala* in wastewater treatment that residual from food manufactures which achieved high removal percentage of chemical and biological oxygen demand, heavy metals and TSS at pH between 2-4. The study of [11] indicated that the natural coagulants of Moringa and fenugreek leaves extract have been used to remove the turbidity and microbiological contamination and COD in sewage wastewater without affecting pH and the electrical conductivity (Ec), also those were used for reducing oil which associated water during petroleum product process [12]. Review of [5] confirmed that natural coagulant is very effective for sweeping most parameters like COD, BOD, turbidity, Heavy metals, TSS and TDS.

This study aimed to examine the efficiency of some plant extracts prepared of Leucaena seeds, Concarpus leaves, and Moringa seeds, those compared alum as a chemical coagulant for reducing COD and turbidity in sewage wastewater.

2. Methods

2.1. Preparations of Plants

Leucaena leucocephala seeds, *Conocarpus lancifolius* leaves, and *Moringa oleifera* seeds were brought and diagnosed in the department of horticulture and crops, college of agriculture/university of Baghdad. They were cleaned and kept in a sealed container to use for experiment work.

2.2. Plant Extraction

Aqueous extraction was prepared according to mention [13] with some modifications, by weighting 1 gm of dried and grind of each plant source after sieving through mesh 0.4 mm then washed twice using distilled water, the filtrate was ignored after adjusting pH at 5 and 10 by adding a diluted solution of HCL and NaOH respectively, added distilled water into residual suspension to obtain 1 L as final volume to use it in laboratory experiments.

2.3. Diagnosing Some Properties of Plant Extracts

Some properties of the prepared extract were determined at room temperature 30 C° which included parameters of EC and total dissolved solids (TDS) using a conductivity meter [3], pH was measured by pH meter, the refractive index was determined using the Abbe refractometer, also estimating flow rate of extract solution[14], determination of sediment volume of suspension solution by placing 250 ml of each extract in the graduated cylinder then settled for 10 days to evaluate the percentage of sediment volume [14].

2.4. Preparation of Wastewater

Turbid sewage wastewater was prepared by adding 20-50 g of pure clay gradually after grind and sieved by a mesh of 0.2 mm to 50 liters of sewage water, mixing 1 hour using a shaker device at speed of 100 rpm to homogenize the suspension, then settled during 2 hours to complete hydration to obtain turbid water of 100 units using turbidity meter [15], at final COD, pH and EC were measured.

2.5. Preparation of Chemical Coagulant

Aluminum sulfate (alum) as an inorganic synthetic coagulant was prepared according to the method of [16], dissolving 10 g of material in 1 liter of distilled water to obtain the concentration of 10,000 ppm, then kept in a glass container until use for experiment work, every 1 ml of coagulant contain 10 mg of aluminum sulfate.

2.6. Using Plant Extract to Find Optimum Conditions to Reduce COD in Wastewater

Wastewater sample was used to find optimal conditions comprised extract doses and pH compared alum to reduce COD according to a study of [3], putting 1 liter of sample in baker of the jar test device. The plant extract was added to the sample at five doses of each source, they were (10, 25, 50, 75 and 100) ppm, applying five levels of pH (3, 5, 7, 9 and 11) at the optimal dose of extract.

The treatment process included mixing at 120 rpm for 1 min to homogenize suspension, then mixed at 40 rpm for 30 min and remained until 30 min for settling. The filtrate was withdrawn and underwent some analysis including COD, turbidity, pH, and EC. The analysis of COD comprised digestion of the sample with acids and oxidant materials, this parameter was estimated at specific absorbance using a spectrophotometer [3]. The turbidity was measured using a turbidity meter device and the percentage of COD was calculated at three replicates for each treatment according to mention [17] as the followed equation:

$$\textbf{COD removal}\ (\%) = (\textbf{initial conc of COD} - \textbf{final conc of COD})/\textbf{initial conc of COD} \times \textbf{100} \quad (1)$$

Data of result underwent Statistical analysis using Genstat program applying complete random design (CRD) to find the significant differences between the mean of three replicates of COD removal percentage for each experiment using the least significant difference test LSD at a level of significance of 0.05.

3. Results and Discussion

3.1. Diagnoses of Each Suspension Properties Used in the Experiments

Table (1) comprised the chemical and physical analysis of plant extracts as well as distilled water used for preparing solutions, those included pH, EC, TDS, flow rate, refractive index, and volume of suspension's sediment (VS).

Table (1). Chemical and physical analysis of plant extract and distilled water that used in experiment work.

Plant source	pH	EC (µs/cm)	TDS (ppm)	Flow rate (ml/sec)	Refractive index	VS (ml)
Leucaena seeds extract	6.8	31	19	1.21	1.333	0.1%
Conocarpus leaves extract	7.2	28	16	1.20	1.333	0.2%
Moringa seeds extract	7.0	25	15	1.21	1.333	0.1%
Distilled water	7.1	2	1	1.21	1.333	0.0%

There was no change in pH through the treatment process ranging between 6.8-7.2 which was close to the pH of distilled water 7.1, the result was similar to the mention [12] who noted the natural coagulants did not affect the pH of treated water, also the extract of Coccinia and okra that were used as coagulants for purifying turbid water gave slight variation of pH, as well as close to the conclusion of [9] that comprised for using extract of Moringa leaves to reduce the COD in wastewater and did not affect pH at final experiments.

There was no significant increase in EC and TDS, those ranged between 25-31 µs/cm and 15-19 ppm compared to distilled water which was 2 µs/cm and 1 ppm, respectively.

The flow rate of suspension's filtrate did not exceed the flow rate of distilled water, this showed the similarity of viscosity between them. The result observed an increased flow rate of solutions compared to that found by [14] to estimate the same parameter that was prepared from Devil's cotton which was 1.03 ml/s, due to various concentrations between the two solutions [3].

The refractive index of prepared solutions attained 1.333, which was the same value as distilled water at a temperature of 30 °C, this result below according to CMC extract that was prepared at a concentration of 2%, as it was 1.336 due to the difference of concentration between them [18].

There was the highest percentage of residual sediment concluded by using Concarpus leaves which was 0.2% compared to other suspensions. The parameter of estimating sediment volume of suspensions occupied an important issue for evaluating the efficiency of using natural coagulants in industrial and food applications, the huge volume of sediment may be led to several problems during manufacturing processes, as well as loading more cost and effort to remove this material at final product [19].

3.2. Optimum Conditions to Reduce COD in Water Using Plant Extract

Chemical and physical analysis of wastewater involved EC, turbidity, COD and pH were 1350 µ/cm, 100 units, 150 ppm and 7.8 respectively. Table (2) showed the influence of various doses of Leucaena seeds extract for reducing COD in sewage water which was found highest significant difference at a dose of (50, 75) ppm and COD removal percentage of (64, 66) % compared to other doses, otherwise the turbidity removal reached (69, 70) units for both doses respectively, but there was a slight increase of EC that happened gradually according to an increment the doses. The various removal of COD depended on ionic neutralization between the opposite charges of active groups and organic pollutants [7].

Table (2). Relationship between the concentration of Leucaena seeds extract and COD removal in wastewater.

Extract Dose (ppm)	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
10	1355	91	9	146	3 c	6.88
25	1361	55	45	77	49 b	
50	1370	31	69	54	64 a	
75	1379	30	70	51	66 a	
100	1388	43	57	73	51 b	

a: highest significant difference, c: lowest significant difference

Table (3) comprised the influence of pH 3, 5, 7, 9 and 11 at an optimum dose of Leucaena extract which was 50 ppm, for reducing COD. The optimal pH were 3 and 9, those gave reducing percentages reached (74, 73) % respectively, so they have a significant difference compared to other pH values, also noted an increase of turbidity and EC gradually at rising pH values. The pH has an important role to change electrical charges on active groups like the galacturonic acid that affect binding organic pollutants and suspended solid during water treatment [12].

Table (3). pH and COD removal in wastewater at optimal dose of 50 ppm of Leucaena extract.

pH	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
3	1633	19	81	39	74 a	6.32
5	1547	45	55	78	49 c	
7	1476	77	23	70	53 c	
9	1355	26	74	41	73 a	
11	1490	20	80	60	60 b	

The study of [10] used Leucaena seeds extract which was prepared using the acidic solution at a dose of 400 ppm to treat sewage water, the COD was reduced to 38.5% at pH lower than used in the study between 2-4, this plant is used in water treatment due to its high efficiency, otherwise grow a lot on the local area. There is diverse efficiency of water treatment for using Leucaena plant despite applying same methodological process due to the influence of various external environmental factors on cultivated plants such as drought, soil salinity that affect the accumulation of organic compounds like carbohydrates, proteins and others substances in plant tissue to enhance binding water to resist drought conditions [3].

Table (4) focused on the effect of several doses of Concarpus extract for reducing COD in wastewater that observed the highest significant difference at a dose of (50, 75) ppm, to obtain (66, 69) % of COD removal compared to the dose of 100 ppm, as well as reducing water turbidity to (38, 30) units for both doses respectively, also indicated slight increase of EC depending to rise extract concentration.

Table (4). Relationship between Concarpus extract and COD removal in wastewater.

Extract Dose (ppm)	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
10	1340	65	35	133	11 d	6.14
25	1390	50	50	100	34 c	
50	1420	38	62	51	66 a	
75	1459	30	70	46	69 a	
100	1511	59	41	73	51 b	

As shown in Table (5) indicated that pH 9 gave the highest percentage of COD removal reaching 68% at an optimal dose of 50 ppm, and a decrease in water turbidity and EC to 14 units and 1242 µ/cm respectively.

Table (5). Relationship between pH and COD removal in wastewater at the optimal dose of Concarpus extract.

pH	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
3	1380	20	80	105	30 d	6.98
5	1361	33	67	100	33 d	
7	1220	20	80	61	60 b	
9	1242	14	86	47	68 a	
11	1434	19	81	85	44 c	

Several studies showed using Concarpus leaves extract for reducing water turbidity in raw water, but did not focus on other parameters like organic compounds and the COD. The mention of [20] comprised using Concarpus leaves as an assistant coagulant for purifying water turbidity to 30 units at initial turbidity 100 units. The Study of [17] noted that using Moringa seeds extract at dose 200 ppm and pH between 7-9 gave best turbidity and COD removal through treatment process to obtain removal closed of the study attained 99.5%, 65.8%, respectively. There is a linear relationship between residual of both the turbidity and COD concentration of treated water as shown in table (2, 4, 6) [9].

The effect of several doses of Moringa seeds extract to reduce COD in sewage water, which was found highest significant difference at a concentration of (75, 100) ppm and to obtain percentage of (64, 65)%, otherwise reducing water turbidity to (29, 42)% units for both doses respectively, while reached (56, 55)% at doses of (25, 50) ppm respectively, also observed little rising EC according to a gradual increment of added extract dose, but did not affect the accumulation of water salinity in treated water (Table 6).

Table (6). Relationship between Moringa extract dose and COD removal in wastewater.

Extract Dose (ppm)	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
10	1365	73	27	110	27 c	6.11
25	1370	50	50	66	56 b	
50	1379	45	55	67	55 b	
75	1380	29	71	53	64 a	
100	1388	42	58	52	65 a	

Table (7) indicated that the highest percentage of COD removal was at pH limited between 5-9, which reached 69% at optimal extract dose was 75 ppm, as well as the biggest reducing water turbidity and EC at pH 9, as they were 41 units and 1292 µ/cm respectively.

There was decrease of COD a lot of than found by [8] who used the same extract at a dose of 70 ppm and pH 6 for reducing COD in Bandar Abbas wastewater plant which attained 39% at optimum conditions, Moringa plant

plays an important role for reducing organic compounds to keep the environment safe without spreading pollutants, otherwise decreasing the cost of preparation and effort through extraction and treatment process. The result was closed to what [11] found to estimate COD removal by using the same plant extract at a concentration of 100 ppm to treat residual wastewater of a food product factory at pH 9, it reached 65% without significant change in pH and EC in water.

Table (7). Relationship between pH and COD removal in wastewater at the optimal dose of Moringa extract.

pH	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
3	1370	52	48	105	30 c	5.99
5	1365	43	57	44	69 a	
7	1320	45	55	50	66 a	
9	1292	41	59	53	64 a	
11	1434	46	54	77	48 b	

Table (8) explained the effect of diverse doses of alum as a chemical coagulant for reducing COD in water, as it was found no significant difference to decrease COD among concentrations of (25, 50, 75 and 100) ppm, they were (52, 53, 53 and 56) % respectively, with reducing turbidity by raising coagulant doses gradually, as well as rising EC to 1655 at a concentration of 100 ppm.

Table (8). Relationship between alum dose and COD removal in wastewater.

alum Dose (ppm)	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
10	1385	25	75	88	41 b	6.11
25	1411	21	79	72	52 a	
50	1490	20	80	70	53 a	
75	1543	18	82	70	53 a	
100	1655	17	83	66	56 a	

Table (9) showed that the highest reduction of COD at an optimal dose of 25 ppm was limited among 5, 7 and 9, as it reached (60, 57 and 55) % respectively, also observed the biggest decrease in water turbidity, noted little increase of EC according to the addition of alkaline solution gradually. A study of [8] indicated that using alum at a dose of 40 ppm achieved percentage removal of COD reached 52%, which was close to the result of the current study.

Table (9). Relationship between pH and COD removal in wastewater at the optimal dose of alum.

pH	EC (µs/cm)	Turbidity (unit)	Turbidity removal (%)	COD (ppm)	COD removal (%)	COD removal LSD (0.05)
3	1470	42	58	92	39 c	6.67
5	1485	31	69	60	60 a	
7	1520	19	81	64	57 a	
9	1592	22	78	67	55 a	
11	1534	46	54	87	42 b	

Tables (2, 4, 6) explained the influence of different doses of the extract on COD removal showed increment of COD removal depending increase of added doses to obtain the ideal dose that gave the highest removal of COD, then observed decrease of removal gradually despite added more doses, this result was confirmed by [9], who used the extract of Moringa leaves and banana peels to reduce COD in wastewater that used a dose of 1000 ppm and 400 ppm to attain optimal removal of (60, 68)% respectively, after while appearing decrease of COD removal although rising concentration of substance. The plant extract is characterized by its content of ionic charges on

functional groups such as amino, carboxyl, and hydroxyl groups, high molecular weight of these substances work to neutralize opposite charge forming linked bridges to bind suspended particles and organic components at optimal dose forming equilibrium between opposite charges so lead to settle on the bottom [9,21].

4. Conclusions and Recommendation

The possibility of preparing plant extracts is available locally to apply in water treatment. Obtaining the highest reduction of COD using extract of Leucaena seeds, Conocarpus leaves and Moringa seeds at low doses (50, 50 and 75) ppm reached (65, 66 and 64)%. also noted decrease of water turbidity to (31, 38 and 29) units respectively, at pH 9. Observing the biggest removal of COD using the alum coagulant attained 55%, at a concentration of 25 ppm, while noted rising EC and changing pH according to more concentration of alum compared to use green application technology.

Recommendation of applying plant extract for reducing organic compounds and turbidity in water treatment to remain environment without risks, otherwise easy to prepare from trees that are available locally and do not affect changing EC and pH during the water treatment process.

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