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Investigation on Coagulation Properties of Oil Extracted Bio-Materials

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Abstract **- Adaptation of four waste bio-materials from oil extraction industry, namely, *Arachis Hypogea* (Groundnut or peanut), *Azadirachta indica* (Neem), *Cocos nucifera* (copra) and *Sesamum indicum* (till/ sesame), was investigated to treat synthetic turbid water. Batch coagulant experiments were conducted to study the effect of bio-materials on the major physco-chemical water quality parameters like pH, high turbidity, TDS, electrical conductivity, total hardness, alkalinity, BOD, COD. *Azadirachta indica*, *Sesamum indicum* and *Cocos nucifera* showed about 94% reduction in turbidity, while with *Arachis Hypogea* the reduction achieved was 81%. The turbidity and other major water quality parameters were almost in the acceptable range when alum was used as coagulant aid. The optimum proportion was found to be 80 parts of natural coagulant: 20 parts of alum. The Bronsted Lowry method of protein profile of four samples revealed the presence of flocculent proteins in band on approximate 9kDa in 12% gel.**

Keywords-- **Natural coagulants (NC), Turbidity, Water quality, Alum (A), Protein**

I. INTRODUCTION

The coagulation is an important unit process to reduce the concentration of suspended colloidal particles to safeguard and boost the efficiency of unit processes. The aluminium part in the common chemical coagulant, alum, is reported to be as neurotoxin and may be involved in the development of neurological disorder [1-5]. There are also the issues concerning aluminium in acid waters, with acute toxicity to fish. Aluminium binds to functional groups in the gills of the fish and affects the permeability of the membrane. This induces an accelerated cell-death which leads to a high mortality in fish populations [6]. Thus, the researchers are trying to find an alternative to the chemical coagulant. The materials of plant origin have been studied as natural coagulants to treat turbid water.

Moringa Oliefera (M.O) seeds extract has been extensively investigated as a natural coagulant by many investigators[7-19]. The M.O. extracts have shown to be effective in reducing turbidity of water to a greater extent.

The water soluble protein in the extract was reported to be responsible for the coagulation [9,20] .

Many researchers have also experimented with the other natural plant seeds, like bean, neem,nirmali, soyabean, fenugreek, etc., to treat water or wastewater [19,21-35]. The overall outcome of the study revealed that these seed extracts also have the potential to reduce turbidity form water.

In present study, the bio-wastes from the oil extraction industry have been investigated as natural coagulants. Four oil extracted seed materials, viz., *Arachis Hypogea* (Ground nut or peanut cake), *Azadirachta indica* (Neem), *Cocos nucifera* (copra) and *Sesamum indicum* (till/ sesame) were studied to treat lake water. These materials contain some of the hydrophilic amino acids [36-38] which would help in the process of coagulation. The laboratory experimental investigations were planned and results were compared with the conventional coagulant, alum. Further, the experiments were also carried out taking alum as a coagulant aid. The adoptability is based on the performance of the individual or combination with alum.

II. MATERILAS AND METHODOLOGY

A. Preparation of Coagulants

The bio-materials were procured from animal feed shop outlet at Mysore, Karnataka, India. The cakes were dried for a day in an oven for 24hrs at 40^0 C. The dried cakes were blended and sieved through an iron sieve (200 micrometers) to yield a fine powder, which was used for extraction of active agent.

B. Extraction active component

The extraction of active agents from the natural coagulants can be obtained from either by distilled water or spring water or tap water or salt solutions [14,39-42]. The extraction of active agents from the materials was carried out with distilled water in the present study.

A fixed quantity of prepared bio-material was blended with distilled water and made it to 1 liter to obtain the required concentration (Set A experiments- Table 2).

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C. Raw water collection

The water samples were collected from lake Kempambudhi kere, Kempegowda Nagar, Bangalore, Karnataka. The water samples showed low turbidity due to the settlement. The turbidity was artificially increased and is maintained around 300-350 NTU. The physical and chemical parameters of the Raw and Clarified waters were determined according to standard method [43]. Table 1 shows the physico-chemical characteristics of the raw water.

TABLE 1
PHYSICO-CHEMICAL CHARACTERISTICS OF RAW WATER

Parameter	Value
Turbidity (NTU)	320
Alkalinity (mg/L of $CaCO_3$)	240
Hardness (mg/L)	304
pH	7.7
Temp (^{0} C)	23.6
COD (mg/L)	185
BOD (mg/L)	137
TDS (mg/L)	2.73
EC (µs/cm)	689

III. Experimental Analysis And Discussion

Water quality parameters are important for designing suitable unit process. Since the source of coagulation material is organic in nature, it is necessary to investigate the effect of natural coagulant on basic water quality parameters also. The following parameter viz; turbidity, temperature, pH, alkalinity, total hardness, electrical conductivity, total dissolved solids, BOD, COD were investigated for each experiment.

The basic scheme of experimentation is presented in Table 2. The efficiency of reduction in turbidity was determined using standard jar test to arrive at operating parameters.

TABLE 2
SCHEME OF EXPERIMENTATION

Set	Constants	Variable	Objective
A	Time of contact (10 min), Agitation speed (100 RPM) and Ageing: 0th day (freshly prepared coagulants)	concentration of coagulant: 10, 20, 30, 40 and 50 g/l.	To find Optimum quantity of material per litre of distilled water for extraction of active agents
B	Time of contact (10 min), Agitation speed (100 RPM) and Efficient concentration of material extract from Set A	Ageing : Freshly prepared – 0th day to 5 days	To obtain appropriate ageing of material Extract
C	Time of contact (10 min), Efficient concentration (Set A) and Appropriate Ageing of material extract (Set B)	Agitation speed: 100, 150 and 200 rpm	To find Optimum or Operational speed
D	Efficient concentration (Set A), Appropriate ageing of material extract (Set B) and Operational agitation speed (Set C)	Time of contact 5, 10, 20 and 30min	To obtain optimum time of contact
E	Efficient concentration (Set A), Appropriate ageing of material extract (Set B), Operational agitation speed (Set C) and Optimum time of contact (Set D)	Dosage of efficient concentration of material extract : 2 to 14 ml	To find optimum dosage of efficient concentration of material extract

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Figures 1 to 4 show the results of Set-A experiments.

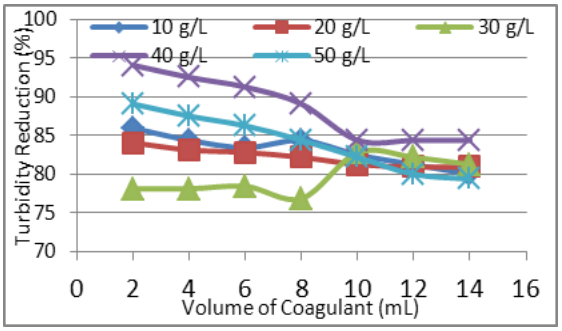

Fig 1: Optimum Concentration Of *Azadirachta Indica*(Neem) Extract

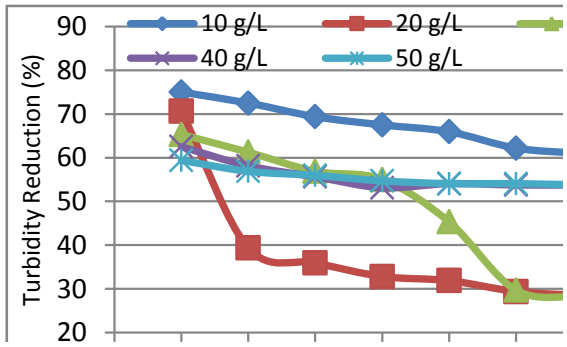

Fig 2: Optimum Concentration Of *Arachis Hypogea* (Peanut) Extract

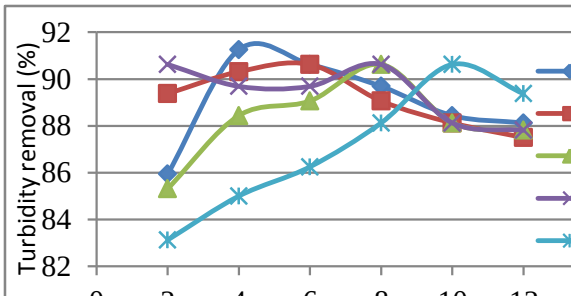

Fig 3: Optimum Concentration Of *Sesamum Indicum* (Till) Extract

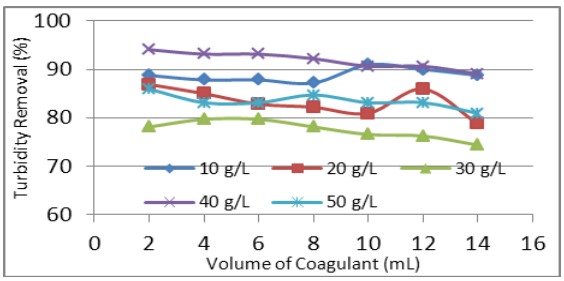

Fig 4: Optimum Concentration Of *Cocos Nucifera* (Copra) Extract

The behaviour, in general, was not exhibiting any definite trend. However for a particular quantity of coagulant extract, the removal efficiency was observed to be maximum. The optimum concentration to extract the active agents was observed to be 40g/L for *Azadirachta indica* and *Cocos nucifera* (Fig 1, Fig 4) and, 10g/L for *Arachis Hypogea* and *Sesamum indicum* (Fig 2, Fig 3)respectively. The volume of the coagulants to be added was found to be 2ml for *Azadirachta indica*, *Cocos nucifera* and *Arachis Hypogea*. But for *Sesamum indicum*, the volume around 4 ml was required to achieve optimum. These concentrations were fixed for the further set of experimentation.

Figure 5 represents the investigation pertaining to effect of ageing (Set-B).

The ageing has an effect in removal of turbidity. As days of storage increases, efficiency reduces in almost all the cases except for copra. It showed the turbidity removal efficiency practically same for all the days. In general, it can be opined that the freshly prepared coagulants, i.e., 0^{th} day, has a better efficiency. Hence for the future set of experiments, freshly prepared coagulant extracts are considered as the operating parameter.

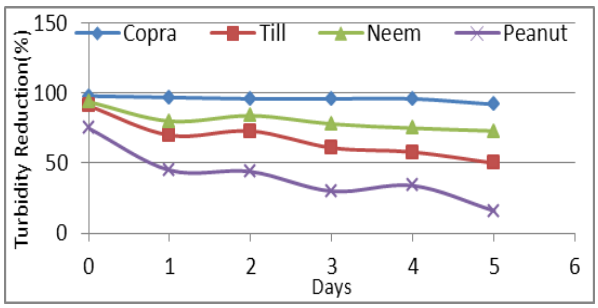

Fig. 5: Variation Of Ageing Versus Turbidity Reduction (Set B)

The reduction in turbidity with speed of mixing is shown in Fig. 6 (Set-C)

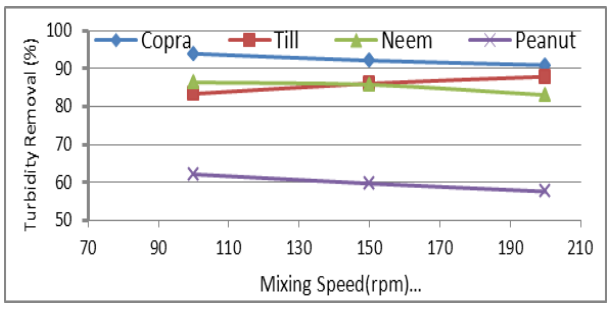

Fig. 6: The Optimum Rpm For All The Considered Natural Coagulant (Set C)

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The behaviour showed the turbidity reduction varied linearly with optimum speed. Except for *Sesamum indicum* (till), all other coagulants extracts showed mild negative correlation. The optimum speed for *Azadirachta indica* (neem), *Cocos nucifera* (copra) and *Arachis Hypogea* (peanut) was observed to be at 100 rpm, and for *Sesamum indicum* (till) 200rpm. These optimum speeds are considered as operating mixing speeds for the further set of experiments.

Figure 7 explains the effect of contact speed on turbidity removal using four considered coagulant extracts.

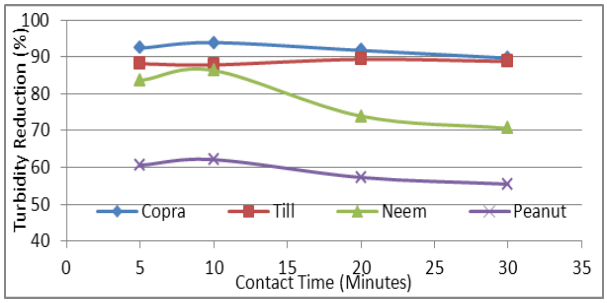

Fig. 7: The Optimum Contact Time For All The Considered Natural Coagulant (Set D)

The optimum contact time for the coagulants was observed to be similar except with *Sesamum indicum*. From the behaviour it can be observed that time of 10 minutes can be considered as the optimum for *Azadirachta indica* (neem), *Cocos nucifera* (copra) and *Arachis Hypogea* (peanut). *Sesamum indicum* (Till) showed the better efficiency at 20 minutes. These timings would be taken as operating contact time in the next set of experiments

Experimental outcome of effect of dosage on turbidity removal is depicted in Fig. 8 (Set E)

It can be opined form the trend that the optimum dosage for *Azadirachta indica* (neem), *Cocos nucifera* (copra) and *Arachis Hypogea* (peanut) extracts was around 2mL with the removal efficiency of 94% for first two, around 75% for *Arachis Hypogea*. *Sesamum indicum* (Till) extract performed better around 4mL (91%). *Arachis Hypogea* (peanut) extract was found to be less efficient than others.

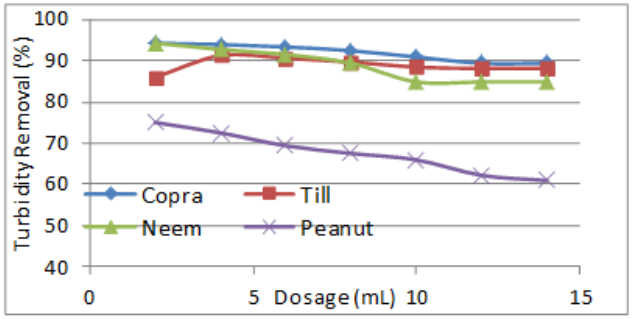

Fig. 8: Optimum Dosage For All The Considered Natural Coagulants (Set E)

In general, the trend in above analysis showed almost similar behavior with *Azadirachta indica* (neem), *Cocos nucifera* (copra) and *Sesamum indicum* (Till). The turbidity removal was observed to be high. *Arachis Hypogea* (peanut) has exhibited trend of lowering the turbidity, but not as comparable as to other materials considered for the investigation.

C. Comparison of Coagulants Behaviour

Apart from turbidity, the other physico-chemical parameters are also important in treatment of water. This comparison would highlight the effect of materials on pH, high turbidity, TDS, electrical conductivity, total hardness, alkalinity, BOD, COD. Table 2 gives details of water quality parameters of raw water, coagulated with alum and natural coagulants considered for the study at their operating conditions

The chemical coagulant, which would be the first choice, has performed effectively in reducing the turbidity to 99%. The bio-materials neem, copra and till were found to be efficient but were not meeting WHO standards of 5 NTU. The natural materials have shown the property of reducing BOD and COD than alum. The other quality parameters did not vary much in both chemical and natural materials.

The possibilities of combinations of natural and chemical coagulants were studied by considering alum as coagulant aid. Table 3 shows the results of water quality parameters for different combinations.

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Alum as a coagulant aid improves treatment efficiency. Among the combinations investigated, 70NC:30A and 80NC: 20A showed reduction in turbidity to below 5 NTU, 80-90% reduction in BOD, 40-60% reduction in COD from synthetic raw water. Peanut in combination with alum showed improved efficiency than its independent form. To reduce the contribution of alum to environment, 80NC:20A would be preferable. All the natural bio-materials in the study have the potential to be considered as coagulants. The performance of them wasfound be improved in combination with the chemical coagulant.

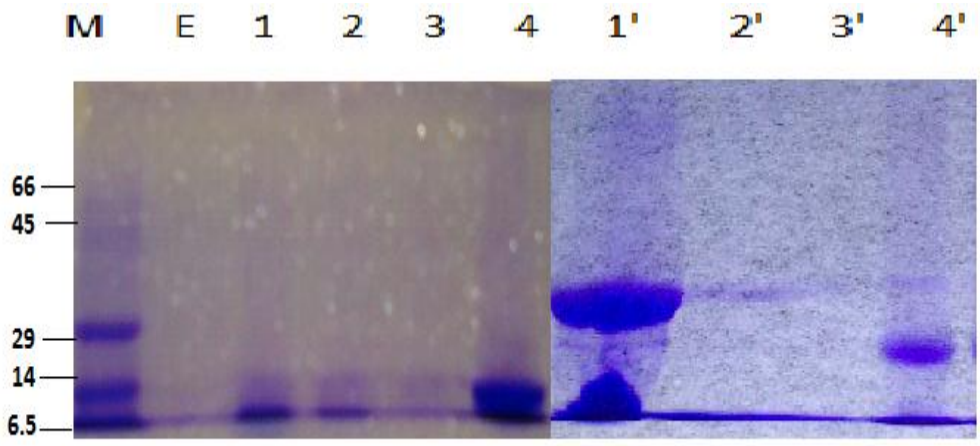
IV. Protein Estimation

Bronsted Lowry method was used to estimate the amount of protein in the extracted sample.

BSA (Bovine Serum Albumin) was used as a standard solution. Polyacrylamide gel electrophoresis was employed in the present study to separate macromolecules.

Two types of gels (seperating and stacking) were used in SDS PAGE for seperating the protien bands of extracts used in the study. Plate 1 shows protein profile of the extracted materials.

The analysis revealed the band on approximate 9kDa in 12% gel. The probable coagulant of 9kDa molecular weight protein are flocculent proteins dominantly present in seed extracts as seen in 12% gel (SwissProt ID : P80208). To analyse differences in band pattern, 15% gel was run. A common band at 26kDa was revealed in all the four samples.



M: MARKER (Molecular weight in Kilo Dalton, kDa)
E: Empty Well (No Sample)
1-4 Sample in 12% SDS-PAGE AND 1'-4' in 15% SDS-PAGE GEL
1: Copra, 2: Neem, 3: Till and 4: Peanut
1': Copra, 2': Neem, 3': Till and 4': Peanut

PLATE 1: PROTEIN PROFILE (SDS PAGE) IN 12% AND 15% GEL

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TABLE 2:
DETAILS OF WATER QUALITY PARAMETERS FOR ALL THE COAGULANTS

Sl No	Parameters	Raw Water	Coagulated Water				
			Alum	Neem	Copra	Till	Peanut
1	Turbidity (NTU)	320	2 (99%)	20 (94%)	22 (93%)	20 (94%)	60 (81%)
2	Alkalinity (mg/L of $cacO_3$)	280	216	236	312	300	280
3	Hardness (mg/L)	328	364	280	360	328	320
4	pH	7.7	7.8	7.5	7.4	8.1	7.1
5	Temperature (^{0}C)	25.6	25.9	24.2	25.2	25.5	26
6	COD (mg/L)	185	210	112 (39%)	92 (50%)	128 (31%)	180 (3%)
7	BOD (mg/L)	137	78 (43%)	53 (61)	54 (61%)	61 (55%)	50 (63%)
8	TDS (mg/L)	3.73	4.02	3.72	4.05	4.09	3.90
9	EC (µs/cm)	689	698	629	624	612	611

TABLE 3 :
OPTIMUM PARAMETERS AND COMBINATION FOR ALL THE COAGULANTS

Sl No	Parameters	70% NC*+30%A**				80% NC*+20%A**				90% NC*+10%A**			
		Neem	Copra	Pea nut	Till	Neem	Copra	Pea nut	Till	Neem	Copra	Pea nut	Till
1	Turbidity (NTU)	1.5	1.6	2	2	2.6	5	3.2	2.5	15	7	4	5.5
2	Alkalinity (mg/L of $cacO_3$)	256	312	340	224	240	304	344	240	300	320	328	336
3	Hardness (mg/L)	320	340	344	320	33.2	320	366	372	316	288	348	384
4	pH	7.84	7.8	7.9	7.4	7.6	7.8	7.9	7.54	7.9	7	7.8	7.76
5	Temperature (^{0}C)	27.1	27.1	28	28.3	27.2	27.1	28.2	28.3	28.3	27.2	28	27.7
6	COD (mg/L)	60	108	115	116	100	70	108	106	100	36	80	100
7	BOD (mg/L)	31.67	10.8	10.5	11.1	21.3	6.67	5.56	12.1	38.6	11.5	8.6	10.2
8	TDS (mg/L)	5.09	4.37	4.77	4.30	4.82	3.91	4.25	4.28	5.67	4.08	4.15	4.24
9	EC (µs/cm)	770	672	763	663	764	578	740	658	914	632	736	650

**Natural Coagulant, **Alum*

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V. CONCLUSION

Oil extracted *Azadirachta indica* (Neem), *Cocos nucifera* (copra) and *Sesamum indicum* (till) were found to reduce turbidity significantly (about 95%) in their independent form from synthetic raw water. Alum as a coagulant aid with bio-materials reduced turbidity below 5 NTU in the combinations of 80 NC: 20A and 70NC:30A. The pollution level indicators BOD and COD were also significantly reduced in the combination. The combination 80 NC: 20A can be adopted as optimum to reduce usage of chemical coagulant. The protein profile and the molecular mass of the protein revealed the presence of flocculent proteins in band on approximate 9kDa in 12% gel.

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