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Coag-Flocculation Parametric Response of *Irvingia Gabonesis* Seed in Dairy Effluent

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ABSTRACT

Coag-flocculation parametric response of *Irvingia Gabonesis* seed in dairy effluent was undertaken. The potentials of *Irvingia Gabonesis* (wild mango) seed as a bio-coagulant was investigated at room temperature, varying dosage, pH, and time. The bio-coagulant was produced following standard method, while a conventional jar-test method was employed for the turbidity measurement of varying effluent sample pH.. The Coagulation results obtained were fitted into the relevant model equation for the determination of coag-flocculation functional parameters. The maximum performance of *Irvingia Gabonesis* seed coagulant obtained at α=1.were coagulation half-life $\tau_{½}$ (0.98min), Coag-flocculation constant K ($9.7x10^{-3}$ l/mg.min), coag-flocculant dosage (500mg/l) and $_{P}$H (4) . The maximum coag-flocculation efficiency E (%) obtained is 97%. Thus, affirming that WMS is a good natural alternative resource for the treatment of dairy effluents.

Keywords: Wild mango seed, dairy effluent, coag-flocculation, kinetics.

INTRODUCTION

The dairy industry, generally considered to be one of the largest source of food processing waste water in many countries. Water is used throughout all steps of the dairy industry including the cleaning, sanitization, heating, cooling, and floor washing. Naturally, this industries quest for water is enormous [9]. In general, wastes from dairy processing industries contain a high concentration of organic materials such as proteins, carbohydrates, lipids, high BOD and COD, high concentrations of suspended solids, suspended oil and grease [15]. All of these require specialized treatments to prevent or minimize environmental problems.

Among all the dairy industrial wastes, milk processing industries causes severe environmental problems due to generation of wastewater characterized by high biological oxygen demand (BOD_5) and chemical oxygen demand (COD) [14]. In the food industries, the dairy industry generates more effluents in terms of volume with high colloidal particles, BOD_5 and COD, hence, the application of coagulation and flocculation method is sought in ameliorating the envisaged problems in dairy waste water treatment. This method of waste water treatment helps in the settling of finely dispersed solids (colloids) suspended in waste waters, which are stabilized by negative electric charges on their surfaces, causing them to repel each other, thus preventing the charged particles from colliding to form larger particles called flocs. Coagulation/flocculation processes, usually done in sequence, are a combination of physical and chemical procedures, where chemicals are mixed with waste water to promote the aggregation of the suspended solids into particles large enough to settle or be removed. Coagulation is the destabilization of colloids by neutralizing the forces that keep them apart. Flocculation, on the other hand, is the action of polymers to form bridges between the flocs and bind the particles into large agglomerates or clumps [10]. Cationic coagulants provide positive electric charges to reduce the negative charge (Zeta potential) of the colloids as a result; the particles collide to form larger particles (flocs). Rapid mixing is required to disperse the coagulants throughout the liquid [16]. The chemical method helps to remove turbidity, color and chemical oxygen demand reduction. Coagulation/flocculation are often applied in waste water treatment because it involves a relatively simple technology, has high efficiency in removing charged suspended and dissolved particles, enhances filtration process, cost effective (uses abundant and low cost chemicals), provided

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that chemicals are available and dosage is adapted to the water composition. Regardless of the nature of the treated water and the overall applied treatment scheme, coagulation-flocculation is usually included, either as pre-treatment or as post-treatment steps after sedimentation [4].

The effectiveness of coagulation/flocculation is influenced by coagulant dosage, effluent concentration, PH, and temperature, among others [6].

Coagulation-flocculation can be achieved by the use of inorganic substances such as alum, $Fecl_3$ etc. [2]. However, the possible link of these inorganic coagulants to Alzheimer's disease and their toxic nature has led to increased interest in the study of animal and plant material as potential source of organic derived coagulants.

This prompted the investigation of African wild mango seed as a possible organic coagulant for the treatment of dairy effluent. The plant, African wild mango is indigenous to the humid forest zone of the Gulf of Guinea from western Nigeria, east to the Central African Republic. Kernels of this fruit yield an important food additive popular in west and central Africa [13]. They are mainly propagated by seed, processed by crushing and grinding, and then used to thicken soups and stews. Physicochemical and nutrient evaluation of African bush mango seeds shows that the seed is non-toxic, bio-degradable, and rich in starch, fat, and protein [11]; [12]. Its sliminess and thickening property indicates a promise of renewable material with application in water treatment technology.

Thus, this work is aimed at investigating of a plant material, wild mango seed, as a potential source of coagulant derivative for the treatment of dairy effluent, by evaluating its coag-flocculation performance and kinetics under varying pH of dairy effluent and coagulant dosage.

THEORETICAL PRINCIPLES AND MODEL DEVELOPMENT

The rate of flocculation is a function of the particle (count) concentration (C), and the intensity of Brownian motion characterized by the diffusivity (D). consideration of the particle diffusion flux in a mono dispersed system towards a particle of radius 'a' (chosen as the central one) on the basis of Fick's equation yields an expression in the particle number.

$$dc/dt = -KC^{\alpha} \quad 2.1$$

$$\text{Integrating Eq. (1) gives } \ln(-dc/dt) = \ln K + \alpha \ln C \quad 2.2$$

From which K and α can be determined from a plot of ln (dc/dt) against lnC

In eq. (2.1), K is coagulation rate constant/collision frequency

α is the order of coagulation reaction

C is the concentration of the particles (TSS)

It has been shown by some researchers that for the conditions described above [5]; [8]; [3].

$$K = 8\pi R' D$$

$$\text{Where } R' = 2a \quad 2.3$$

From Einstein's equation [5]; [17]

$$D = K_B (T/B) \quad 2.4$$

Where B is the friction factor, T is the absolute temperature (^oK) and K_B is the Boltzman constant (Molar gas constant per particle).

For the simplest case of a smooth spherical particle of radius 'a' immersed in a fluid of viscosity μ, B is given by stock's relation [5]

$$B = 6\pi\mu a \quad 2.5$$

Putting Eq. (2.4) gives

$$D = K_B T/6\pi a\mu \quad 2.6$$

But $R' = 2a$

$$\text{Therefore } D = 2K_B T/6\pi\mu R' = K_B T/3\pi\mu R' \quad 2.7$$

Putting Eq. (2.3) gives

$K= 8\pi R'(K_BT/3\pi R'\mu) =8/3(K_BT/\mu)$ 2.8

Putting Eq(2.8) into Eq.(2.1)when α=2 yields

$dc/dt= -8/3C^2 (K_BT/\mu)$ 2.9

Applying the method of separable variable and integrating Eq. (2.1) within the following limits;

At t=0, $C=c_0$, at t=t, C=C, yields

$-dc/dc^2= Kdt$ 2.10

Integrating Eq. (2.10) above yields

$1/c= 1/c_0+Kt$ 2.11

Multiply both sides of Eq. (2.11) by C_0 to give

$C_0/C= 1+C_0Kt$ 2.12

Making 'C' the subject of the formula, yields

$$C = \frac{C0}{1+ C_0Kt} = \frac{C0}{[1+ \frac{t}{(1/ C_0K)}}$$ 2.13

Let $(1/ c_0K) = \tau$ 2.14

Therefore Eq. (2.13) becomes

$$C = \frac{C0}{1+t/\tau = \tau}$$ 2.15

When $t= \tau$, then Eq. (2.15) becomes

$$C = \frac{C0}{1+1} = \frac{C0}{2}$$ 2.16

Thus at $t =\tau$, $C = \frac{C0}{2}$ .This quantity is called the coagulation period, which is the time when the initial concentration of particles is halved. For Brownian coagulation of mono dispersed particles at early stage (t ≤ 30 minutes), the time evolution of the cluster-size distribution for colloidal particle is usually described thus:

$$\frac{dCn}{dt} = \frac{1}{2}\sum_{1+j=n} \beta(i,j)cicj - \sum \beta(i,n)c_ic_n$$ 2.17

Where $\frac{dCn}{dt}$ is the rate of change of concentration of particle of size n, (concentration/time). β is a function of the coag-flocculation transport mechanism. The appropriate value of β for Brownian transport is given by [3]

$$\beta_{BR} = \frac{8\ KBT}{3\ \mu}$$ 2.18

Where K_B is Boltzman's constant (J/K)

T is Absolute temperature (K)

For Brownian aggregation at early stages (t ≤30 minutes) Eq. (2.17) can be solved exactly, resulting in the expression [10].

$$\frac{Cn(t)}{Co} = \frac{[t/_2(1/KCO)]^{n-1}}{[1+ \frac{t}{2(1/KCo)}]^{n+1}}$$ 2.19

Recall from Eq. (2.14) $(1/C_oK) = \tau$, putting Eq. (2.14) in Eq. (2.19)

We have $\frac{Cn(t)}{C_o} = \frac{(t/2\tau)^{n-1}}{(1+t/2\tau)^{n+1}}$ 2.20

Let $2\tau = \tau'$ and put in Eq. (2.20)

$$\frac{Cn(t)}{C_o} = \frac{(t/\tau')^{n-1}}{(1+t/\tau')^{n+1}} \quad 2.21$$

Eq. (2.12) gives general expression for particle on n-th order. Hence for primary particles (n=1)

$$C_1 = C_0 \frac{[1]}{(1+t/\tau')^2} \quad 2.22$$

For twins (n=2)

$$C_2 = C_0 \frac{[(t/\tau')]}{(1+t/\tau')^3} \quad 2.23$$

For triplets (n=3)

$$C_3 = C_0 \frac{[(t/\tau')^2]}{(1+t/\tau')^4} \quad 2.24$$

The process of aggregation is a complicated phenomenon. Analysis shows that Eq. (2.15) holds for the overall concentration of all particles, which monotonically decreases in time like the number of primary particles [5]

$$\sum C1 = \frac{C0}{1+t/\tau'} \quad 2.25$$

Linearizing Eq. (2.25) gives

$$\frac{1}{\sum C1} = \frac{1}{C_0} + \frac{1}{\tau' C_0} t \quad 2.26$$

Where a plot of $\frac{1}{\sum C1}$ verses t gives

Slope = $\frac{1}{\tau' C_0}$, intercept = $\frac{1}{C_0}$

Now that τ' can be obtained from Eq. (2.26) while the theoretical quantities τ' is found with the aid of Eq. (2.14) (Fridrikhsberg, 1984)

$$\tau = \frac{1}{C_0 K} = \frac{3\mu}{8K_B T C_0} \quad 2.27$$

As $C_0 \rightarrow \frac{C_0}{2}$, $\tau \rightarrow \tau_{1/2}$

Therefore, $\tau_{1/2} = \frac{3\mu}{8K_B T (0.5C_0)} = \frac{3\mu}{4K_B T C_0}$ 2.28

Where $\tau_{1/2}$ is coagulation period/half-life.

In the work of [10], it was shown that the coagulation rate constant can be determined by monitoring the changes in the turbidity of the coagulation liquid with time.

MATERIALS AND METHODS

Sample Collection

The effluent was collected from a yoghurt company at Awka, Anambra State. The raw waste water was characterized based on standard method [7]; [1]. The wild mango seed sample was sourced from Eke-Awka market, Anambra State, Nigeria.

COAGULANT PREPARATION

The collected wild mango seeds were dried under sunlight for twenty one days so as to reduce moisture content. The dried seeds were then ground into fine powder and sieved to get particle sizes less than 0.2mm which will allow the complete absorption of the complex salts and water used for the protein extraction. Solutions of wild mango seed are prepared before starting the experiment.

EXPERIMENTATION

This was carried out in batches using a conventional jar test apparatus. The waste water samples were adjusted from an initial $_{P}H$ value to determine the coagulant effects on various concentrations. The $_{P}H$ was controlled by adding either strong acid (HCL) or strong base (NaoH). Before fractioned into beakers containing about 100ml-500ml of suspension each, the samples of the waste water was mixed homogenously, and then measured for color, turbidity, some heavy metals, BOD_5 and COD, among others, for representing an initial concentration. After adding the desired amount of the coagulants to the suspension, the beakers were agitated at various mixing time and speed, which consist of initial rapid mixing for 5minutes at 150rpm, followed by slow mixing stage for 20minutes at 30rpm and final settling step of 60minutes after the agitation is stopped.

While completing the settling time, samples were withdrawn at intervals using a pipette from the top inch of supernatant for analysis of total suspended solids, COD, BOD and other parameters, this represents the final concentration. All tests were performed at room temperature. The study was conducted by varying a few experimental parameters which are the coagulants dosage, PH, and mixing time, in order to study their effects in flocculation and obtain the optimum condition for each parameter. The data obtained were subsequently fitted in appropriate kinetic models for evaluation.

RESULTS AND DISCUSSION

Coag-Flocculation Parameters

The values of coag-flocculation reaction parameter are presented in tables 1 to 5 while the linear plots of lnC which yields K and $1/N_O$ as the slope and intercept are presented in figures 1 to 6. The results presented in tables 1 to 5 indicates that optimal K values are recorded for all coagulant dosages and $_{P}H$. However, the coag-flocculation performance at $_{P}H$=4 is high, followed by $_{P}H$ =10, and P^{H} =8 at 500mg/l. These facts are supported by the low values of $\tau_{1/2}$ recorded. The results show that low values of $\tau_{1/2}$ correspond to high values of K, which favors fast coag-flocculation process [3].

Variation in K_R is very minimal as shown in tables 1 to 5, because K_R is a function of viscosity and temperature, both of which are the coag-flocculation factors controlling the process, and did not vary considerably during the study. At nearly constant values of K_R, ε_p relates directly to $2K= \beta_{BR.}$ The implication is that high ε_p results in high kinetic energy to overcome the zeta potential. From the tables, it can be deduced that high values $\tau_{1/2}$ corresponds to low ε_p and K, an indication of repulsion in the system. Also, at all dosages and $_{P}H$, $\alpha = 1$, this is because the complexity of the system makes it difficult to get values of $\alpha = 2$, and a lower value of K is required to achieve this effect since K varies inversely with α. It can also be deduced from the tables that all values of R^2 fall within the range of 0.9, with few exceptions.

From the efficiency plots, it is shown that maximum efficiency is attained in all cases at 500mg/l coagulant dosages. With an increase in dosage from 100 to 500mg/l, there was a progressive increase in removal efficiencies of the coagulants. The peak $_{P}H$ value at which performance is highest is at $_{P}H$ =4 and at a dosage of 500mg/l. The efficiency here is within the range of 80-97% but at a lower percentage in other cases.

Efficiency E (%) Vs. Time Plots

Plots of E (%) vs. time are presented in figures 7 to 12. The efficiency illustrates the effectiveness of wild mango seed coagulant to remove turbidity with time, at varying dosage. Critical observation shows that the best coag-flocculaton performances at the conditions of these experiments were achieved at $_{P}H$ of 4, 6 and 8. The higher the degree of solubility of the coagulant, the greater the probability of their collision with the total dissolved solid particles. This is supported by the

maximum efficiency recorded as 97% and at low values of $\tau_{1/2}$. From the graphs, performance efficiency peaked in the first few minutes, thus satisfies the theory of rapid coagulation [3] which is actually obtained in real life application of coag-flocculation process where 90% of particle removal is usually achieved within the first 5mins..

Plot of Efficiency E (%) Vs. $_{P}$H

This is presented in figure 13. It shows the performance of wild mango seed coagulant at varying $_{P}$H and dosage. The figure presents that $_{P}$H affects the performance of the coagulant in removing total dissolved solid particles in dairy effluent. All doses have similar trend, attaining their highest coag-flocculation performance at $_{P}$H of 4 and lowest at $_{P}$H =12. The efficiency values all peaked at $_{P}$H of 4 as is evident in figure 13. This observation is a clear indication that wild mango seed is effective in acidic medium at all dosages.

Plot of E (%) Vs. Dosage

This is presented in figure 14. It shows that addition of coagulant caused substantial increase in turbidity removal. As the coagulant dosage is increased from 100mg/l to 500mg/l, the removal efficiency also increases. Hence, the higher the coagulant dosage used, the better the coag-flocculation performance. The optimum efficiency obtained here is E=97.22% at 500mg/l and $_{P}$H =4. Between 100mg/l to 500mg/l coagulant dosage, $_{P}$H =4 gives better performance and $_{P}$H of 10 has the least efficiency for all the doses.

Table1. *Coag-Flocculation Kinetic Parameters For Varying $_{P}$h And Constant 100mg/L Wms Dosage*

Parameters	PH=2	PH=4	PH=6	PH=8	PH=10	PH=12
α	1	1	1	1	1	1
R^2	0.7292	0.9458	0.9311	0.9437	0.8471	0.7084
K(l/mg.min)	1.9×10^{-3}	2.4×10^{-3}	3.1×10^{-3}	4.9×10^{-3}	3.5×10^{-3}	3.6×10^{-3}
$^{\beta}B_R$(l/mg.min)	3.8×10^{-3}	4.8×10^{-3}	6.2×10^{-3}	9.8×10^{-3}	7.0×10^{-3}	7.2×10^{-3}
K_R	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}
$^{\varepsilon}p$	5.63×10^{14}	7.12×10^{14}	9.19×10^{14}	1.45×10^{15}	1.04×10^{15}	1.07×10^{15}
$\tau_{1/2}$ (min)	4.22	3.14	2.50	1.67	2.35	2.34
-r	1.9×10^{-3}C	2.4×10^{-3} C	3.1×10^{-3} C	4.9×10^{-3} C	3.5×10^{-3} C	3.6×10^{-3} C

Table2. *Coag-Flocculation Kinetic Parameters for Varying $_{P}$h And Constant 200mg/L Wms Dosage*

Parameters	PH=2	PH=4	PH=6	PH=8	PH=10	PH=12
α	1	1	1	1	1	1
R^2	0.9685	0.8416	0.928	0.9004	0.9204	0.7671
K(l/mg.min)	2.8×10^{-3}	8.9×10^{-3}	8.9×10^{-3}	4.8×10^{-3}	5.1×10^{-3}	2.8×10^{-3}
$^{\beta}B_R$ (l/mg.min)	5.6×10^{-3}	1.78×10^{-2}	1.78×10^{-2}	9.6×10^{-3}	1.02×10^{-2}	5.6×10^{-3}
K_R	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}
$^{\varepsilon}p$	8.301×10^{14}	2.6×10^{15}	1.216×10^{15}	1.423×10^{15}	1.512×10^{15}	8.301×10^{14}
$\tau_{1/2}$ (min)	2.96	1.05	1.96	1.79	1.71	2.76
-r	2.8×10^{-3}C	8.9×10^{-3}C	4.1×10^{-3} C	4.8×10^{-3} C	5.1×10^{-3} C	2.8×10^{-3}C

Table3. *Coag-Flocculation Kinetic Parameters for Varying $_{P}$h And Constant 300mg/L Wms Dosage*

Parameters	PH=2	PH=4	PH=6	PH=8	PH=10	PH=12
α	1	1	1	1	1	1
R^2	0.9075	0.7683	0.8848	0.9092	0.8751	0.9875
K(l/mg.min)	2.7×10^{-3}	6.9×10^{-3}	3.7×10^{-3}	3.6×10^{-3}	4.1×10^{-3}	1.9×10^{-3}
$^{\beta}B_R$ (l/mg.min)	5.4×10^{-3}	1.38×10^{-2}	7.4×10^{-3}	7.2×10^{-3}	8.2×10^{-3}	3.8×10^{-3}
K_R	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}	6.75×10^{-18}
$^{\varepsilon}p$	8×10^{14}	2.05×10^{15}	1.1×10^{15}	1.07×10^{15}	1.22×10^{15}	5.63×10^{14}
$\tau_{1/2}$ (min)	3.03	1.30	2.14	2.33	2.08	4.01
-r	2.7×10^{-3}C	6.9×10^{-3} C	3.7×10^{-3} C	3.6×10^{-3} C	4.1×10^{-3} C	1.9×10^{-3} C

Table4. *Coag-Flocculation Kinetic Parameters For Varying $_{P}$h And Constant 400mg/L Wm Dosage*

Parameters	PH=2	PH=4	PH=6	PH=8	PH=10	PH=12
α	1	1	1	1	1	1
R^2	0.8568	0.9786	0.9586	0.9428	0.7598	0.7315
K(l/mg.min)	2.4×10^{-3}	2.2×10^{-3}	3.1×10^{-3}	4.8×10^{-3}	3.1×10^{-3}	5.3×10^{-3}
$^{\beta}B_R$ (l/mg.min)	4.8×10^{-3}	4.4×10^{-3}	6.2×10^{-3}	9.6×10^{-3}	6.2×10^{-3}	1.06×10^{-2}

K_R	$6.75x10^{-18}$	$6.75x10^{-18}$	$6.75x10^{-18}$	$6.75x10^{-18}$	$6.75x10^{-18}$	$6.75x10^{-18}$
$^{\epsilon}p$	$7.12\ x10^{14}$	$6.52\ x10^{14}$	$9.19x10^{14}$	$1.42x10^{15}$	$9.19x10^{14}$	$1.57x10^{15}$
$\tau_{1/2}$ (min)	3.38	3.44	2.51	1.73	2.69	1.64
-r	$2.4\ x10^{-3}C$	$2.2\ x10^{-3}\ C$	$3.1\ x10^{-3}\ C$	$4.8\ x10^{-3}\ C$	$3.1\ x10^{-3}\ C$	$5.3\ x10^{-3}\ C$

Table5. *Coag-Flocculation Kinetic Parameters for Varying $_{P}h$ and Constant 500mg/L Wms Dosage*

Parameters	PH=2	PH=4	PH=6	PH=8	PH=10	PH=12
α	1	1	1	1	1	1
R^2	0.9753	0.8729	0.9509	0.9606	0.9672	0.8516
K(l/mg.min)	$2.7x10^{-3}$	$9.7x10^{-3}$	$4.5x10^{-3}$	$5.8x10^{-3}$	$6.5x10^{-3}$	$4.3x10^{-3}$
$^{\beta}B_R$ (l/mg.min)	$5.4x10^{-3}$	$1.94x10^{-2}$	$9.0x10^{-3}$	$1.16x10^{-2}$	$1.3x10^{-2}$	$8.6x10^{-3}$
K_R	$6.746x10^{-18}$	$6.746x10^{-18}$	$6.746x10^{-18}$	$6.746x10^{-18}$	$6.746x10^{-18}$	$6.746x10^{-18}$
$^{\epsilon}p$	$8.005x10^{14}$	$2.8764x10^{15}$	$1.334x10^{15}$	$1.720x10^{15}$	$1.927x10^{15}$	$1.275x10^{15}$
$\tau_{1/2}$ (min)	3.09	0.98	1.82	1.52	1.39	1.84
-r	$2.7x10^{-3}$ C	$9.7x10^{-3}$ C	$4.5x10^{-3}$ C	$5.8x10^{-3}$ C	$6.5x10^{-3}C$	$4.3x10^{-3}$ C

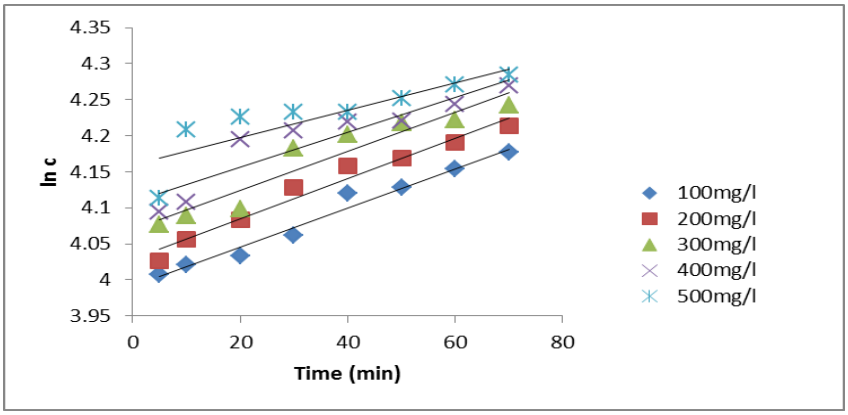

Fig1. *Linear plot of lnC as a function of time for varying WMS dosage and $_{P}H$ =2*

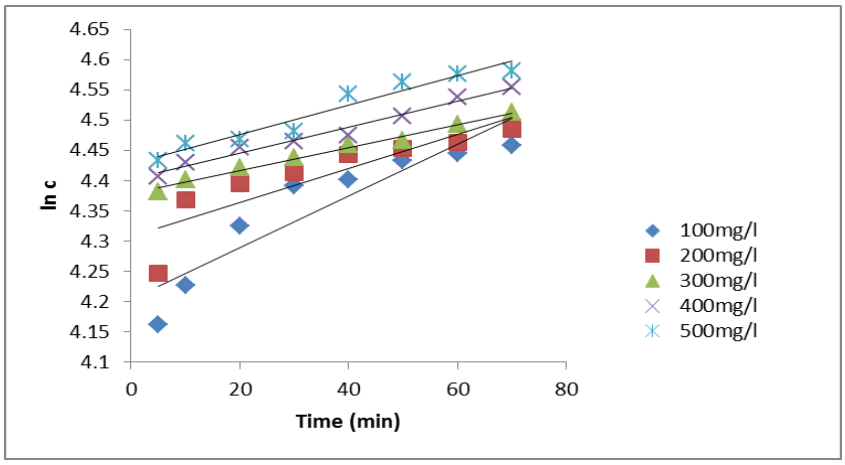

Fig2. *Linear plot of lnC as a function of time for varying WMS dosage and $_{P}H$ =4*

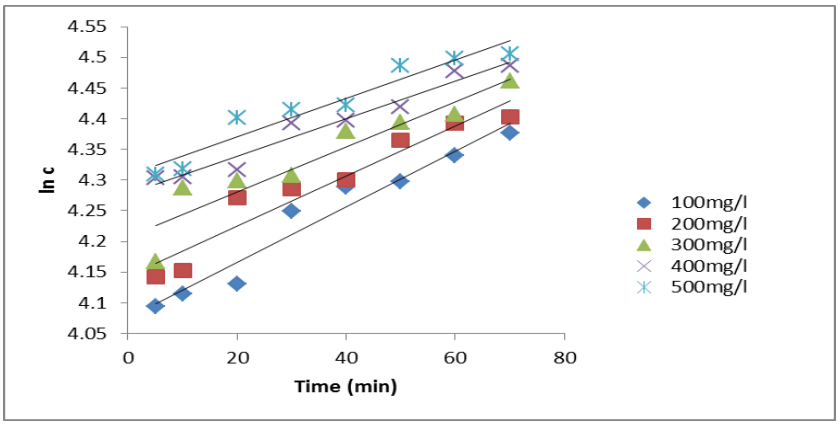

Fig3. *Linear plot of lnC as a function of time for varying WMS dosage and $_{P}H$ =6*

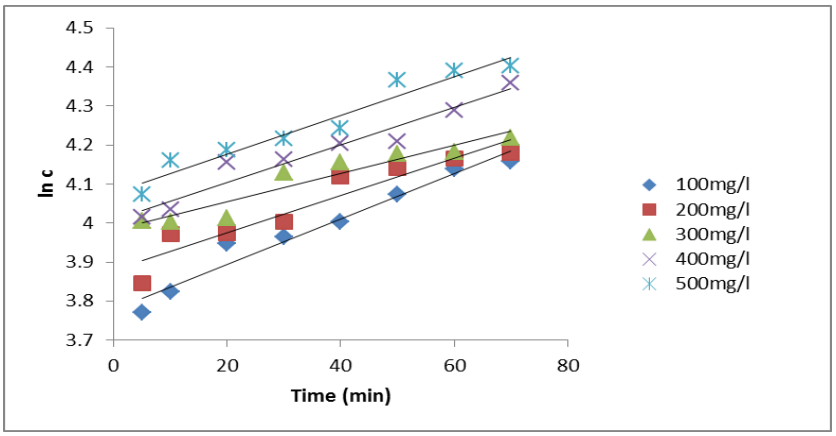

Fig4. *Linear plot of lnC as a function of time for varying WMS dosage and $_pH$ =8*

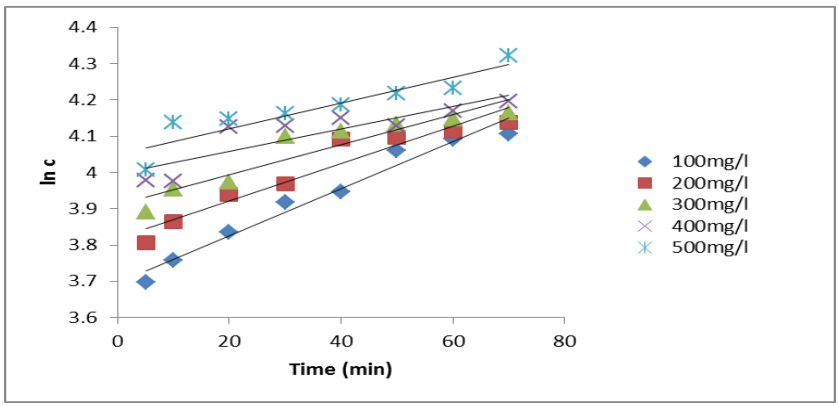

Fig5. *Linear plot of lnC as a function of time for varying WMS dosage and $_pH$ =10*

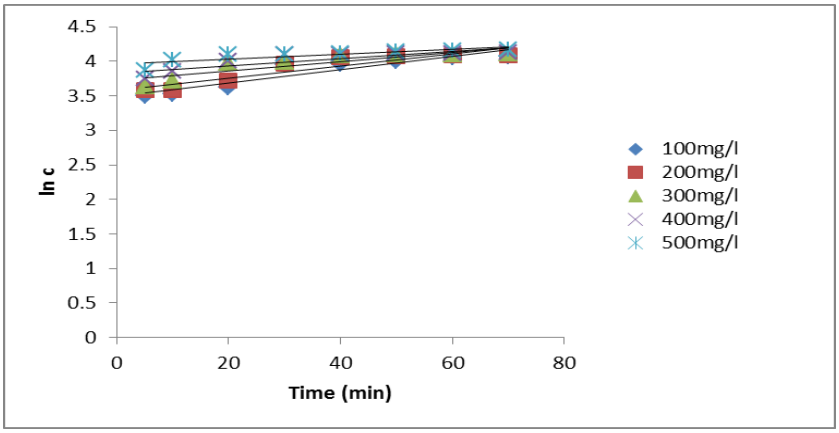

Fig6. *Linear plot of lnC as a function of time for varying WMS dosage and $_pH$ =12*

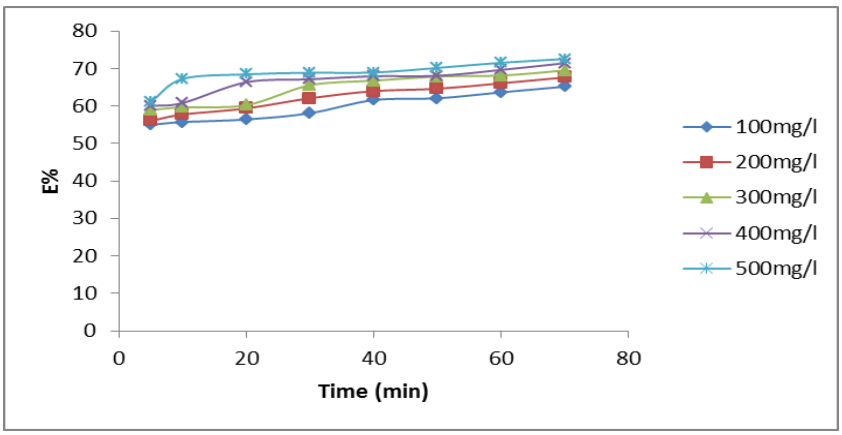

Fig7. *Representative plot of E% Vs coag-flocculation time at constant $_pH$ of 2 and varying WMS dosage*

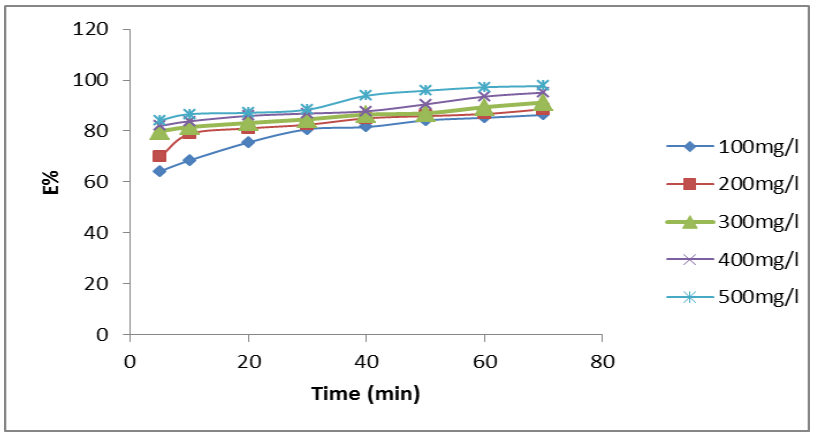

Fig8. *Representative plot of E% Vs coag-flocculation time at constant ₚH of 4 and varying WMS dosage*

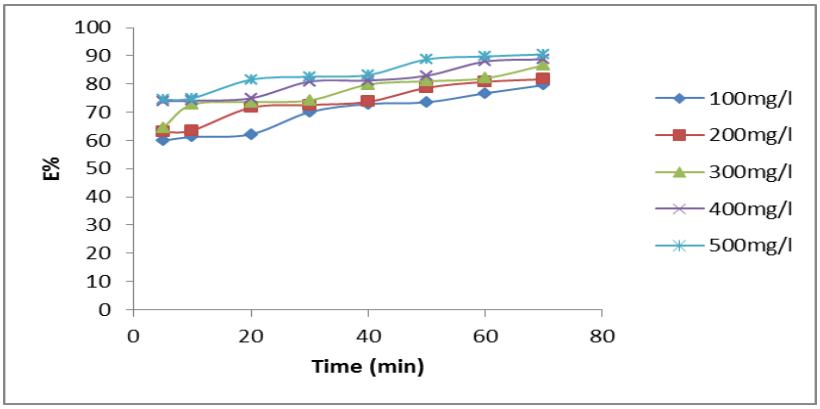

Fig9. *Representative plot of E% Vs coag-flocculation time at constant ₚH of 6 and varying WMS dosage*

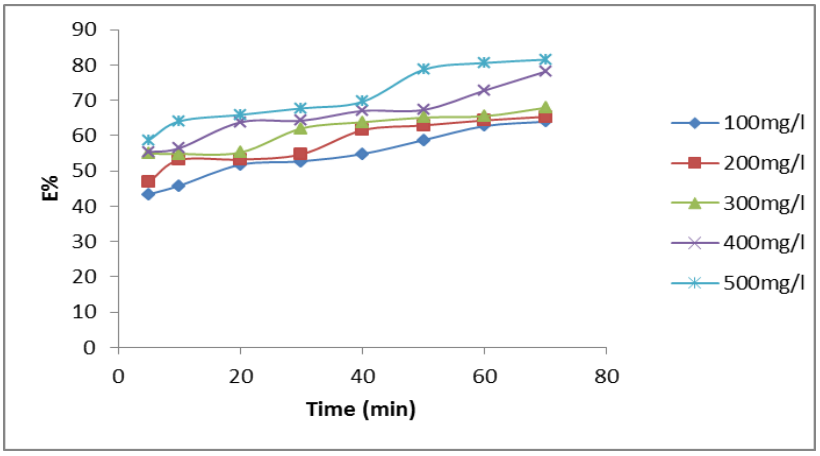

Fig10. *Representative plot of E% Vs coag-flocculation time at constant ₚH of 8 and varying WMS dosage*

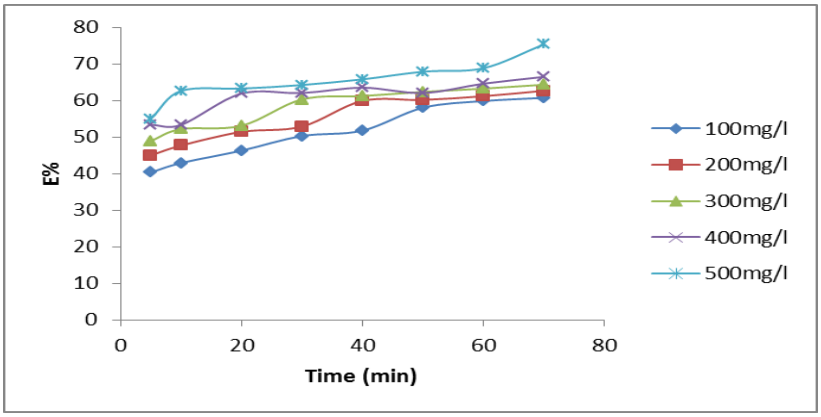

Fig11. *Representative plot of E% Vs coag-flocculation time at constant ₚH of 10 and varying WMS dosage*

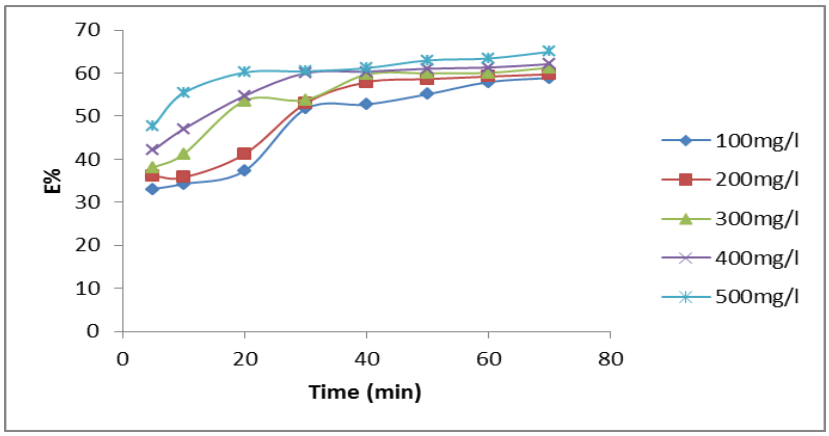

Fig12. *Representative plot of E% Vs coag-flocculation time at constant $_{P}H$ of 12 and varying WMS dosage*

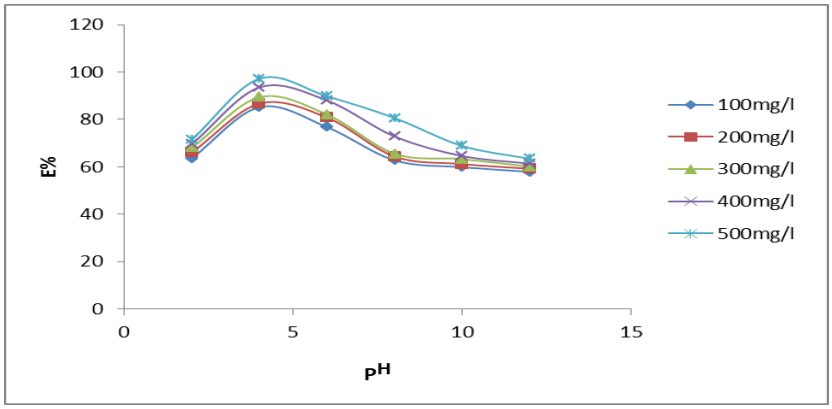

Fig13. *Representative plot of E% Vs $_{P}H$ at 60mins for varying WMS dosages*

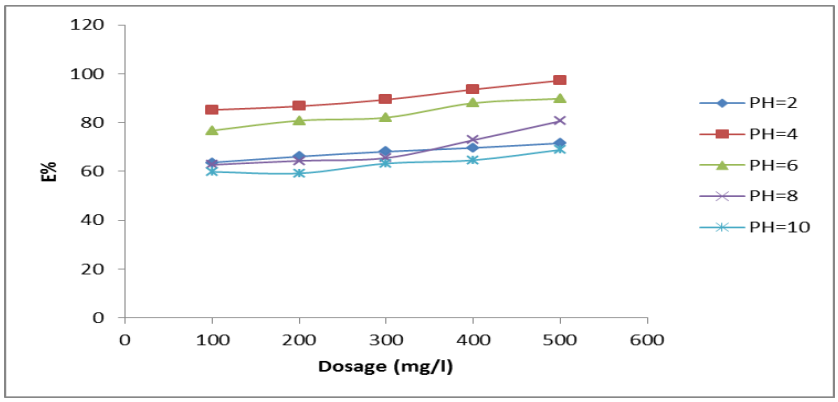

Fig14. *Representative plot of E% Vs dosage at 60mins for varying $_{P}H$*

CONCLUSION

Under the conditions of the experiment, the evaluation on the effectiveness and efficiency of WMS for the removal of turbidity in dairy effluent has been carried out. Experimental results indicate that for dairy effluent, maximum value of K is recorded for $_{P}H$ =4 with corresponding low value of $\tau_{1/2}$ (mins). This means that wild mango seed was successfully used to treat dairy effluent. The experimental deduction therefore, presents wild mango seed as a plant-based-derived coagulant. The experimental results with respect to functional parameters agree with similar previous works [3]: [8]: [6]

NOMENCLATURE

K: α^{th} order coag-flocculation constant

β_{BR}**:** Collision Factor for Brownian Transport

ε_{p}**:** Collision Efficiency

$\tau_{1/2}$ **:** Coagulation Period/ Half life

E: Coag-flocculation Efficiency

R^2: Coefficient of Determination

α**:** Coag-flocculation Reaction Order

-r: Coag-flocculation Reaction Rate.

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