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APPLICATION OF WATERMELON SEED CAKE FOR TURBIDITY REMOVAL AND TREATMENT OF MICROOGANISM FROM WASTE WATER

FRANCIS SAMUEL, SARAH OLOBOH, S.O OMALE,

Department of Chemical Engineering, Kaduna Polytechnic, Kaduna, Nigeria.

Abstract

This paper is aimed at the removal of turbidity from raw water and treatment of microorganism from the water using watermelon seed cake. The high turbid raw water was obtained from river Kaduna and Jar test experiment to determine the effect of dosage, stirring time and mixing speed on coagulation was conducted. The

Keywords

Watermelon seed, Water treatment, Coagulation, Turbidity removal, Microorganism reduction,

INTRODUCTION

Most of the time water from surface water resources have a high level of turbidity and need to be treated with flocculation/coagulation to remove the turbidity. Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. Turbidity is considered as a good measure of the quality of water. High turbidity levels can reduce the amount of light reaching lower depths of lakes, rivers and reservoirs, which can impede the growth of submerged aquatic plants and subsequently affect species which are dependent on them such as fish and shell fish. World Health Organization

results showed that at dosage of 0.2 g/l stirring time of 5 min and mixing speed of 100 rpm, optimal removal of turbidity was achieved. The turbidity removal obtained was below the world health organizations (WHO) recommended value of 5NTU. The microbial investigation on the raw water found the presence of E. coli (Escherichia coli) bacteria and Pseudomonas Species, using Membrane Lauryl Sulphate Broth and Modified Wallerstein Laboratory Nutrient Agar respectively. After the treatment it was found that the colonies of the microorganism were greatly reduced. The results obtained show that watermelon seed can be used as a natural coagulant also for the microbial treatment of water.

established that the turbidity of drinking water should not be more than 5 NTU (EPA, 2006). The turbidity of water also causes the suspended solids particles to act as shields for the virus and bacteria (Vlyssides *et al.*, 2002). This further increases microbial load of the water.

In water treatment, coagulation-flocculation is involved. It entails the addition of compounds that promote the clumping of fines into larger flocs so that they can be more easily separated from the water. Coagulation is a chemical process that involves neutralization of charge whereas flocculation is a physical process and does not involve neutralization of charge. Most colloids are stable because they possess a negative charge that repels other colloid particles before they collide with one another (Ebeling *et al.*, 2004). Since colloids are stable because of their surface charge, in order to destabilize the particles, the charge must be neutralized by addition of an ion of opposite charge to the colloid. Both the terms coagulation and flocculation convey the same connotation, implying the aggregation of suspended colloidal or fine particles in a liquid. Nevertheless, in coagulation, this aggregation process is aided by the addition of multivalent inorganic electrolytes, such as $AlCl_3$, $FeCl_3$, alum or $CaCl_2$ into the medium, whereas in the process of flocculation, the inducing agents are organic electrolytes such as polymers (or flocculants). For the removal of turbidity from water or wastewater, these are the most commonly used methods (Gregory, 1989). The two main aims of the coagulation or flocculation process are: to settle the suspended colloidal particles in water/wastewater rapidly, which settle very slowly, or perhaps do not settle at all under normal conditions, hence leading to residual turbidity, and to remove residual turbidity from the water/wastewater and consequently to obtain clearer water/wastewater, which is a natural outcome of the former. In a turbid water (or suspension), the optimum conditions for the rapid sedimentation of suspended particles, i. e., flocculant/coagulant type, dosage, and pH of medium, may not be the optimum conditions for removal of residual turbidity from the water (Bahri et al., 2009)

Developing countries like Nigeria are facing potable water supply problems because of insufficient financial resources. Approximately 80% of illnesses in developing countries are directly connected with unclean drinking water (WHO, 2004). The available sources of water in the localities are usually the ground water, surface water and rain water. Potable water which is safe for drinking must be free from pathogenic organisms, toxic substances and excess of minerals and organic pollutants. In addition, it must be colourless , tasteless and odourless for consumers to find it attractive (Yongabi, 2010). The increased in the number of industries and urbanization, the volume of domestic and industrial effluent discharge, agricultural waste and urban run offs is gradually increasing. These gradual increase in the amount of water used and waste water produced by urban communities and industries throughout the world poses potential health and environmental problems (Coleman *et al.*, 2001). Waste water treatment is necessary in order to remove the contaminants so that the treated water can meet the acceptable quality standards (Madhavi and Rajkumar, 2013). The quality standards usually depend on whether the water will be re-used or discharged into a receiving stream.

There are a number of processes involved in the treatment of waste water before drinking. This is based on the quality of the water sources such as turbidity, amount of microbial load present in water and others include cost and availability of chemicals in achieving desired level of treatment (Muyibi *et al.*, 2009). In the raining season, the quality of the river water is not steady due to suspended and colloidal particle load caused by anthropogenic activities and high storm run-off, and the need for water treatment chemicals increase as well, which leads to high cost of treatment (Rusal *et al.*, 2006). Not only is the use of chemical coagulants expensive but detrimental to health. The monomers of some synthetic organic polymers such as acrylamide have neurotoxic and strong carcinogenic properties (Ghebremichael, 2004). In addition, Muhammad *et al.* (2015) reported a number of serious setbacks associated with the use of aluminium salts such as Alzheimer's disease caused by high aluminum residuals in treated water, excessive sludge production during water treatment and considerable changes in water chemistry due to reactions with OH- and alkalinity of water. The common chemical coagulants are aluminum sulphate, ferric chloride, polyaluminum chlorides and synthetics polymers.

Considering all the problems associated with the use of chemical coagulant in water treatment, there is a need to replace it with natural coagulant because the latter is safer for human health and biodegradable (Ghebremichael, 2004). Furthermore, studies have shown that using natural coagulants instead of aluminum salts for water treatment provide advantages such as lower costs of water production, less sludge production and ready availability (Daniyan *et al.*, 2011). The seeds of moringa oleifera have been proven to be one of the most effective coagulants in water treatment or purification (Ali *et al.*, 2010). It is reported that watermelon (*Citrulluslanatus*) seeds is a potential natural coagulant for water treatment because of its high protein, vitamin and mineral contents (Muhammad *et al.*, 2015). (Misau and Yusuf, 2016) reported that the mineral elements present in water melon seeds which may have aided its coagulant properties were Al, Ca, Mg and Fe etc. It is also reported that the active coagulants in plant extracts are proteins, tannins and saponins, and they possess an ability to bind with other molecules tightly. (Talbot *et al.*,1995). Hence, this study aims at harnessing watermelon seed cake as coagulant for turbidity removal and reduction of microbial load from waste water.

MATERIALS AND METHODS

Materials

The materials used included water from river Kaduna, watermelon seed cake, N-hexane, distilled water, Soxhlet extractor, pH metre , electronic weighing balance, thermometer, drying oven, electric hot plate, flocculator, pipette, beakers, cylinders, conductivity meter, turbidimeter, stop watch. All the chemicals used were of analytical grade.

Methods

a. Watermelon Seed Cake Preparation

Fresh seeds of water melon (citrullus lanatus) of the cucurbitaceous family were obtained from the rail way market in Kaduna north local government area Kaduna state, Nigeria. The fruits were sliced open using a sterilized stainless steel laboratory knife. The seeds were washed severally with water, sun dried two weeks, sorted to remove bad ones, shelled and grounded with a high speed laboratory electric blended and packed in an air tight container. 150 g of the crushed seeds were then packed in a thimble and placed in a soxhlet extraction apparatus. 500 ml N-hexane was used to extract oil from the crushed seed in the column. The apparatus was left to run for six hours and stopped when the extraction was complete. The cake was then washed with distilled water to remove residual hexane, and sun dried and then sieved in a 120 μm sieve. The finer particles were then used as the coagulant.

b. Raw Water Collection and Characterization

The raw water sample was collected from River Kaduna by immersing a 25 L plastic container into the water until it was filled up. The cap was inserted while it was still underway. The physical properties of the raw water were then determined.

c. Raw Water Microbial Analysis

100 ml of the raw water sample was taken to the laboratory for analysis to determine the microorganisms present, the medium used were Modified wallerstein Laboratory Nutrient Agar and Membrane Lauryl Sulphate Broth and the technique used was membrane filtration technique in a Laminal membrane Filter.

d. Water Quality Tests

i. Turbidity

Turbidity of the water sample was measured before and after treatment using a turbidimeter in accordance with the international methods of water quality measurement and the results was recorded.

ii. Total Solid

Sample of the raw water was taken in 100 ml beaker. A clean and dry crucible was weighed empty and he sample was then poured into it and reweighed. The respective weight was recorded and the crucible together with the sample water was placed on hot plate at 104^0C to evaporate the water. When all the water evaporated, the crucible was allowed to cool down and reweighted together with the residue the total solid present was calculated using the equation:

TS = 100 (A-B) 1200 ml Where

A = weight of (crucible + water) - weight of crucible empty

B = weight of (crucible + residue)

iii. Total Suspended Solid (TSS)

100 ml of the raw water was poured in a sample bottle. The weight of a dry filter paper was taken empty and the sample water was filtered and the residue dried at 35 - 40^0C in an oven. The new weight of the filter paper plus residue was taken down. The difference in the weight of the filter paper empty and with residue after drying was calculated and divided by total volume of sample.

iv. Total Dissolved Solid (TDS)

This was obtained by taking the difference between TSS and or two – thirds of the conductivity using the conductivity meter.

v. pH

The pH of the sample was taken using an electronic pH meter

e. Jar Test

The Jar test setup was employed to carry out coagulation and flocculation on the water samples and to determine the effects of coagulant dosage, stirring time and mixing speed and the optimum conditions which they occur. Five beakers each 1litre capacity was used to study the effect of coagulant dosage on coagulation, effect of pH an coagulation and the effect of stirring time and mixing speed an coagulation. The following parameters (turbidity, TDS and conductivity) were measured on the filtrate after the coagulation was completed.

Five different samples of the coagulant of weight 0.2 g, 0.4 g, 0.6 g, 0.8 g and 1.0 g were placed in each beaker. The raw water sample was added to make up the 1000 ml mark and the jar's were placed in the jar test kit and the stirrers lowered into each. The mixing speed was set at 100 rpm for rapid mixing for 2 mins. After this step was completed the samples was allowed to settle for 30 min and flocs filtered using a filter paper and the parameters listed above were measured on the filtrate. From the results, the dosage with the best results in turbidity removal was taken as the optimum.

To determine the optimum stirring time, the same procedure was used. The optimum dosage of 0.2 g was used. The stirring time was varied from 5 mins-25 mins at 5 mins time interval. After the coagulation-flocculation process was completed for each, the samples were then filtered and the filtrate was used to test for the physical parameter. The stirring time with the best turbidity removal was taken as optimum.

The optimum dosage of 0.2 g was again maintained in all the beakers while the mixing speed was varied from 50 rpm-250 rpm at 50 rpm interval. After the coagulation-flocculation process was completed for each, the samples were filtered and the filtrate was used to determine physical properties of the treated water. The mixing speed with the best turbidity removal was taken as the optimum.

The same procedure above was repeated with a coagulant dose of 0.2 g/L being maintained in all the five beakers. The pH was varied from 6.0 – 8.0 by the addition of few drops of 1M NaOH into the beakers to increase the alkalinity. A few drops of 1M H_2SO4 solution were also added in the first two beakers to make it slightly acidic at 5.5. – 6.5. The pH at which the best turbidity removal was observed at was taken to be the optimum pH for coagulation. Effect of temperature was also studied. The optimum dosage of 0.2 g/l was used in all the beakers.

The temperature of water was varied from 10 – 30^{o}C. The temperature at which the best turbidity removal occurred was taken to be the optimum temperature for coagulation.

f. Microbial Analysis of the Treated Water

Using the optimum dosage, optimum stirring time and optimum mixing speed of 0.2 g, 5 mins and 100 rmp respectively, the treated water was subjected to the same test as was done for the raw water to determine whether there was reduction in concentration of the microoganism after coagulation and flocculation.

RESULTS AND DISCUSSION

Results

Table 1: Initial Raw Water Properties

Property	Raw water	WHO Standard
Temperature (0C)	26.1	Ambient
PH	7.9	6.5-8.5
Conductivity (µS/cm)	0.04	1000
Turbidity (NTU)	542	5
Tolal dissolved solid (mg/L)	39	<300
Dissolved Oxygen (mg/L)	3	5-7

Table 2: Effect of Watermelon Seed Dosage on Coagulation

S/No	Dosage g/L	Tempt. ^{0}C	P^H	Conductivity µs/cm	Turbidity NTU	TDS mg/L	DO
1	0.2	26.7	6.6	0.03	248	37	3.47
2	0.4	26.9	7.0	0.04	284	42	4.82
3	0.6	27.1	7.2	0.04	302	39	5.21
4	0.8	26.9	7.4	0.03	310	53	6.27
5	1.0	27.9	7.7	0.05	348	62	8.02

Table 3: Effect of mixing speed on coagulation at a dosage of 0.2 g

S/No.	Speed Rmp	Tempt. ^{0}C	pH	Conductivity µs/cm	Turbidity NTU	TDS mg/L
1	50	27.1	7.2	0.04	283	41
2	100	26.6	7.4	0.06	233	48
3	150	26.8	7.3	0.07	343	53
4	200	27.2	7.2	0.08	371	56
5	250	27.1	7.2	0.11	498	61

Table 4: Effect of stirring time on coagulation at a dosage of 0.2 g

S/No.	Time Min	Tempt. ^{0}C	pH	Conductivity µs/cm	Turbidity NTU	TDS mg/L
1	5	27.2	7.4	0.04	253	37
2	10	27.1	7.4	0.03	308	43
3	15	27.2	7.6	0.05	373	57

4	20	27.2	7.7	0.07	404	62
5	25	27.2	7.2	0.07	427	79

Table 5: Effect of P^H on coagulation at a dosage of 0.2 g

S/No	P^H	Tempt.^{0}C	Conductivity, µs/cm	Turbidity, NTU	TDS mg/L
1	**5.5**	**27.2**	0.08	450	43
2	**6.5**	**27.1**	0.06	435	50
3	**7.5**	**26.8**	0.06	366	67
4	**8.5**	**27.3**	0.05	327	72
5	**9.5**	**27.1**	0.06	398	59

Table 6: Effect of temperature on coagulation at a dosage of 0.2 g

S/No	Tempt.^{0}C	P^H	Conductivity, µs/cm	Turbidity, NTU	TDS mg/L
1	**10**	**7.1**	0.05	446	45
2	**15**	**6.8**	0.07	435	57
3	**20**	**7.3**	0.07	302	67
4	**25**	**7.2**	0.06	312	62
5	**30**	**7.4**	0.07	319	65

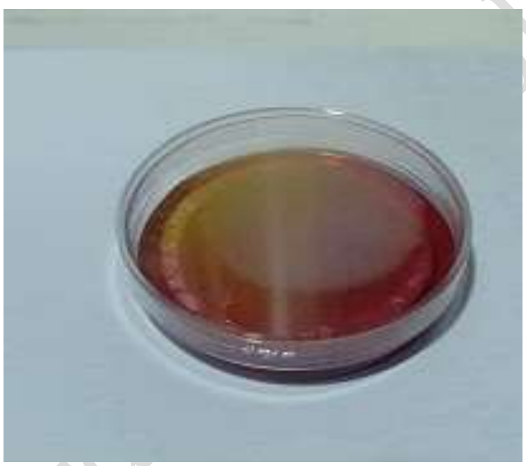

Plate 1a: E. coli present in raw water

Plate 1b: Pseudomonas present in raw water

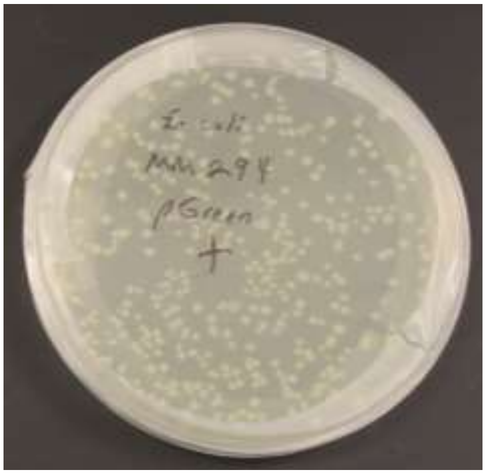

Plate 2a: E.Coli colony after treatment

Plate 2b: Pseudomonas colony after treatment

Discussion of Results

From Table 1 above, it is observed that the turbidity value of raw water was with the range of 150-1500 NTU which is classified as high turbidity water (Doerr, 2005). The Temperature and pH of the raw water were almost at the same range as the WHO recommended values.

Table 2 shows the results of the effect of coagulant dosage on coagulation. The dosages were varied from 0.2 g/L – 1.0 g/L for each sample treated. The settling time of 25 minutes was used and the samples filtered as longer time periods were observed for complete settling to take place. At varying dosage no significant changes were observed on pH, temperature, conductivity and TDS for the water sample treated with watermelon seed cake as coagulant, however, there was a notable decrease in the turbidity of the water sample after treatment. The observation on pH and conductivity made in this present study were in accordance with previous studies on coagulation and flocculation ability of some seeds by Ndabigengesere *et al.,* (1995). The greatest decrease was seen at the dose of 0.2 g/L of raw water which reduced the turbidity from 542 to 248 NTU, this value is still above the WHO recommended level of 5 NTU, however, according to Arnoldsson *et al*., (2008), the optimal dosage for a specific water is defined as the dosage which gives the lowest turbidity in the treated water therefore the optimum dosage is 0.2g/L. However, TDS result was not in agreement with Mangale *et al*., (2012) who stated that

TDS was reduced after the treatment with watermelon seed cake. This may have been due to the different pre-treatment step used in this study. This value is still large in comparison with the WHO recommended standard of less than 15 TCU. It showed that with increase of coagulant the conductivity increases. Regarding the DO, it improved from 3.0 to 8.02 mg/L after the treatment. Watermelon seed cake concentration is directly proportional to the DO value. DO value was between 3–8.02 mg/L after the treatment. Therefore, it was concluded that water treatment with watermelon seed has an important role in increasing the DO value.

From Table 3, the effect of mixing speed on coagulation is observed to only have a moderate effect on the coagulation process. This is in conformity with the conclusions of Othman *et al.,* (2008). Slight changes were observed for the pH and temperature values recorded, however the pH after coagulation remained more neutral than acidic or alkaline. There was no much difference in the temperature change from the original to that after coagulation; therefore there is no marked effect on temperature. No significant changes were recorded at speed of 150 and 200rpm for turbidity. It therefore means that at lower stirring speed the removal of turbidity was higher due to reduced shearing of the flocs during initial formation may be improved. This is in agreement with the results of Ebeling *et al* (2004).

Table 4, shows the result for the optimum stirring time. The stirring time of 5-25 mins was used. The results obtained show no significant changes in pH or temperature. The temperature remained constant, over a range of stirring time. The TDS values obtained are below 300 which are excellent; it has its highest value at the highest stirring time. This would indicate that significant increased stirring time at 25 mins and above can cause increase in the TDS and conductivity content in the treated water. Also at stirring time of 5 mins a turbidity value below the WHO recommended value was obtained. Therefore, the best turbidity removal was obtained at a stirring time of 5 minutes.

From the result of the effect of P^H shown in Table 5, the recommended pH range for efficient coagulation is usually between 6.0 to 8.5 (Othman *et al*., 2008). When the pH of the raw water was made more acidic at 5.5, the values of the turbidity removal was 450 NTU. Also, when the pH of the raw water was made slightly basic, at 9.0, the value of the turbidity removal was 398 NTU. At pH of 8.5 the best turbidity removal was obtained to be 327 NTU. The results of Table 5 shows that pH that is too low may not allow efficient coagulation process to proceed while a high pH can cause a coagulated particle to re-disperse.

The temperatures of the water affect the coagulants during water treatment (Zhang *et al*., 2009). Table 6 shows that when the temperature of the raw water was kept to 10^{o}C, the value of the removal of turbidity was 446 NTU which showed a decrease in the efficiency of the coagulant. Likewise, when the temperature of the raw water was increased to 30^{o}C, the value of the turbidity was 319 NTU this value revealed a decrease in the efficiency of the coagulant. The best result of removal of turbidity was 302 NTU at 25^{o}C. This suggested an increase in the efficiency of the coagulant to removing turbidity.

Plate 1a and 1b shows that the microorganisms found were E.coli (*Escherichia coli) bacteria and Pseudomonas Specie, using Membrane Lauryl Sulphate Broth and Modified Wallerstein Laboratory Nutrient Agar respectively.* 727 total coliform strains representing 98 species belonging to the Enterobacteriaceae for the E. Coli and 56 CFU/ml of sample for the Pseudomonas.

The effect of treatment of the water on microbial load is shown in plate 2a and 2b.

Using the optimum dosage, stirring time and mixing speed of 0.2 g, 25 mins and 100 rmp respectively, it was observed that the total strain dropped from 727 to 437 total coliform strains representing 72 species belonging to the Enterobacteriaceae for the E. Coli and for the Pseudomonas, the concentration of the bacteria dropped from 56 CFU/ml to 37 CFU/ml. This shows that the coagulant has the potential of reducing microorganism in waste water.

CONCLUSIONS

From the study the following conclusions can be drawn:

i. The optimum dosage of 0.2 g/L, optimum mixing speed of 100 rpm, and optimum stirring time of 5 minutes were the best for turbidity removal.

ii. The microorganisms found in the raw water were E.coli (*Escherichia coli) bacteria and Pseudomonas Specie. After* the treatment with the seed cake the total strain dropped from 727 to 437 total coliform strains representing 72 species belonging to the Enterobacteriaceae for the E. Coli and for the Pseudomonas, the concentration of the bacteria dropped from 56 CFU/ml to 37 CFU/ml.
iii. This shows that the use of watermelon seed cake as a coagulant was found to improve the quality of the treated water.

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