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Performance of Granulated Groundnut (Arachis Hypogea) as Coagulant for Water Treatment

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Abstract

Natural plant materials are cost effective and environmentally friendly; they do not produce poisonous secondary by-products and therefore cannot result to climate change. They are also locally available and readily implementable. These characteristics makes them potential alternative to aluminium sulphate and other chemicals in water coagulation. In this Project work, the effect of the performance of granulated groundnut as a coagulant for water treatment was aimed and the specific objectives were to fabricate a jar tester, study the effect of selected parameters such as the effect of speed, dose and time on the coagulation process, analyze the chemical composition of groundnut, and evaluate the performance of the granulated groundnut as coagulant in reduction of total suspended solid in turbid water. This was done by conducting laboratory test for total suspended solids in turbid water. Total suspended solids in turbid water sample were measured before and after the Jar testing using varying doses of groundnut extracts by using portable instruments. The experiments were carried out with coagulant dosage of 20 ml, 50 ml and 100 ml respectively. Total dissolved solids removal efficiency of groundnut obtained from this study was 80.00% at a dosage of 0.9mg/l. Groundnut thus exhibited high efficiency in removing Total Suspended Solids. Also, Regression test was done using Excel software and Data Fit software to obtain an equation to study the relationship between selected parameters such as the effect of speed, dose and time on the coagulation process and it was concluded from the equation obtained that the total suspended solid in turbid water produced was reduced best at the reliability (R2) value gotten as 0.9839 which indicates that granulated groundnut when used as a coagulant in removal of total suspended solids will be 98.39% efficient.

1. Introduction

The fresh water is of vital concern for mankind, since it is directly linked to human wellbeing. The surface waterbodies, which are the most important sources of water for human activities are unfortunately under severe environmental stress and are being threatened as a consequence of developmental activities. In developing countries, large sections of the population may be dependent on raw water for drinking purposes without any treatment whatsoever [1-3].

This water source can be polluted by various ways like chemicals, agricultural runoff and human and animal feces. Furthermore, unhygienic handling of water during transport or within the home can contaminate water that was previously safe. The World Health Organization has estimated that up to 80% of all diseases and sickness in the world is caused by inadequate sanitation, polluted water or unavailability of water however, 10% could be prevented by improvements related to drinking water, sanitation, hygiene and water resource management [4]. The people at greatest risk due to unsafe water are children, people living under unsanitary conditions and the elderly (WHO, 2006). But this can be reduced through the provision of household water treatment techniques and potentially billions of people can benefit from effective household water treatment. Household water treatment applications are any of a range of technologies, devices or methods purposes of treating water at the household level or at the point [5].

Coagulation and flocculation are important processes in water treatment. Raw water may contain suspended particles of clay, sand and silt that are too tiny to settle and which cannot be removed by sedimentation or filtration. The purpose of coagulation is to alter these particles such that they can adhere to themselves and grow to such a size that they can be removed by sedimentation and filtration. Coagulation is a process of water treatment which destabilizes colloidal particles (particles in the range of 0.001 to 1μm). Coagulation is usually followed by flocculation, sedimentation and filtration which are physical processes. Colloidal particles remain suspended in solution because of the net negative charge which they carry and which causes the particles to repel themselves. Therefore, the action of the coagulant is to neutralize the net negative charge and allow the colloidal particles to come together, adhere to themselves and form larger particles (flocs) which is easily removed from the raw water.

Coagulation is the process of destabilization or neutralization of negatively charged colloidal particles in water usually by a chemical means so that they form coagulum which are capable of settling under gravity owing to their weight. Therefore, coagulation can be applied to remove dissolves chemical species and turbidity from water [6-8]. However, filtration process can also be used for the treatment of water. Filtration can be referred to as a process used to separate solids from liquids or gases using a filter medium that allows the fluid to pass but not the solid.

Filtration as a term applies whether the filter is mechanical, biological, or physical. The fluid that passes through the filter is called the filtrate and the solid material is held back is called the residue. Filtration is typically an imperfect process since at the end of the process, some fluid remains on the feed side of the filter or embedded in the filter media and some small particles fine their way through the filter. Other methods/process of water treatment include; Disinfection process, Sterilization process, Adsorption process, Sedimentation Process, etc.

The commonly used metal coagulants can be classified into two general categories: those based on aluminum and those based on iron [9-11]. The aluminum coagulants include aluminum sulfate, aluminum chloride, sodium aluminate, aluminum chlorohydrate, polyaluminum chloride, polyaluminum sulfate chloride, polyaluminum silicate chloride, and forms of polyaluminum chloride with organic polymers. The iron coagulants include ferric sulfate, ferrous sulfate, ferric chloride, ferric chloride sulfate, polyferric sulfate, and ferric salts with organic polymers. Other chemicals used as coagulants include hydrated lime and magnesium carbonate [12].
Although many plant-based coagulants have been reported, only four types are generally well known within the scientific community, namely, Nirmali seeds (Strychnospotatorum), Moringa oleifera, Tannin and Cactus

2.. Methodology

2.1 Equipment used for the experiment

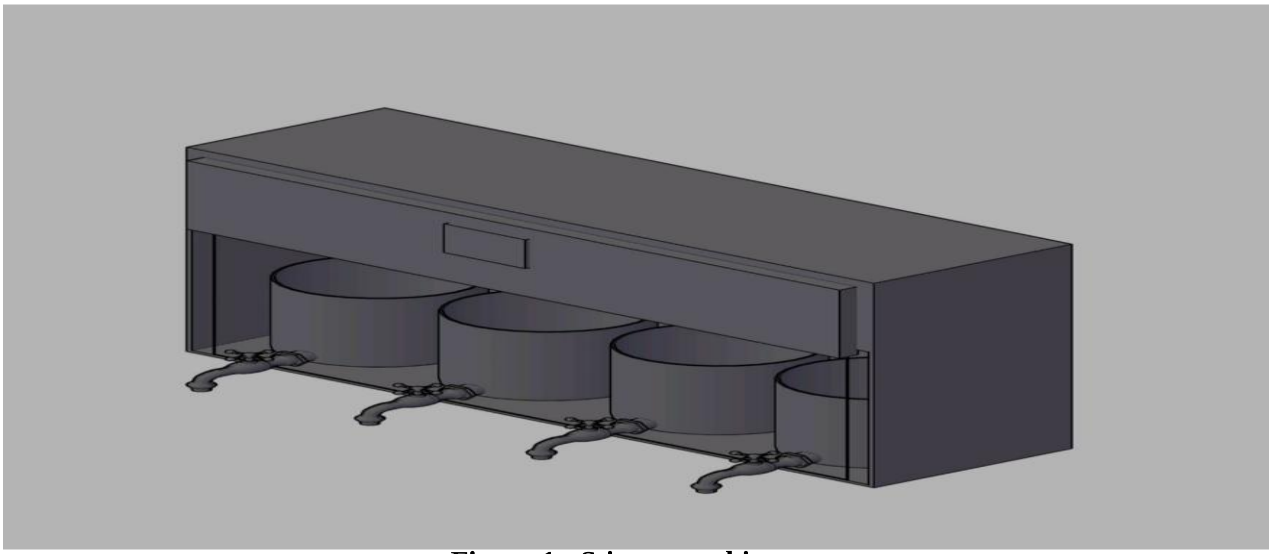

Figure 1: Stirrer machine

The stirrer machine is cuboidal in shape and have the following dimensions: length-787.4mm, height-609.6mm, and width-228.6mm. It is made of 10mm hard steel pan. The stirrer machine weighs approximately 20.5kg and can operate fully with a 220V-5KVA generator. Air vents are around the sides of the stirrer machine. This is to allow air inside the stirring compartment for cooling purpose.

The stirrer machine is use to perform the experiment. Its major use is to stir different liquids. It is electrically powered and consist of the following:

- Power cable (2.5mm copper wire).
- Four heating elements (500 watt each).
- A stirring drive (304.8mm long).
- Stirring compartment made up of four units, each 1.8mm thick.
- Four stop and discharge taps (made with pvc).
- Four motor drive (85 watt each) with three speed 1050rpm, 850rpm and 650rpm.
- A contactor which gives the element direct current.
- A temperature controller.
- A thermo couple for sensing heat.
- A motor regulator for regulating speed.
- Gum and silicon sealant.

Other major equipment used in this study is presented in Table1. Minor equipment includes: digital weighing balance and sieves while the glass wares include: reagent bottles, conical flask, measuring cylinder, glass funnels and beakers.

Table 1. Equipment Detail

S/N	Equipment Description
1	Scanning Electron Microscope (SEM) Department of Chemistry (Kwara State University) Model- APEX 3020 PSEM
2	Fourier Transform Infra-red (FTIR) Cherish Environmental Lab (IBADAN) Model- FTIR 2000, Shimadzu Kyoto, Japan
3	X-ray Fluorescence (XRF) Cherish Environmental Lab (IBADAN) Model- APEX 3022
4	Digital Turbidity Meter Civil Engineering Lab (UNIBEN) Model- DHG 9101-2A

2.1.1 Analysis of Microstructures

To examine the microstructural arrangement of granulated groundnut, scanning electron micrograph (SEM) was employed. Result of the scanning electron micrograph is presented in Figure 3.4.

2.1.2 Chemical Composition

The chemical composition of the coagulant was studied using X-Ray Fluorescence[13]. Chemical digestion of the solid coagulant was done in accordance with the procedure given by [14] as follows: (1:1 v/v) mixture of 0.25M solution of hydrochloric acid and Nitric acid was prepared. A mixture of (1:10 w/w) of the solid coagulant to acid solution was obtained and stirred for 30 minutes. The solution was filtered and the filtrate was used for the analysis.

2.2 Design of Experiment

The focus of the design of experiment was to investigate the effect of three variables which were very critical to the treatment process namely; Stirring speed, coagulant dose and stirring time. The design response was to look at the effects of these variables on the level of total suspended solids. Selectivity of the response variable total dissolved solids was based on the fact that it is one of the important parameters that can be employed to justify the adequacy of coagulation as a water treatment process. The optimization objective was to minimize total suspended solids. The final solution of the optimization process was to determining the optimum value of each input variable viz; coagulant dose (ml), stirring time (min) and stirring speed (rpm) that will yield a product water with total suspended solids.

2.2.1 Preparation of turbid water

10% concentrated solution of natural clay (turbid water) was prepared by dissolving 10g natural clay in 100ml distilled water. The solution was made up to 20000ml using distilled water and the initial values of total suspended solids (TSS) of the turbid water was measured and recorded as 4.5mg/L. The solution was kept in cleaned dried plastic container for use throughout the period of experimentation.

3. Results and Discussions

Table 2: Summary of Results

Sample label	Volume of suspension (V) ml	Speed used () rpm	Total time interval () min	Dose of Coagulant added () ml	Initial weight of filter paper(A) g	Final weight of filter paper + residue after dry (B) g	Total Suspended Solid () mg / l
A	20	5	31	20	1.216	1.248	1.6
B	20	5	31	50	1.185	1.242	2.85
C	20	5	31	100	1.138	1.216	3.9
A	20	10	32	20	1.208	1.237	1.45
B	20	10	32	50	1.200	1.253	2.64
C	20	10	32	100	1.232	1.306	3.72
A	20	20	33	20	1.219	1.239	1.01
B	20	20	33	50	1.202	1.245	2.15
C	20	20	33	100	1.207	1.271	3.20

Table 3: Obtained TSS values

Input Parameters				Output Parameters	Initial TSS, (mg/l)
S/N	Speed, (rpm)	Dose, (ml)	Time, (min)	TSS Obtained,(mg/l)	
1	Low	20	31	1.6	4.5
2	Low	50	31	2.85	4.5
3	Low	100	31	3.9	4.5
4	Medium	20	32	1.45	4.5
5	Medium	50	32	2.64	4.5
6	Medium	100	32	3.72	4.5
7	High	20	33	1.01	4.5
8	Hig	50	33	2.15	4.5
9	High	100	33	3.20	4.5

Table 4: Optimal Table of Results:

Input Parameters				Output Parameters
S/N	Speed () rpm	Dose() ml	Time() min	% TSS removal (Y)
1	5	20	31	64.44
2	5	50	31	36.67
3	5	100	31	13.33
4	10	20	32	67.78
5	10	50	32	41.33
6	10	100	32	17.33
7	20	20	33	77.56
8	20	50	33	52.22
9	20	100	33	28.89

3.1 Analysis of Generated Equation from Data Fit

Table 5: Optimal Table of results showing changes in %TSS from generated equation

Input Parameters				Output Parameters		
S/N	Speed () rpm	Dose() ml	Time() min	% TSS Observed (Y) Mg/L	% TSS Predicted (mg/L) = 1.349- 0.610 – 2.743 + 151.0	Error difference │ – Y│
1	5	20	31	64.44	60.51	3.93
2	5	50	31	36.67	42.21	5.54
3	5	100	31	13.33	11.71	1.62

4	10	20	32	67.78	64.51	3.27
5	10	50	32	41.33	46.21	4.88
6	10	100	32	17.33	15.71	1.62
7	20	20	33	77.56	75.26	2.30
8	20	50	33	52.22	56.96	4.74
9	20	100	33	28.89	26.46	2.43

To evaluate the performance of the coagulant (moringa leaf) based on the observed and predicted TSS, a reliability plot of regression was generated using the observed TSS as the X axis and the Predicted TSS as the Y axis. Result obtained is presented in Figure 2

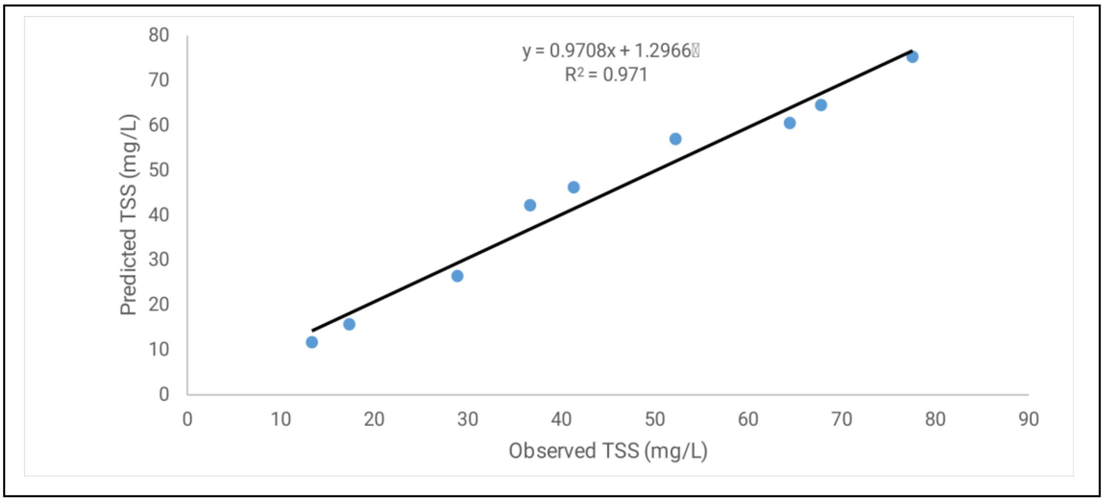

Figure 2: Reliability plot of regression

From Figure 2, the Reliability (R^2) is gotten as 0.971. This indicates that powdered moringa leaves when used as a coagulant will be 97.1% efficient

4. Conclusion

Natural coagulants generated from plant sources are a significant advancement in ‘ grassroots' sustainable environmental technology since they focus on improving the quality of life for disadvantaged areas. Fortunately, environmentalists around the world are warming to the use of granulated groundnut as a coagulant for water treatment because it avoids the common problem with biofuels, where skeptics believe that the benefits are outweighed by global food shortages and deforestation caused by mass plantation of biofuel plants. Nevertheless, there are a number of pressing issues impeding the development of this coagulant's process, including a lack of mass plantation of the plants, which allows for bulk processing, a perceived low-volume market, and virtually no supportive regulation that specifies the quality of the processed coagulant extracts.

As a result, it is believed that applicability is now limited to small-scale use and academic research, but it may benefit from vigorous promotion and endorsement from important stakeholders, particularly the authorities. This research also shown that granulated peanut coagulant is a viable option for reducing total suspended solids. According to the findings, groundnut is an effective natural coagulant for the treatment of turbid water. It was also established from the observations that when granulated groundnut was added as a coagulant aid, total suspended solids were reduced. Groundnut is extremely effective at reducing total suspended particles in water, with a performance efficiency of 98.39 percent.

References

[1] Edzwald JK. Water Quality and Treatment a Handbook on Drinking Water. New York: McGraw-Hill; 2010 Enderlin. 1997. Water quality requirements. In: Helmer R, Hespanhol I, eds. Water pollution control - A guide to the use of water quality management principles. UNEP, 23-54.

[2] Isleib, T.G., Wynne, J.C. & Nigam, S.N. (1994.) Groundnut breeding. p. 552-620. In Smartt, J. (ed). The groundnut crop: A Scientific Basis for Improvement. Chapman and Hall, London.

[3] Kalibbala, Herbert. (2007). Application of Indigenous Materials in Drinking Water Treatment.

[4] Khayyat AMA. Study of point of use treatment methods for the disinfection of drinking water in Nepal [Doctoral dissertation]. Massachusetts Institute of Technology; 2000

[5]Abbas SH, Ismail IM, Mostafa TM, Sulaymon AH. Biosorption of heavy metals: A review. Journal of Chemical Science and Technology. 2014;3:74-102.

[6] Adewole, Taiwo & Kuku, Adenike & Okoya, Aderonke. (2020). Efficacy of a natural coagulant protein from Moringa oleifera (Lam) seeds in treatment of Opa reservoir water, Ile-Ife,Nigeria.Heliyon.6.e03335.10.1016/j.heliyon.2020.e03335.

[7] Alley ER. Water Quality Control Handbook. Vol. 2. New York: McGrawHill; 2007

[8] Bratby, J. Coagulation and flocculation in water and wastewater treatment. Water 2016, 15.

[9] Okagbare G.O., Omotehinse S.A., and Ighodaro O.O (2022) – An Investigation of the Hydro-Power Potential of the Ojirami Dam in Nigeria. *Journal of Energy Technology and Environment (NIPES)* 4(1) 83 – 10

[10] Brief T. A National drinking water clearinghouse fact sheet by, Mohamed Lahlou. Tech Brief Twelve. 1999

[11] Choy, S.Y.; Prasad, K.M.N.; Wu, T.Y.; Ramanan, R.N. A review on common vegetables and legumes as promising plant-based natural coagulants in water clarification. Int. J. Environ. Sci. Technol. 2015, 12, 367– 390

[12] Coates, J., (2000), Interpretation of infrared spectra, a practical approach, Encyclopedia of analytical chemistry, R.A Meyer’ s Edition, pp; 10815-10837

[13] Cole S, Codling I, Parr W, Zabel T, Nature E, Heritage SN. Guidelines for Managing Water Quality Impacts within UK European Marine Sites; 1999 CRC (2003). Drinking Water Treatment. http://www.waterquality.crc.org.au/DWFacts_Treatment_Water.pdfvAccess date: 3rd September 2017

[14] Daverey, Achlesh & Tiwari, Nisha & Dutta, Kasturi. (2018). Utilization of extracts of Musa paradisica (banana) peels and Dolichos lablab (Indian bean) seeds as low-cost natural coagulants for turbidity removal from water. Environmental Science and Pollution Research. 26. 10.1007/s11356-018-3850-9.