Extraction of natural coagulant from peanut seeds for treatment of turbid water

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Abstract. This study investigates the potential of peanut seeds as an environmental friendly and natural coagulant for the treatment of high turbid water. The peanut seeds have been used after oil extraction; and the active coagulation component was extracted by distilled water and salt solution of different salt concentrations. The salts used were NaCl, KNO₃, KCl, NH₄Cl and NaNO₃. Synthetic water with 200 NTU turbidity was used. Peanut extracted with NaCl (PC-NaCl) could effectively remove 92% of the 200 NTU turbidity using only 20 mg/l, while peanut seeds extracted with distilled water (PC-DW) could remove only 31.5% of the same turbidity with the same dosage. The coagulant dosage did not affect by the concentration of the salt; however, residual turbidity decreased with increasing the concentration of the salt; and the relationship was found to be a second order polynomial curve with R² of 0.9312. The other salts tested were also found to be good solvents to extract the active coagulation component with no much difference from NaCl solution in terms of efficiency.

1. Introduction
The production of potable water from most raw water sources usually entails the use of a flocculation/coagulation stage to remove turbidity in the form of suspended and colloidal material. Aluminum and iron salts are the chemicals most commonly used together with synthetic organic polymers. With aluminum salts, there is always the concern about residuals in the treated water, and Alzheimer's disease and, strong carcinogenic properties, the cost of any imported chemicals can be a serious problem for developing countries. Thus, in recent years, there has been considerable interest in the development of natural coagulants [1].

Natural coagulants have been used for domestic household for centuries in traditional water treatment in tropical rural areas. Some reports describe natural coagulants from Nirmali seed and maize [2], mesquite bean and Cactus latifaria [3], and Moringa Oleifera seeds [4].

The main advantages of using natural plant-based coagulants as water treatment material are apparent; they are cost-effective, unlikely to produce treated water with extreme pH and highly biodegradable. Naturally occurring coagulants are usually presumed safe for human health [5]. The objectives of this study were to investigate the potential of peanut seeds in coagulation of the turbid water, as well as to improve the coagulation activity by extracting the active coagulant component by using salt solution.
2. Materials

2.1 Preparation of Peanut Seed Powder
The peanut seeds used in this study were obtained from Sudan. The seed cover was shelled by hand just before extraction. The extraction of the active ingredients was carried out by removing the shell to collect the kernel inside the shell. In order to ensure the efficiency of Peanut seeds extraction, the kernels have been crushed and grinded to medium fine powder by using the domestic blender (Assparo, Model 900) every time when the preparation of Peanut seeds extraction was needed.

2.3 Oil Extraction of Peanut Seeds
Oil extraction from Peanut seed was carried out as in Ali et al. [6] method.

2.4 Preparation of Peanut Seeds Extraction
Peanut seeds extraction was prepared by using a salt solution of NaCl with varied concentrations, and Peanut cake in 5% (w/v) suspension mixed with a domestic blender (Assparo, Model 900) for 10 minutes and left settling for 10 minutes. The suspension was then filtered using a vacuum pump filter with filter paper of 70 μm pore size (Whatman). The five salts used were, NaCl, KNO₃, KCl, NH₄Cl and NaNO₃. Different concentrations for each type were tested. This extraction was used to obtain the required dosage of coagulant.

2.5 Preparation of synthetic turbid water
Synthetic turbid water for coagulation tests was as in [7]. This kaolin suspension was used as the stock solution for the preparation of water samples in the coagulation tests. The suspension was diluted using tap water to prepare synthetic turbid water of about 200 NTU.

2.6 Coagulation test
Jar tests were carried out by using a jar tester (Phipps and Bird, Model 300) to evaluate coagulation activity at several dose levels of Peanut seeds coagulant. Six 500-ml beakers were filled with 500 ml of synthetic water were placed in the slots of the jar tester. One beaker acts as a control while the other five beakers were fed with different dosages of coagulant. The synthetic waters were agitated at 80 rpm. During this agitation, various amounts of Peanut seeds coagulant were added to each beaker and agitated for 2 min at 80 rpm. The mixing speed was reduced to 40 rpm and was kept for 30 min for slow mixing. After sedimentation for 1 h; five ml of the sample was collected from about 1 cm below the surface of the water and residual turbidity of each coagulated water sample was measured using a turbidimeter (HACH 2100N).

3. Results and Discussion

3.1 Improvement of extraction of the active coagulant component by NaCl solution
Figure 1 shows turbidity removal by coagulation with peanut seeds extracted by distilled water (PC-DW); and that coagulated by peanut seeds extracted by NaCl (PC-NaCl) with different concentrations, namely, 1, 2 and 3 mole/l. The initial turbidity of synthetic water was in 208 – 214 NTU range. The coagulant dosage is expressed in mg/l throughout this study. Figure 1 shows that the residual turbidity obtained by PC-DW was 140 NTU at an optimum dosage of 20 mg/l. On the other hand, the residual turbidity obtained by PC-NaCl of 1, 2 and 3 mole/l, was 129, 57 and 31.5 NTU respectively, and the corresponding optimal dosages were 30, 20 and 20 mg/l. It can be significantly observed that NaCl solution gave lower residual turbidity than distilled water. The efficiency of the 3 mole PC-NaCl in terms of residual turbidity was 4.4 times better than that of PC-DW.

The improvement of turbidity removal implies improvement in coagulation activity. This could be losing-up of the protein associations leading to more soluble and coagulation active species in
solution. This mechanism was reported by [7], in that study, 1.0 mole of NaCl solution was significantly improved the coagulation activity of Moringa oleifera seeds. This mechanism was also cited in [8] and [9] as increasing protein solubility with the addition of 1:1 salts or the salting-in effect. They found that addition of salt solution enhanced the breaking of protein associations, leading to increased protein solubility.

Based on the above mentioned mechanism and the results of the present study; it could be concluded that the peanut seeds have a high potential of coagulation of turbid water; and that the protein associations inside the peanut seeds are responsible for coagulation activity.

Figure 2 shows residual turbidity and the corresponding percentage of turbidity removal for the synthetic water. Results are represented by residual turbidity at the optimum dosage of each concentration. The optimum dosage for all concentrations was 20 mg/l except for 1 mol/l NaCl, which was 30 mg/l. The initial turbidities of all tests varied between 200 to 217 NTU. It can be observed that the residual turbidity decreases with increasing the concentration of NaCl, this relationship can be represented by second order polynomial curve with a coefficient of determination ($R^2$) of 0.9312. On the other hand, the percentage of turbidity removal increases by increasing the concentration of NaCl and the relationship also can be represented by second order polynomial curve with $R^2 = 0.9212$.

The residual turbidity achieved by 6 mol/l PC-NaCl was 8.2 times better than that achieved by PC-DW. This result (Increasing coagulation activity by increasing NaCl concentration) is in agreement with [7]. The decrease in coagulation activity at 7.0 mol/l could be due to saturation stage where by the NaCl solution reaches saturation stage at 7 mol/l. The phenomena that solubility of proteins decrease with salt concentration at high salt ionic strength is also well known as well as salting-in [8] [9].

Figure 1. Coagulation of Synthetic Water with Peanut Seeds Coagulant Extracted by Distilled Water and NaCl solution.

Figure 3 shows coagulation by peanut seeds extracted by NaCl, KNO$_3$, KCl, NH$_4$Cl and NaNO$_3$. The turbidity removal for each concentration was calculated at the optimum dosage. The optimum dosage for most concentrations of the different salts was found to be 20 mg/l, whereas, it was 30 mg/l for both 1 mol/l of NaCl and 1 mol/l of NaNO$_3$. It is observed that for all types of salt, turbidity removal increases with increasing salt concentration. It varies from 22 % at low salt concentration to 93.2% at higher concentrations. This result confirmed the mechanism of salting-in effect that discussed in Figure 1. Turbidity removal up to 3 mol/l is rabidly increases, however, the rate of increment become slowly at higher concentrations, as the salt solution approaches its saturation stage. No significant difference in removal efficiency for NaCl, NH$_4$Cl and NaNO$_3$ was observed, however, for KNO$_3$ and KCl the removal efficiency was little bit lower. This could be due to the difference in ionic strength. This result indicates that not only NaCl can be used to extract the ingredient coagulant, but others salts
can also be used for the same purpose. However, NaCl seems to be more suitable as it is cheap and available everywhere.

Figure 3. Coagulation of Synthetic Water Coagulated by Peanut Seeds Coagulant Extracted by Different Salts with Different Concentrations. Results are taken at optimum dosage of each test.

4.0 Conclusions
The specific conclusions derived from this study are as follow:

The peanut seeds have a high potential for coagulation of turbid water with an initial turbidity of 200 NTU. Thus, turbidity removal reached up to 93.2 %.

PC-NaCl improved the coagulation activity significantly. PC-NaCl extracted by 6 mol/l NaCl solution could effectively remove 92% of the 200 NTU turbidity using only 20 mg/l, while PC-DW could remove only 31.5 % of the same synthetic water with the same dosage of coagulant. This result implies that the protein associations inside the peanut seeds are responsible for coagulation activity.

The optimum dosage of PC-NaCl for coagulation of the turbid water for all concentrations was 20 mg/l except that of 1 mol/l NaCl solution which was found to be 30 mg/l. Nevertheless, residual turbidity decreased with increasing the concentration of NaCl, and the relationship was found to be a second order polynomial curve with a \( R^2 \) of 0.9312.

KNO\(_3\), KCl, NH\(_4\)Cl and NaNO\(_3\) solutions were also found to be good solvents to extract the active coagulant component for peanut seeds; leading to improvement of coagulation activity; with no much difference from NaCl solution in terms of efficiency.

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