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Assessment Of Turbidity Removal Efficiency Of Pea Pod Extract For Surface Water Treatment

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Abstract: ***Locally available natural coagulants are considered affordable and efficient substitutes to chemical coagulants for use in developing countries where raw materials such as Cicer arietinum (green pea) are readily available. This study investigated the turbidity removal efficiency of pea pod extract from surface water. Chemical and bioactive constituents of pea pod were evaluated. Optimum values of coagulant dose, pH and stock solution concentrations were determined using jar test. Turbidity removal efficiencies and residual turbidity of the coagulant were also evaluated. The highest turbidity removal efficiency was found to be about 97% at 10% w/v stock solution concentration of the pea pod extract. The optimum pH suitable for coagulation of surface water using pea pod extract was found to be 6.6 at 10% w/v stock solution of pea pod extract. The pea pod extract was found to be most efficient in removing turbidity from surface water at 10% (w/v) stock solution with optimum dose of 1600mg/L. After comparing residual turbidity of coagulated water, it was found that the coagulated water had a residual turbidity of about14NTU at 10% w/v stock concentration of the pea pod extract; this is higher than the allowable value of 5 NTU recommended by the WHO Guidelines for Drinking treatment. With further improvement, the findings in this study suggest that C. arietinum (pea pod) extracts can be used to remove turbidity from high turbid surface waters.***

I. INTRODUCTION

Growing population, increased economic activity and industrialization have not only created an increased in demand for fresh water, but also resulted in the misuse of natural resources. According to a survey conducted by United Nations Environmental Program (UNEP), 20% of world's population lacks access to safe drinking water, and 50% lacks access to safe sanitation. WHO, 1997).In addition, polluted water is estimated to affect about 1200 million people and contribute to the death of 15 million children in the world per year (WHO, 1997).

Turbidity in water occurs due to the presence of colloidal particles which can mainly be treated by the use of coagulants. Seeds of *Moringa oleifera*, pea, and okra have shown promising results as the source of natural coagulant in the clarification of turbid water. This happens due to the presence of polyelectrolytes, proteins, lipids, carbohydrates and alkaloids containing –COOH and free –OH surface groups in the seeds (National Research Council, 2006). For instance, comparative study on the coagulation property of *M. oleifera* seed and pod extract by Modibbo (2016) reported promising results.

Coagulation and flocculation are essential parts of drinking water treatment. In potable water treatment, clarifications of water using coagulating agents have been practiced from ancient times (International Crops Research Institute for the Semi-Arid Tropics, 2014). As early as 2000BC, the Egyptians used almonds smeared around vessels to clarify river water and the use of aluminum sulphate (alum) as a coagulant by the Romans was mentioned in around 77AD. By 1957, alum was used for coagulation in municipal water treatment in England. Coagulation with extracts from natural and renewable vegetation have been widely practiced (International Crops Research Institute for the Semi-Arid Tropics, 2014).

Coagulation takes place when coagulants contain significant quantities of water-soluble proteins which carry an overall positive charge when in solution. The proteins bind to the predominantly negatively charged colloidal particles. Coagulation happens when the positively and negatively charged particles are chemically attracted together. They can then accumulate to form larger and heavier particles that settle easily, reducing turbidity level of the given water sample (MRWA, 2003). Coagulation may also improve the microbiological quality of water (MRWA, 2003).

Cicer arietinum (green pea) is a legume of the subfamily Faboideae of the flowering plant family (Saha *et al.,* 2014) It is known as gram or Bengal gram or Egyptian pea. Ancient people associated pea with medical uses. It is widely grown in India, Turkey, and Nigeria. It is an annual plant with a life cycle of one year. The immature peas are used for vegetable. Fresh, canned or frozen matured peas are used as dry peas or slit peas. It is starchy, high in fiber, vitamins, minerals, proteins and lutein. The dry weight obtained is approximately 1/4 protein, and 1/4 sugar (Saha *et al*., 2014) Various researches on the nutritional value of pea were conducted by a number of researchers including Garg (2015), and on its coagulating characteristics by Marina *et al*. (2005). But no or little research was done on the possibility of using the pea pod as coagulant for water treatment.

In many developing countries like Nigeria, the cost of treating surface is a major concern. It was also discovered that chemicals used change the pH of the water which can probably affect the health and raise environmental issues (Kaggawa *et al.*, 2001). Many researches have been done on using agricultural products/seeds especially *Moringa oleifera* as coagulants, but little research was done on the use of pea pod as coagulant. Marina, *et al.,* (2005) investigated the coagulation activity of natural coagulants from seeds of peas. He suggested the use of pea pods, rather than pea seeds, as coagulant to avoid conflict of interest, considering the use of the latter in food and nutrition. In addition, Saha *et al*., (2014) reported that the presence of bioactive compounds in pea pod is equal to that present in pea cotyledon or seed. As such, this research focuses on investigating the possible use of pea pods as coagulant for turbidity removal from surface water.

This study will explore the potential possibility of using pea pod extract as coagulant, which may supplement alum, and may serve as an alternative to conventional chemical coagulants and other natural coagulants.

The aim of this research is to evaluate the suitability of using pea pod extract in turbidity removal from surface water and the objectives are; To determine the chemical composition of pea pod, to determine the optimum pH suitable for coagulation of surface water using pea pod extract**,** to determine the optimum stock solution concentration of pea pod extract for turbidity removal from surface water, to determine the optimum dose of pea pod extract for turbidity removal from surface water**,** to determine the turbidity removal efficiency of the pea pod extract.

II. METHODOLOGY

PHYTOCHEMICAL ANALYSES OF PEA POD

Complete proximate standard procedure analyses of the pea pod were done in department of animal science and also in biochemistry department Bayero University Kano.

SAMPLE COLLECTION AND PEA POD SEED EXTRACT PRAPARATION

Some amounts of peas were procured locally from Yankaba market Kano, and the pods were separated from the seeds, dried under the sun for about 7days. The pea pods were ground to fine powder using the mill of a domestic blender. All ground materials were sieved through 0.4-0.6mm BS membrane sieve, and then fractioned with particle size less than 0.4mm was used in the experiments. Mature pea pods showing no signs of discoloration, softening or desiccation were used (Musa, 1016)

PREPARATION OF SYNTHETIC WATER

Synthetic water for jar tests was prepared by adding kaolin clay to distilled water to make it turbid of 416NTU. The suspension was stirred for about 1hr to achieve a uniform dispersion of kaolin or clay particles. Then it was allowed to settle for at least 24hrs for complete hydration of the clay materials or kaolin. The supernatant suspension of synthetic turbid water was added to the sample to achieve the desired turbidity just before coagulation (Asfaruzzaman *et al*., 2011).

PREPARATION OF STOCK SOLUTION OF NATURAL COAGULANTS

Distilled water was added to the powder of pea pod to make 5, 10 and 15% stock solutions. The suspension was vigorously shaken for 30-45minutes using a stirrer. The filtrate portions were used for required dose of natural coagulants. Fresh solutions were prepared at 10% and 15% as earlier stated and kept refrigerated to prevent any ageing effects (such as change in pH). Solutions were shaken vigorously before use.

JAR TEST OPERATIONS

According to Singh, (2014); the sample was mixed homogeneously, and then the samples ought to be measured for turbidity coliform count for representing an initial concentration. Coagulants of varying concentrations were added in the beakers.

After the desired amount coagulants were added to the suspensions, the beakers were agitated at various mixing time and speed, which consist of rapid mixing for about 1-3 minutes, and slow mixing for 12-15 minutes. After agitation being stopped, the suspensions were allowed to settle for 20-60 minutes. Finally a sample was withdrawn using a pipette from the middle of supernatant for physiochemical and turbidity measurement. All tests were performed at ambient temperature in the range 26-32^{0}C, and for equal turbidity values (which is 416NTU). In the experiment, the study was conducted by varying a few experimental parameters, which were coagulant dosage and mixing time in order to study their effect in coagulation and obtain the condition for each parameter (Asfaruzzaman *et al*., 2011).

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JAR TEST PROCEDURE

APPARATUS

Jar test apparatus: synthetic water and stock solutions.

PROCEDURE

- ✓ 1l of water was placed each of six beakers and were positioned under the paddles of the jar test machine.
- ✓ Appropriate quantities of coagulant in each of six test tubes were placed on the rack (2ml,
- ✓ 4ml, 8ml, 10ml, and 12ml of 5g/100ml stock solution) and the paddle speed was adjusted.
- ✓ The coagulant is poured into the beakers while stirring the beaker and 5ml of distilled water was quickly added to each test tube, rinsed and poured into the beakers.
- ✓ After about 30 seconds of initial rapid mixing, the speeds was reduced to 20-50 rev/mm for flocculation, and the time of the first appearance of visible, discrete flock particles in each beaker was observed.
- ✓ The motion was stopped after 20 minutes and the appearance, size arid quantity of flock were observed. The flock size in terms of the appearance of a flock comparator was observed.
- ✓ The settling velocity of the majority of the flocks from the depth of the water and the time taken to settle were estimated.
- ✓ About 100ml of the settled water from the top of each beaker was carefully decanted and its color, turbidity, pH and alkalinity were determined.
- ✓ The procedure is repeated for 10g/100ml and 15g/100ml stock solution of pea pod extract respectively.

ANALYTICAL METHODS

Turbidity was measured using turbidity meter and pH was measured using pH meter. Each experiment was repeated in triplicate.

III. RESULTS AND DISCUSSION

PEA POD CHEMICAL ANALYSIS RESULTS CHEMICAL COMPOSITION OF PEA POD EXTRACT

RESULTS CHEMICAL COMPOSITION OF PEA POD EXTRACT

/N	SAMPLE IDENTIFICATION	% ASH	% MOIST	% CP	% CF	% Ee	% CHY	% NFE
LS04	PEA POD SAMPLE (A)	7.62	3.98	8.49	20.15	1.10	33.38	62.64
LS05	PEA POD SAMPLE (B)	7.43	4.33	9.06	19.77	0.97	32.90	62.77

Table 1: Proximate analyses of pea pod samples

PEA POD CHEMICAL ANALYSI

%ASH: % Ashing
%MOIST: % moisture content
% CP: % Crude protein content
% CF: % Crude fibre content
% Ee: % Fat content
% CHY: % Carbohydrate content
% NFE: % Nitrogen Free Extra content

The presence of polyelectrolytes such as proteins and cabohydrates containing –COOH and free –OH surface groups in the pods was found, since most of the particles in water are negatively charged, any positive ion like sodium compound contributes a monovalent ion Na^+, a Calcium compound contributes a divalent Ca^{2+}, Aluminum and Iron compounds contributes trivalent ions Al^{3+} and Fe^{3+} which will neutralize the negative ion in H_2O compounds, bind them together and form heavier turbid particles reducing turbidity level.

Bichi, (2013) reviews that the active ingredient responsible for coagulation in *M. Oleifera* was polyelectrolyte. This also applies to other natural coagulants including pea pod extract.

Research by Garg, (2015) on the chemical analysis of pea pod powder shows almost the same presence of chemical constituents found in the pea pod powder which are responsible for coagulation.

VARIATION OF TURBIDITY REMOVAL EFFICIENCIES WITH DOSES OF CICER ARIETINUM (PEA) POD EXTRACT

Jar test experiments with different pea pod coagulant was performed. These coagulants were prepared by using a standard preparation method as discussed in Chapter three. Initially the optimum dosage for each coagulant was determined; this was the dosage of coagulant corresponding to the lowest residual turbidity in NTU or highest turbidity removal in percentage.

Figure 1, 2 and 3 show the effects of doses of pea pod extract on turbidity varying the stock solution of pea pod extract. The turbidity removal efficiencies and the optimum doses can be found from the graphs.

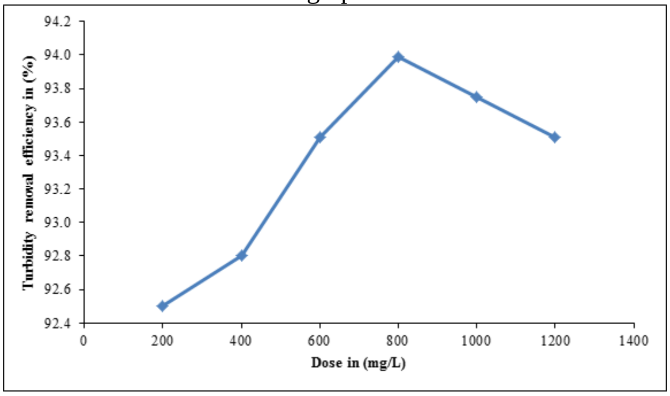

Figure 1: Variation of turbidity removal efficiency with dose of pea pod extract at 5% (w/v) stock solution concentration of pea pod extract

The highest turbidity removal efficiency was 94% at 5% w/v stock solution concentration of pea pod extract and the optimum dose was found to be 800 mg/L

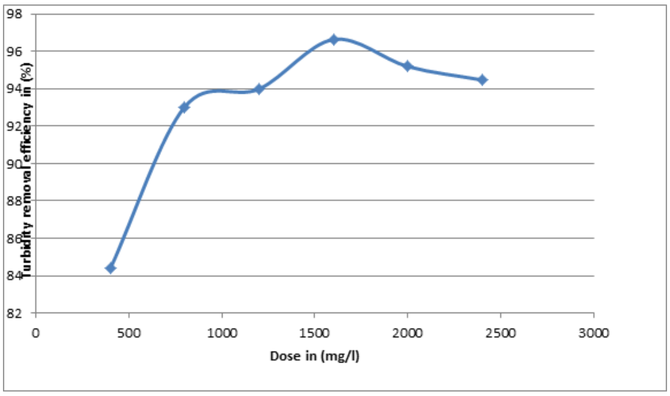

Figure 2: Variation of turbidity removal efficiency with dose of pea pod extract at 10% stock solution of pea pod

The highest turbidity removal efficiency was 97% for the 10% stock solution of pea pod extract and the optimum dose for the 10% stock solution of pea pod extract was 1600mg/l

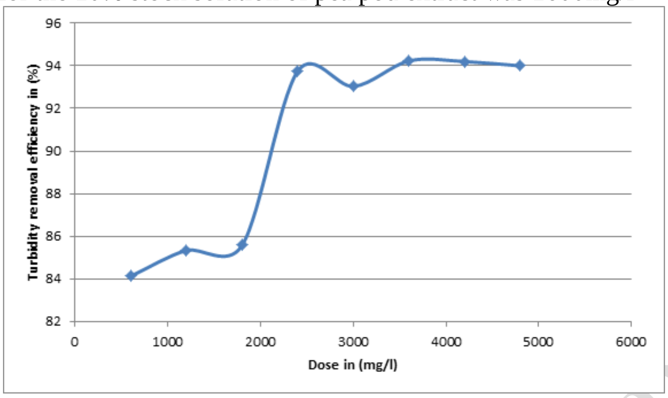

Figure 3: Variation of turbidity removal efficiency with dose of pea pod extract at 15% stock solution of pea pod

The highest turbidity removal efficiency was 94% at 15% stock solution of pea pod extract.

These graphs will help in determining the optimum dose of the pea pod extract in all the stock solutions used and the optimum dose was 3600mg/l which has the highest turbidity removal efficiency (i.e. 94%).

There was, therefore, a notable decrease in turbidity of the synthetic high turbid waters. This can be compared with *Cassia alata* with coagulation activity of 93% (Aweng *et al.*, 2012), water melon seed of 88% (Muhammad *et al.*, 2015) and *Moringa oleifera* seed extract of 94% (Mustapha, 2013).

Research by Asfaruzzaman *et al.*, (2011), compare the turbidity removal efficiencies of *Moringa oleifera*, *Cicer arietinum* (pea seeds), and *Dolichos lablab* as available natural coagulants in this study to reduce turbidity of synthetic water and found that *C. arietinum* (peas) having the highest removal efficiency of 96%. This shows the similarity between the pea pods and seed.

The fall in the coagulation activity in doses above in 800, 1600 dose for 5%, 10% stock solution of pea pod extract for high turbid synthetic water could be attributed to the coagulants that remained in excess of the optimum coagulant dose.

The increase in residual turbidity after the optimum point could also be due to increase in plant chlorophyll concentration in water (Kihampa *et al.*, 2011).

Kihampa *et al.*, (2011) reported faecal coliform removal increase with *Solanu mincunum* and found that a maximum removal of 99% was achieved at 2.2×10^{-4} g/ml.

The fall in the coagulation activity in doses above after optimum value is reached for the high turbid water could be attributed to the coagulants that remained in excess of the optimum coagulant dose. The increase in residual turbidity after the optimum point could also be due to increase in plant chlorophyll concentration in water (Kihampa *et al.*, 2011)

Ahmed *et al.*, (2010)emphasized that there were many parameters that affect coagulation performance (and hence turbidity removal) and that include the amount and type of particulate material, the amount and composition of natural organic matter (NOM), and chemical and physical properties of the water. The common parameters are: coagulant type, dose and pH (Yan *et al.*, 2008 and Uyak, 2007). Many researches, they said, have shown that natural organic matter reacts or binds with metal ion coagulants and that coagulant dosage is determined by NOM-metal ion interaction and not particle-metal ion interaction (Matilainen *et al.*, 2002). Asfaruzzaman *et al.*, (2011) found that pea seed was found most effective for coagulation when the dose were 100 mg/L for high-, medium-, and low turbidity water at a 3-min slow mixing time, 12 min slow mixing, and 30 min settling time. Pea is cheap, easily cultivable, and available in Bangladesh. On the other hand naturally occurring coagulants are biodegradable and presumed safe for human health.

The optimum doses obtained for 5, 10 and 15% stock solutions of pea pod extract respectively when compared to those obtained with the aforementioned researches on pea seed and other natural coagulants considering the high turbidity of the turbid water, the optimum dose is appropriate and conforms to other similar researches.

VARIATION OF TURBIDITY REMOVAL EFFICIENCY WITH pH AT 5, 10 AND 15% (v/w) STOCK SOLUTION OF PEA POD EXTRACT

Solubility of organic matter in aqueous medium depends on pH. The particles usually have some negative charge and they are stable at the isoelectric point. At that pH, the solubility of organic matter is the lowest. Because of that, we have to investigate the influence of pH on coagulation activity and to determine optimum pH value for further coagulation tests.

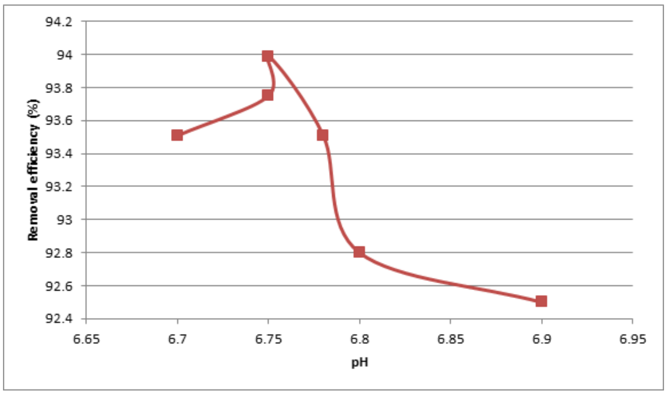

Figure 4: Variation of turbidity removal efficiency with pH at 5% stock solution of pea pod extract

Figure 4 shows that the pH decreases with increases in removal efficiency at the beginning, and then later diminishes when the optimum pH was reached at 6.7.

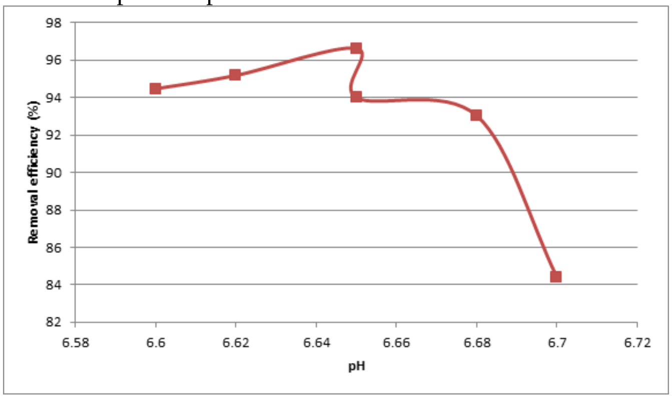

Figure 5: Variation of turbidity removal efficiency with pH at 10% stock solution of pea pod extract

Figure 5 shows that the pH decreases with increases in removal efficiency at the beginning, and then later diminishes when optimum pH was reached at 6.6.

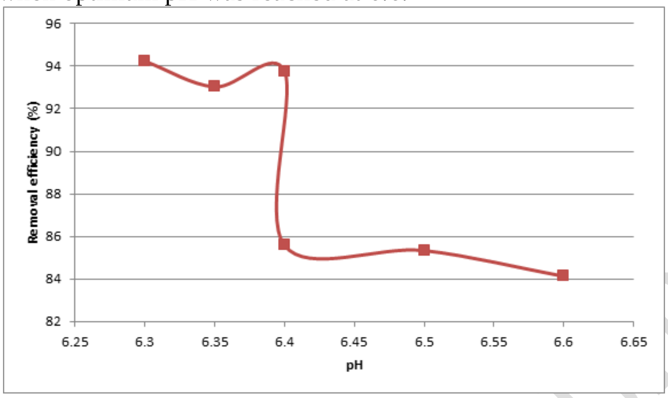

Figure 6: Variation of turbidity removal efficiency with pH at 15% stock solution concentration of pea pod extract

Figure 6 shows that the pH decreases with increases in removal efficiency at the beginning, and later diminishes when optimum pH was reached at 6.3.

It was be observed that the optimum pH found for both 5, 10 and 15% stock solutions of pea pod extract were within the range of acceptable drinking water standard, only a slight deviation between the pH values is seen which is considered insignificant.

Chidanand *et al.*, (2015) found that there is no significant change in pH due to natural coagulants. It is changing in decimal values so it is considered as almost negligible

Sunita *et al.*, (2014) also found that that both natural coagulants produce appreciable reduction of turbidity at 6-8 pH and it was declined at 10 to 12 pH while Chidanand *et al.*, (2015) argued that there was no direct influence of pH on turbidity, although his research was specific on wastewater.

VARIATION OF TURBIDITY REMOVAL EFFICIENCY WITH STOCK SOLUTIONS OF PEA POD EXTRACT

Figure 7, shows the highest turbidity removal efficiencies for all the stock solutions of pea pod extract. The optimum stock solution concentration was found at 10% (w/v) pea pod extract at 97% turbidity removal efficiency.

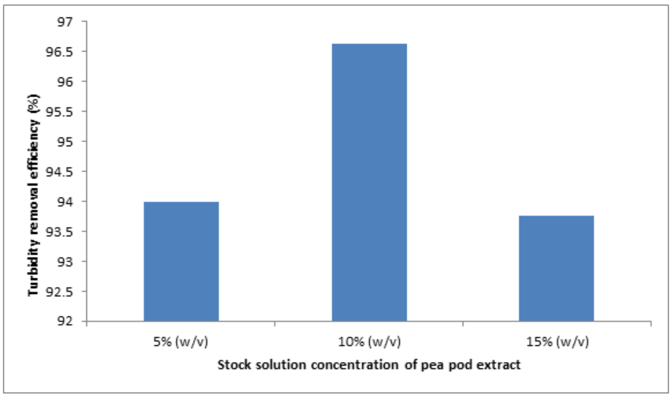

Figure 7: Variation of Turbidity removal efficiency with stock solutions of pea pod extract

Similar research on the turbidity removal of pea seed by Asfaruzzaman *et al.*, (2011) found that the most efficient stock solution of pea seed extract is at 1.0%. From the graph it can be seen that at 10 %(w/v), there is higher turbidity removal efficiency compared to 5% and 15%.

VARIATION OF pH WITH DOSE OF PEA POD EXTRACT

The initial pH values of the prepared synthetic water was 6.9 for high turbidity and the initial pH of the pea pod extracts were 5.9, 5.5, 5.1 at 5,10, and 15% (v/w) stock solution concentration of pea pod extract.

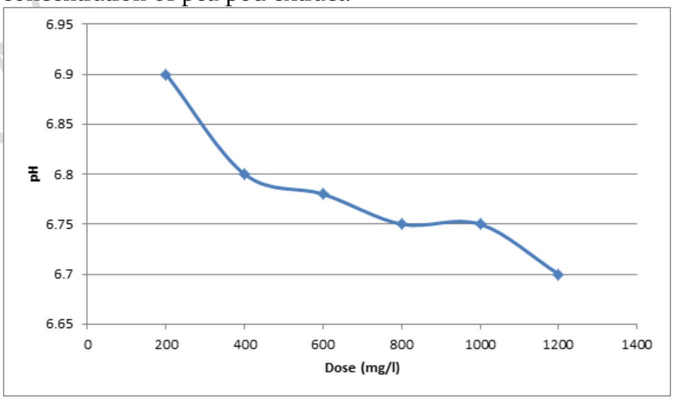

Figure 8: pH values versus dose of pea pod extract at 5% stock solution of pea pod extract

When the prepared high turbid water were treated with various doses of the pea pod extract filtrates, the pH values changed as shown in Figure 8.

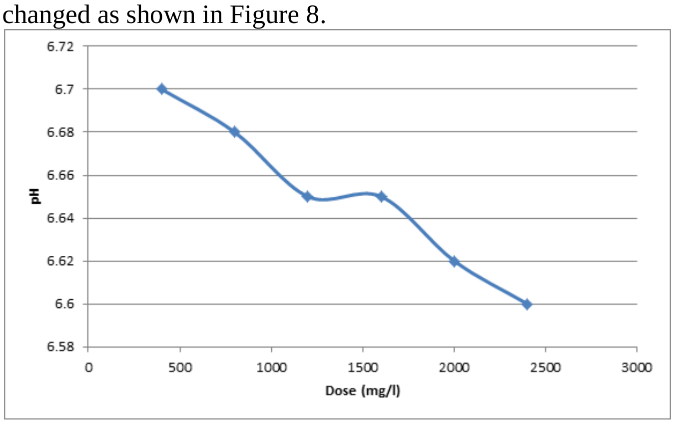

Figure 9: pH values versus Dose (mg/l) of pea pod at 10% stock solution concentration of pea pod extract

When the prepared high turbid water were treated with various doses of the pea pod extract filtrates, the pH values changed as shown in Figure 9.

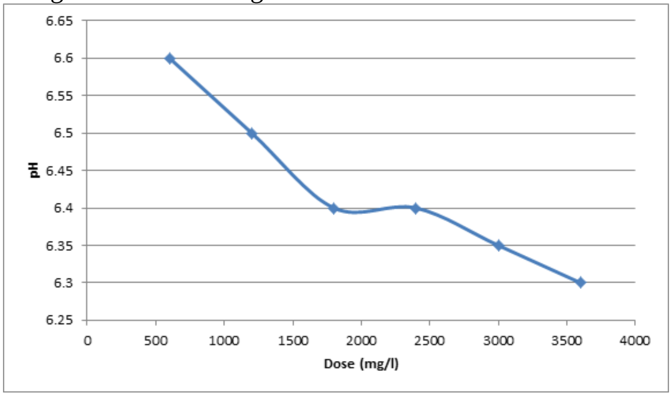

Figure 10: pH values versus Dose (mg/l) of pea pod at 15% stock solution concentration of pea pod extract

When the prepared high turbid water were treated with various doses of the pea pod extract filtrates, the pH values changed as shown in Figure 10.

Musa (2016) in his work, discovered a similar pH reduction while treating water with *Poliostigmathonningischum and Tamarinds india L.* leaves extracts.

Sethupathy (2015), in his work, discovered a similar pH reduction while treating water with *Moringa oleifera* seed powder: The pH was observed in alkaline nature after treatment with Moringa seed powder. That was confirmed by the work of Jodi *et al.*, (2012).

Although the pH of the water varied as a result of the introduction of the plant extracts, it was within the range set by Clause 5.1.2 of the Nigerian Industrial Standard for Drinking Water Quality (NIS 554:2007)(i.e. 6.5 - 8.5).

VARIARION OF RESIDUAL TURBIDITIES WITH DOSE

Residual turbidity of the samples using 5%, 10% and 15% stock solution of pea pod extract

The initial turbidity of the synthetic turbid water is made constant which is 416NTU, but after coagulation it reduces.

Dose (ml)	Residual turbidity of the samples using 5% stock solution of pea pod extract (NTU)	Residual turbidity of the samples using 10% stock solution of pea pod extract (NTU)	Residual turbidity of the samples using 15% stock solution of pea pod extract (NTU)	WHO Standard Turbidity in NTU
2	31	66	66	4-25
4	30	29	61	4-25
6	27	25	60	4-25
8	25	14	26	4-25
10	26	20	29	4-25
12	27	23	24	4-25

Table 2: Variation of residual turbidity with dose for 5, 10 and 15% stock solution of pea pod extract

Md. Asfaruzzaman, (2011) found that pea seed reduced turbidity to 5.9, 3.9, and 11 NTU, from 100 NTU after dosing and filtration.

From the above table, it can be seen that the residual turbidity was found to be slightly above 5 NTU.

IV. CONCLUSION AND RECOMMENDATION

CONCLUSION

From the overall research findings, it can be concluded that;

The highest turbidity removal efficiency was found to be 97% at 10% stock solution of pea pod extract, the optimum pH suitable for coagulation of the surface water at 10% stock solution of pea pod extract was found to be 6.7, the optimum stock solution concentration suitable for coagulation of the surface water was found to be 10% (w/v) of pea pod extract, the optimum dose was found to be 1600 mg/L at 10% (w/v) stock solution of pea pod extract.

RECOMMENDATIONS

Thus improved application of the use of Pea pod extract in surface water treatment should be encouraged, especially in rural water supplies where the water requirement is relatively small. Thus in order to improve on the application of Pea pod extract in water treatment, certain questions still needs to be answered. The studied material can be used for turbidity removal, perhaps for small communities or households, in developing countries. The following are some of the areas requiring further investigations; the mode of attack of the extract on the microbes, the effect of settling time of coagulants on coagulation property of pea pod extract, the use of pea pod extract in the removal of bacteria and bacteriophage from turbid waters, the use of pea pod extract in the removal of heavy metals.

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