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Study of the Phytochemical Kabuli Chickpea (*Cicer Arietinum L*) as an Anionic Coagulant for the Treatment of Water

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The treatment of water by coagulation, flocculation and sedimentation, is a highly realized treatment throughout the world, and the most commonly used coagulant substances are aluminum sulphate, aluminum polychloride and ferric chloride; these substances produce a large quantity of sludge with high aluminum and iron salts, the production of these coagulants is carried out by complex chemical reactions, which demand a large amount of natural resources and produce sludge with high concentrations of these metals, and has shown that aluminum is toxic to plants and animals in different ways; This study shows the comparison of efficiencies between aluminum sulphate and a chickpea extract, which shows a very important coagulant activity. The turbidity and color removal efficiency were evaluated using an anionic coagulant obtained from Kabuli Chickpea (Cicer arietinum L) with an isoelectric point at pH of 3,7, its performance being compared with aluminum sulphate, for the treatment of synthetic water. Laboratory-scale synthetic solutions were prepared at initial values of 200 NTU. Parameters such as turbidity, color, pH and conductivity were measured. The Jar test was used to determine the optimal doses of coagulants, using 70, 80, 90 and 100 mg / L doses for the anionic coagulant and 60, 70, 80 and 90 doses of aluminum sulphate mg / l. The highest removal of turbidity and color was for the anionic coagulant with 98% and 94.71% with a dose of 90 mg / L and in the case of aluminum sulphate values of turbidity removal of 97.5% and of Color of 93.94% with the same dose, respectively. For the tests performed values were obtained within the range established by current Colombian legislation. It was concluded that the anionic coagulant can be used as a primary coagulant.

1. Introduction

Safe and easily accessible water is important for public health, whether it is used for drinking, for domestic use, for food production or for recreational purposes. Improving water supply, sanitation and water resource management can boost countries' economic growth and contribute greatly to poverty reduction (World Health Organization, 2011). The quality of drinking water is a growing concern in developing countries, because sources are under increasing threat of pollution (INICEF, 2012).

In Colombia, significant resources have been invested in the construction of infrastructure for the treatment of water in rural areas, but the early abandonment of these advances is evident because their economic sustainability is not feasible or because of the lack of technology implemented. Does not allow their appropriation by the beneficiaries. This problem is recurrent and is part of the state and regional negligence of Latin America and the Caribbean, which ultimately leads to the abandonment of the purpose of supplying drinking water to these populations (O. Ospina, 2011). For water to be used for various activities, including human consumption, a treatment is necessary, which can include different phases such as coagulation, flocculation, sedimentation, filtration, disinfection, among others (L. Fuentes, 2011). Turbidity in wastewater is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms. Turbid water has muddy or cloudy appearance and it is aesthetically unattractive. The turbidity increases as sewage becomes stronger (P.Geetha priya, 2016). Coagulation and flocculation processes are intended to form particles large enough to be separated and removed by subsequent sedimentation, or alternative clarification processes. The natural coagulants that are locally available have bright future and are concerned by many researchers because of

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their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification (P.Geetha priya, 2016).
Aluminum and iron salts are frequently used as coagulant agents, for their effectiveness and low cost (P.Geetha priya, 2016). It has been suggested that aluminum exposure is a risk factor for the development of Alzheimer's disease in humans (World Health Organization, 2011). In addition, the use of chemical coagulants represents high acquisition costs, production of large volumes of sludge and alteration of the pH of the treated water, so it is necessary to search for alternatives such as natural coagulants, which are less toxic, both for humans and for the environment (L. Guzmán, 2013). Natural coagulants of mineral and vegetable sources were used by the water and Wastewater treatment industry long before the advent of synthetic chemicals like the salts of iron and aluminum (A. Ndabigengesere, 1995).Natural coagulants are of great interest to many researchers today because they are biodegradable, low cost, multifunctional, abundant in source and environmentally friendly (M. Asrafuzzaman, 2011) (K. R. Gunaratna, 2007). Several effective coagulants from plant origin have been identified: Nirmali, Okra, red bean, sugar and red maize (K. R. Gunaratna, 2007), Moringa oleifera (S. A. A. Jahn, 1988), Cactus latifera, and seed powder of Prosopis juliflora (A. Diaz, 1999). Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification (M. Asrafuzzaman, 2011). The chickpea (Cicer arientinum L.) belongs to the family Leguminosae. It is an annual plant, has deep roots, hairs and branched stems, reaching a height of up to 0.60 m. The type of Kabuli chickpea is characteristic for forming long pods; its seeds are large, less wrinkled, white or cream (A. K. Jukanti, 2012).

Table 1: Information nutritional Kabuli Chickpea (Cicer arietinum L).

Information nutritional 100 g	
Humidity	13,00 g
Proteins	19,60 g
Lipids	5,50 g
Total carbohydrates	59,10
Calcium	150 mg
Phosphor	300 mg
Iron	6,40 mg
Potassium	756, 20 mg
Sodium	30,20 mg

The objective of this research was to evaluate the efficiency of the anionic coagulant Kabuli Chickpea (Cicer arietinum L) in synthetic waters prepared in the laboratory and to compare its performance with that of the commercial coagulant aluminum sulphate, verifying that the limit values for the required parameters were met by Colombian legislation such as turbidity, pH color and conductivity.

2. Materials and Methods

For the development of this study the seeds of the anionic coagulant Kabuli Chickpea (Cicer arietinum L) of a local market of Valladolid were obtained. The tests were carried out in the laboratories of the Faculty of Sciences of the University of Valladolid, Spain using synthetic water.

2.1 Extraction and preparation of anionic coagulant

The seeds of the Kabuli Chickpea anionic coagulant (Cicer arietinum L) were washed with copious amounts of water to remove impurities, then dried for two days in the sun. The material was ground using a mixer (Oster), the resulting powder was sieved with a No. 200 sieve to obtain a very fine powder for storage in plastic containers to avoid hydration and subsequent use in the preparation of the solutions of the coagulant. 1% solutions were prepared by adding 10 g of the anionic coagulant in 1000 ml with Milli-Q® water, obtaining a solution of 10,000 mg / L, after which a stirring was carried out for one hour in order to homogenize the mixture, from which this solution was carried out the tests to know the suitable dosages to treat the synthetic water prepared in the laboratory.

2.2 Preparation of synthetic water

Laboratory grade clay was used for the preparation of turbid water samples for all experiments runs. Twenty grams of clay was added to one liter of distilled water. The suspension was stirred gently for 1 hour on a magnetic stirrer in order to achieve a uniform dispersion of the clay particles. The suspension could stand for

24 hours to achieve complete hydration of the clay. This clay slurry served as stock solution using distilled water to prepare water samples of 200 NTU.

2.3 Instruments and Materials

In order to characterize the solutions of the anionic coagulant and to know the initial conditions of the same, certain physicochemical parameters such as turbidity (SM 2130B), apparent color (SM 2120B), pH (Standard Methods 4500B), and conductivity (Standard Methods 2510), were measured, following the standardized methodologies for the water analysis of APHA-AWWA-WEF [13].For the measurement of these parameters a HACH 2100Q turbidimeter was used, the color was measured by a HACH spectrophotometer at 475 nm, the pH was determined by pH meter basic 20 Crison and the conductivity was measured by means of a conductimeter GLP 32 Crison. The measured parameters were compared with that established in the Colombian legislation (Ministerio de Protección Social, 2007) (Resolución 2115, 2007), for drinking water quality, where the following limits are established.

2.4 Coagulation test and operation.

To determine the efficiency of the anabolic coagulant Kabuli Chickpea (Cicer arietinum L), the solutions prepared were tested by the Jar test using progressive doses from 70, 80, 90, 100 mg / L of the stock solution of 10,000 mg / L. It was determined that the formation of the floc for the anionic coagulant was evidenced with doses close to 60 mg/L and that was why it was decided to work with initial doses of 70 mg/L onwards.
The efficiency of the anionic coagulant Kabuli Chickpea (Cicer arietinum L) was compared with the commercial coagulant aluminum sulfate in order to show which one had greater capacity of elimination of contaminants of the water.
For the coagulant aluminum sulfate was evaluated from an initial dose of 50 mg / l since at doses higher than this could be appreciated formation of the floc. The Jars test was performed with a team consisting of a multi-speed four-blade multi-speed agitator (Velp Scientific a, model FC45). To start the pitcher test, 1000 mL of tap water was added to each beaker; the four beakers were placed on the team, assigning each vessel a pallet. Then the coagulation / flocculation and sedimentation process was performed, starting with a rapid mixing at a speed of 150 rpm for 2 min. Thereafter a slow mixing was carried out, reducing the speed to 45 rpm for 25 min. Finally, the pallets were removed from the samples contained in the beaker and allowed to settle for 30 min. At the end of the sedimentation period, the supernatant sample was removed from each vessel. Subsequently, the physicochemical parameters were determined: turbidity, color, pH and conductivity using the standardized methodologies of APHA-AWWA-WEF (American Public Health Association, 1995).

3. Results and Discussion

3.1 Initial parameters synthetic water

Table 2: Initial parameters synthetic water treated with anionic coagulant.

Beaker	Turbidity (NTU)	Color (Pt-Co)	pH	Conductivity (µs/cm)
1	200	245	7	271
2	200	227	7	280
3	200	227	7	292
4	200	231	7	287

Table 3: Initial parameters synthetic water treated with aluminum sulfate.

Beaker	Turbidity (NTU)	Color (Pt-Co)	pH	Conductivity (µs/cm)
1	200	246	7	312
2	200	229	7	307
3	200	226	7	309
4	200	228	7	305

3.2 Efficiency of the anionic coagulant and aluminum sulphate.

After the tests on the jar test the values of residual turbidity and apparent color applying the solution of the anionic coagulant are presented in Figure 1. It was obtained that the smaller removal was when applying a dose of 90 mg/L to the synthetic water with an initial turbidity of 200 NTU and an apparent color of 245 Pt-Co, decreasing the value of turbidity to 4 NTU and color to 12 Pt-co complying with the values stipulated in Colombian legislation.

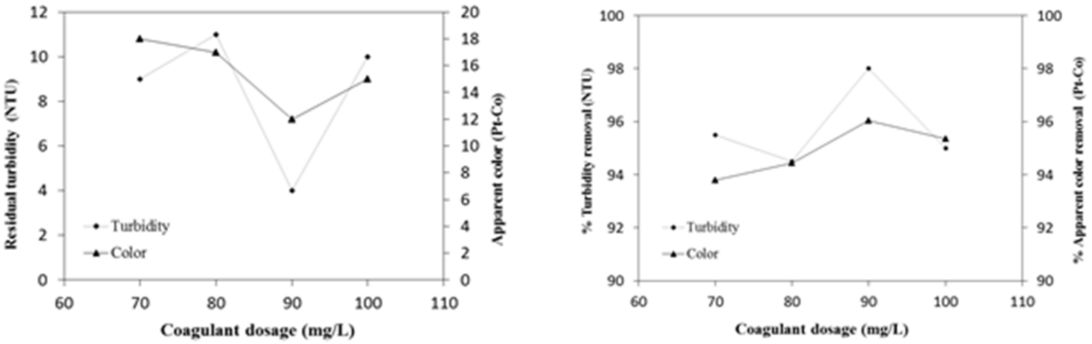

Figure 1: Residual turbidity and apparent color removal rate of water treated with anionic coagulant Kabuli Chickpea (Cicer arietinum L) and % Turbidity removal and apparent color removal rate of water treated with anionic coagulant Kabuli Chickpea (Cicer arietinum L.

The evaluated doses were 70 mg/L, 80 mg/L, 90 mg/L and 100 mg/L, obtaining the highest percentage of turbidity and color removal for the dose of 90 mg / L with a value of 98% for turbidity and 94.71 for color, as can be seen in Figure 2 in which the percentages of removal of turbidity and color are represented. It is demonstrated that this coagulant has good efficiency since the values of removal of both parameters are between 94.50% and 8% for turbidity and for color between 92.51% and 94.71%.

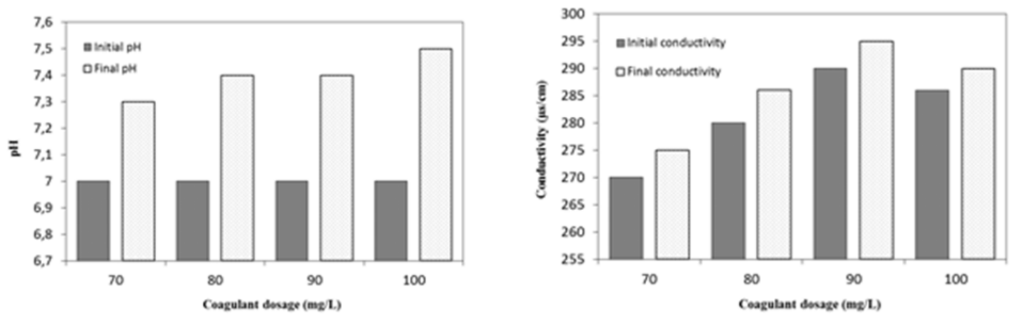

Figure 2: pH variation according to anionic coagulant dose and Conductivity variation according to coagulant dose.

The pH in which the anionic coagulant works with a better performance is 7, for this reason we worked with the solutions starting from this pH which how we can observe in Figure 3 does not present a considerable variation with respect to the dose of coagulant being the final pH 7.4 for the dose of 90 mg/L being in the limit allowed by the Colombian legislation that is between 6 and 9. In the figure of conductivity can see the variation of the conductivity with respect to the dose, in the case of the anionic coagulant to be used the conductivity has a small increase which may be due to the interaction of the coagulant with the salts present in the medium being, the initial conductivity for the optimum dose of 292 µs/cm and increasing after the tests to 297 µs/cm.

3.3 Efficiency of aluminum sulfate

To compare the efficiency of the anionic coagulant aluminum sulphate was used as shown in Figure 5, starting from an initial turbidity of 200 NTU and an apparent color of Pt-Co, was worked with doses of 60 mg/L, 70 mg/L, 80 mg/L and 90 mg/L, the latter being the optimum dose, allowing to reach values of residual turbidity of 5 NTU, and a final color of 14 Pt-Co complying with the values required by Colombian legislation, but being higher than those achieved with the anionic coagulant. The values reached by the optimum dose of 90 mg/L correspond to 97.5% efficiency in the removal of the turbidity and 93.94 for the removal of color as can be seen in Figure 6, noting that the removal values For the turbidity were between 96% and 97.5% and for the apparent color 91.63% and 93.94% being values that allow to verify once again the great power of removal of particles by the chemical coagulant.

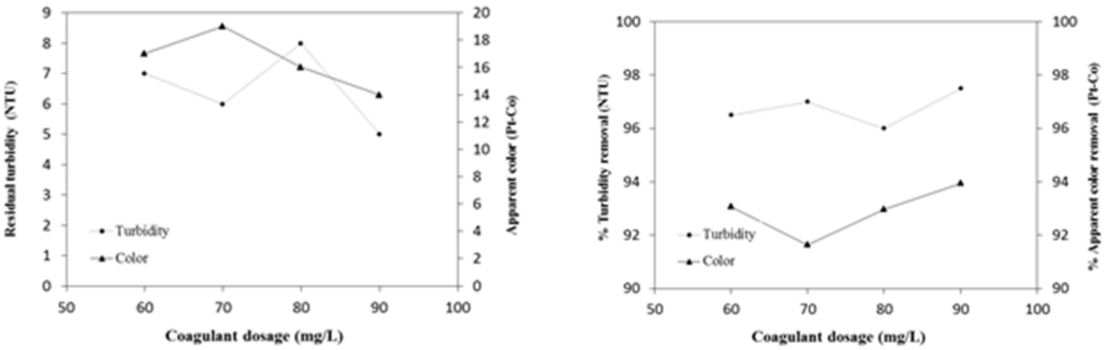

Figure 3: Residual turbidity and apparent color removal rate of water treated with aluminum sulphate and % Turbidity removal and apparent color removal rate of water treated with aluminum sulphate.

The aluminum sulphate was used starting from a neutral pH, thus obtaining an optimum point of comparison with the anionic coagulant, as it can be seen in Figure 4 the aluminum sulphate, after the tests has tended to lower the pH of the water the final pH for the optimal dose of 6.6 due to its acid character.

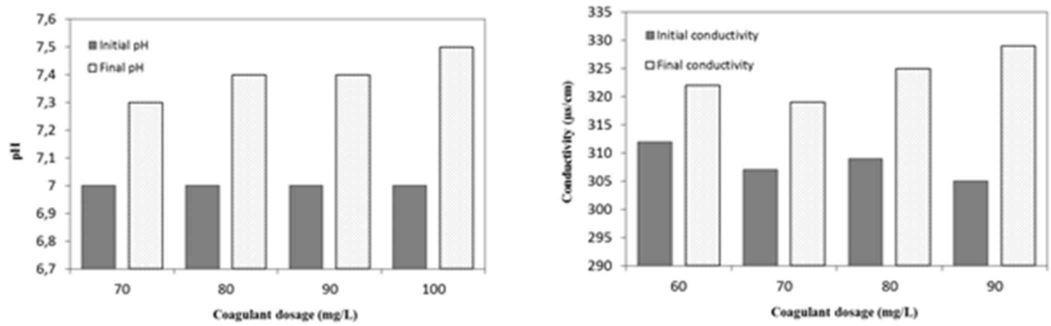

Figure 4: pH variation according to the dose of aluminum sulphate and Conductivity variation according to the dose of aluminum sulphate.

3.4 Isoelectric point

Table 5: Zeta potential Kabuli Chickpea (Cicer arietinum L).

pH	Zeta potential (mV)	pH	Zeta potential (mV)
3	15,1	7	-21,9
4	-2,5	8	-21,9
5	-11,8	9	-24,5
6	-19,8	10	-27,1

Potential Z is measured using a 1% solution, prepared with 5 g of Kabuli Chickpea (Cicer arietinum L) in 500 ml of Milli-Q® water, being filtered through a 1-micron membrane Whatman to remove impurities that may affect the measurement. The equipment used was a ZETAMASTER Malvern. Equipment that allows the evaluation and measurement of the zeta potential (ζ) of water with presence of colloidal materials, by electrophoresis, for particle sizes between 5 and 5000 nm. The zeta potential study reveals that the isoelectric point of Kabuli Chickpea (Cicer arietinum L) would be around pH 3,7. Below this pH, the adsorbent surface is positive charged and above in the surface is negatively. The mechanism of action of Kabuli Chickpea (Cicer arietinum L), can be attributed to the formation of hydrogen bonds or by means of calcium since it has carboxyl group and the charge of this tends to make a net negative charge.

4. Conclusions

The anionic coagulant Kabuli Chickpea (Cicer arietinum L) was more effective than aluminum sulphate in synthetic water with turbidity of 200 NTU, since at all doses used removal percentages greater than 94% were obtained before filtration. The highest removal of turbidity and apparent color occurred when using an optimal dose of 90 mg/L. The parameters of turbidity and color after the treatment fulfilled for both coagulants with the Colombian legislation in force with respect to the maximum acceptable value of 15 UPC for the color for the doses of 90 mg/L before filtering; After the filtration process it was possible to comply with the maximum turbidity value 2 NTU stipulated in the legislation.

The anionic coagulant Kabuli Chickpea (Cicer arietinum L) can be used as an environmentally friendly primary coagulant during water purification because the combination of the treatment processes that encompasses coagulation, flocculation, sedimentation and filtration allowed to generate an effluent that met the desirable levels of color and turbidity. This anionic coagulant Kabuli Chickpea (Cicer arietinum L) is of great importance for the Colombian communities since there is no Colombian literature that stipulates that this product was used for the treatment of water being an innovative solution and that would allow to provide water suitable for the Communities. The Anionic coagulant is polymers whose particles get faded in water by inter particle bridging. The seed extracts contain -COOH and -OH groups that can increase the coagulation competence because lipids, carbohydrates and alkaloids.

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