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Literature Review: Influence of pH and turbidity on the use of vegetable tannin as a flocculant in water treatment

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Abstract. *Studies have shown that tannin, a natural substance extracted from the bark and leaves of trees such as black wattle, is promising as a flocculant for water treatment, since it can be used in wide pH ranges, i.e., without the need for additional chemicals to stabilize the pH of the water. Furthermore, its use has proven efficient in removing turbidity and toxic metals. This work aims to study the influence of physical parameters, turbidity and pH on the efficiency of tannin as a natural coagulant through case studies and data found in the literature with their respective concentrations and data's studies to verify the behavior of these parameters. It was observed that pH between 7 and 8 has a great effectiveness in removing turbidity from water for optimum concentrations of tannin as coagulant from 1.82 mg/L up to 3 mg/L, for a Turbidity up to 139 NTU.*

Keywords. *Tannin; flocculant; water treatment; turbidity; toxic metals.*

Introduction. The effluents from treatment plants require several complex process steps (pre-treatment, primary, secondary and tertiary treatment), all of these steps are followed by unit operations such as coagulation, flocculation, decantation, filtration and pH correction. Studies by Silva (1999)[1] and Fiorentini (2005)[2] show that the use of tannin as a coagulant presents low cost and excellent color removal for a wide variety of dyes, reaching removal percentages of 86%, making it a promising technology also for effluent decolorization. The production of sludge at the end of the treatment process can be minimized by optimizing the process parameters and selecting the appropriate coagulants and flocculants, since tannin is of vegetable origin and biodegradable. The removed substances causing the turbidity of the water usually consist mostly of clay minerals and important proteins of various sizes. Water treatment plants always seek the most efficient and most economical option, so the choice of coagulants and flocculants are fundamental to the process.[3] Coagulation and flocculation are traditional methods in water treatment, in which metallic salts are used as coagulants and long-chain non-ionic polymers are used as flocculants. After the addition of these salts, a chemical hydrolysis reaction will occur forming cations that will be adsorbed by negatively charged colloidal particles forming microfocus.[4] In Brazil, inorganic substances such as ferric chloride and aluminum sulfate are used for water treatment in the primary and secondary phases. These non-biodegradable inorganic compounds can release unwanted substances into the water, and also

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after treatment. Due to these ions "released" during the effluent treatment process into the water, it has generated concerns, since these soluble ions can cause harm to human health and environmental problems.[5] Given this context, studies have sought ecological solutions of plant origin to be used in water treatment as coagulants to mitigate these impacts on health and environment . The use of these natural coagulants or associated with polymers, which are not toxic, has proven to be efficient in reducing sludge and toxic metals. Tannin has proven to be the most efficient, functional and easy to obtain in Brazil and has been used in different areas such as beverage industries, anti-corrosion and plastics, wastewater treatment and drinking water.[6] Therefore, this project searches to analyze, in a way of a bibliographic revision, just how the concentration of tannin witch acts in the physico-chemical parameters (pH and turbidity) in that way to get a curve of efficiency of the tannin like as flocculant in the treatment of waters.

Methodology. The study it's about a descriptive study as a qualitative approach in which is like as a bibliographic review, using as like premises of the scientific method in a systematic search of literature using the descriptors: "tannins" and " flocculants" as complete scientific articles in the data base of "Web of Science", analyzing how the tannins affects the physico-chemical parameters (ph and turbidity) in the middle**.**

Results And Discussion. With the values found in the literature (presented in Table 1) of the tannin physical parameters (pH and turbidity) and their respective concentration data for coagulation, it was possible to analyze and characterize the best tannin concentration and pH range for the treatment of water for human consumption. Table 1 shows the values of these parameters commonly used for tannin.

Table 1. Values of pH and turbidity with the respective concentrations the tannin

pH	Turbidity Removal [%]	Concentration [mg/L]	Authors
7.00	95	1.8	Oliveira C.[9]
7.00	90	2	Frigini de Marchi, H.[10]
7.90	100	2.5	Skoronski et al.[11]
7.00	90	3	Frigini de Marchi, H. [10]
6.30	92	3	Silva I.[1]
7.58	80	10	Skoronski et al.[11]

7.00	76	10	Moraes et al.[12]
7.60	74	10	Skoronski et al.[11]
6.00	76	20	Coral A. et al.[13]
9.00	62	20	Beltrán-Heredia[14]
6.80	72	30	Coral A et al.[13]
7.00	60	50	Moraes et al.[12]
7.50	50	50	Oliveira C..[9]

The arithmetic mean of the pH was calculated by Equation 1 from the data in Table 1 and it was observed that this pH value is around 7, considered an optimal value, because it is close to the pH of the water. With the use of tannin, the removal of turbidity is excellent, above 80% (for optimal concentrations), meeting the values required by the Ministry of Health according to the ordinance No. 518[16] , which considers a maximum of 15 NTU as potable for human consumption. According to Piantá[7] generally untreated water presents turbidity between 0 and 300 NTU. With the data in Table 1, the dispersion (Equation 2) and error (Equation 3) were calculated for the best treatment of the data. The values of the calculations of mean, standard deviation and standard error are in Table 2.

Table 2. Treatment of the data

Parameters	Mean	Standard Deviation	Error
pH	7.23	0.85	0.1957
Turbidity	77.42105	14.07	3.228

The calculations shows that even with different concentrations, the turbidity and pH have an excellent average, this may have occurred because the pH data are close to the alkalinity. With the data presented in Table 1, the linear regression shown in Graph 1 was performed for the understanding of the behavior of the R parameter and turbidity in relation to concentration.

Graph 1. Linear regression Concentration x Turbidity Removal

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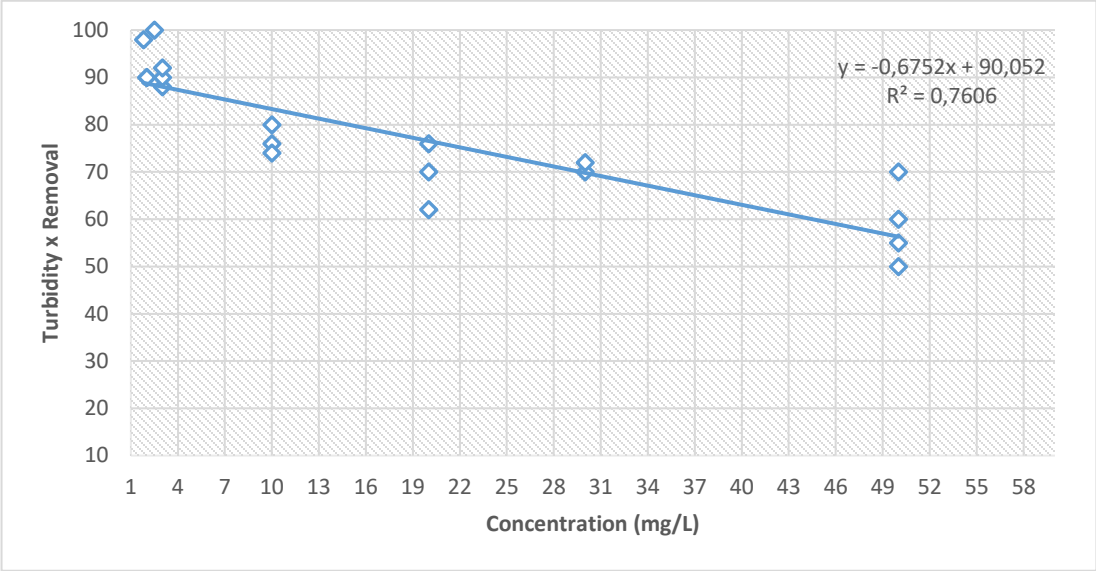

The value of the parameter R given by the regression, shows that the quality of the data is close to 1, this shows that the concentrations used in the dosages of tannin for flocculation, presents to be one of the factors that influence the turbidity to a certain value. The calculated values show that the ideal pH of the tannin is around 7 with optimal concentrations around 1.8 to 3 mg/L for a satisfactory treatment of the physical parameters analyzed in this work. It is possible to observe from Graph 1 that for a concentration value above 10 mg/L (without sudden pH changes, shown in Table 1) the turbidity removal decreases with increasing concentration, this may have occurred because according to Santos W. *et al.*[8], the ideal concentration of tannin is around 3mg/L for turbidity analysis, because according to the same the tannin presents to be inversely proportional to the increase in dosage of this coagulant decay. One justification for this fact is because a more acid pH consumes the alkalinity of the medium, which ends up hindering the removal of turbidity. In Graph 2, it is possible to analyze how the turbidity varies with pH for each concentration.

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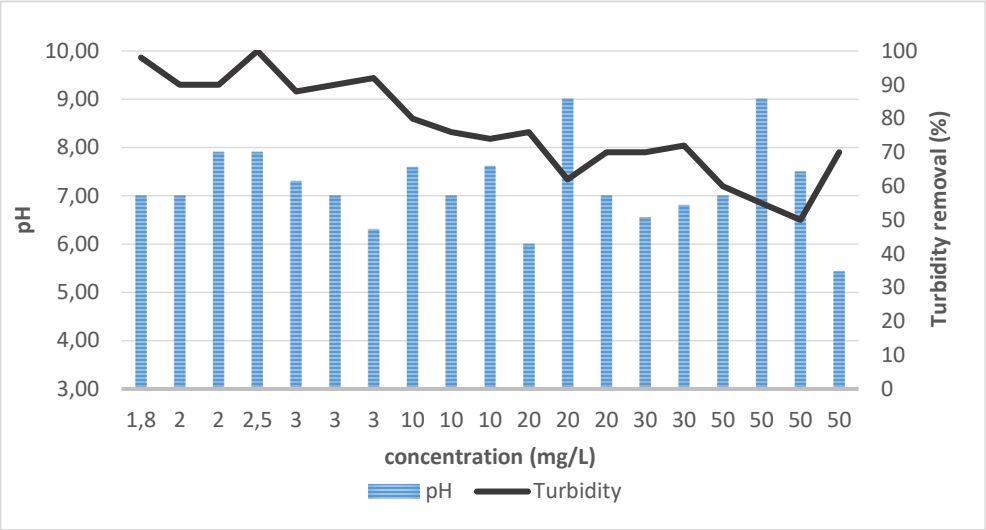
Graph 2. pH variation x Turbidity removal



It was possible to observe from Graph 2, that the pH is a great influence on the removal of turbidity along with the concentration. An example is the concentration of 20 mg/L, when the pH becomes more acidic the removal of turbidity increases and when the pH is more basic the removal of turbidity is around 60% for this concentration.

Equations.

$$\bar{X} = \frac{X_1 + X_2 + X_3 + \ldots + X_n}{n} \quad (1)$$

$$\sigma = \sqrt{\frac{(X_i - \bar{X})^2}{n}} \quad (2)$$

$$EP = \frac{\sigma}{\sqrt{n}} \quad (3)$$

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Conclusion. All comparative studies analyzed in this literature review were satisfactory for the use of vegetable tannin. The data show that tannin is an excellent option for primary water treatment to decrease turbidity present is excellent pH range. Concentrations above 3mg/L of the coagulant will not present better turbidity removal results, and possibly above this value the concentration of tannin will have to be higher, up to a certain point, because the turbidity removal using tannin is inversely proportional to the concentration.

Nomeclature.

$\overline{X}$ = Arithmetic mean.

X_1 , X_2 , X_3 , X_n = Data values;

n = Number of elements in the data set;

σ = Standard Deviation;

EP = Standard Error.

uH = Hazen unit

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