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New additive to improve coagulation for turbidity and total solids removal from greywater

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ABSTRACT

Alum-coagulation, Iron-coagulation and Iron-NH_4 enhanced with ascorbic acid were used on the samples that were synthetically prepared and treated in reactors at ambient temperature to meet the Brazilian water quality discharge limits or to be reused. A series of jar test experiments was run at 150 rpm for 2 min and 30 min for settling. 95 mg/L dose of traditional coagulant (alum, iron or iron-NH_4) was applied at pH ranging from 4-10. The coagulation was enhanced by adding doses of ascorbic acid resulting in three concentrations: 2.38, 7.14 and 11.9 g/L. Raw and coagulated greywater samples were analyzed for their turbidity, TS and conductivity as a function of time. The jar test experiments provided evidence that coagulation process could not provide sufficient TS removal efficiency in the greywater except at an iron-NH_4 + acid in all concentrations of the acid reaching a maximum removal after 4-5 h decanting. Turbidity was better removed when the small concentrations of ascorbic acid was employed. Generally, enhanced coagulation process using ascorbic acid was not sufficient to meet turbidity (< 20 mg/L) and TS (100 mg/L) limits. The highest turbidity removal (95%) was obtained at the range of 2.0–4.3 pH values, whereas turbidity removal was lesser in the greywater treated with Iron Chloride in the 11.90 g/L concentration. All experiments with controlled pH resulted in treated greywater with increasing in conductivity. Conductivity was found significantly high when controlled pH was used in the coagulation process.
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INTRODUCTION

The coagulation process proves a high removal efficiency of different parameters, mainly chemical oxygen demand (COD) and suspended solids (SS). The process is based on the use of Al(III) or Fe(III) salts alone or in combination with calcium salts and the use of polymers as flocculants. Coagulant doses vary in a wide range like 150– 600 mg/L and 250–2000 mg/L of $Al_2(SO_4)_3$ (alum) used for treatment of domestic[1,2,3] and industrial wastewaters[4, 5], respectively while 20–60 mg/L of alum was applied as the proper interval for drinking water production[6, 7].

In addition to aluminium sulfate, alternative coagulants, such as ferric chloride[3], NH_4-ferric chloride[8,10] can used trying to improve coagulation efficiency as well as associated with ascorbic acid in the water. Furthermore, the coagulation process was optimized for optimum time decanting and turbidity by results obtained when monitoring experiments were carried out.

The present study was carried out on synthetic greywater with specific composition to evaluate the efficacy of enhanced coagulation for complying with the brazilian discharge standards[13] in the body water [12, 13]. The effect of auxiliary coagulant in the coagulation pH, applied alum dose, turbidity and TS concentrations on coagulation efficiency and removal (%R) was discussed.

MATERIALS AND METHODS

Greywater

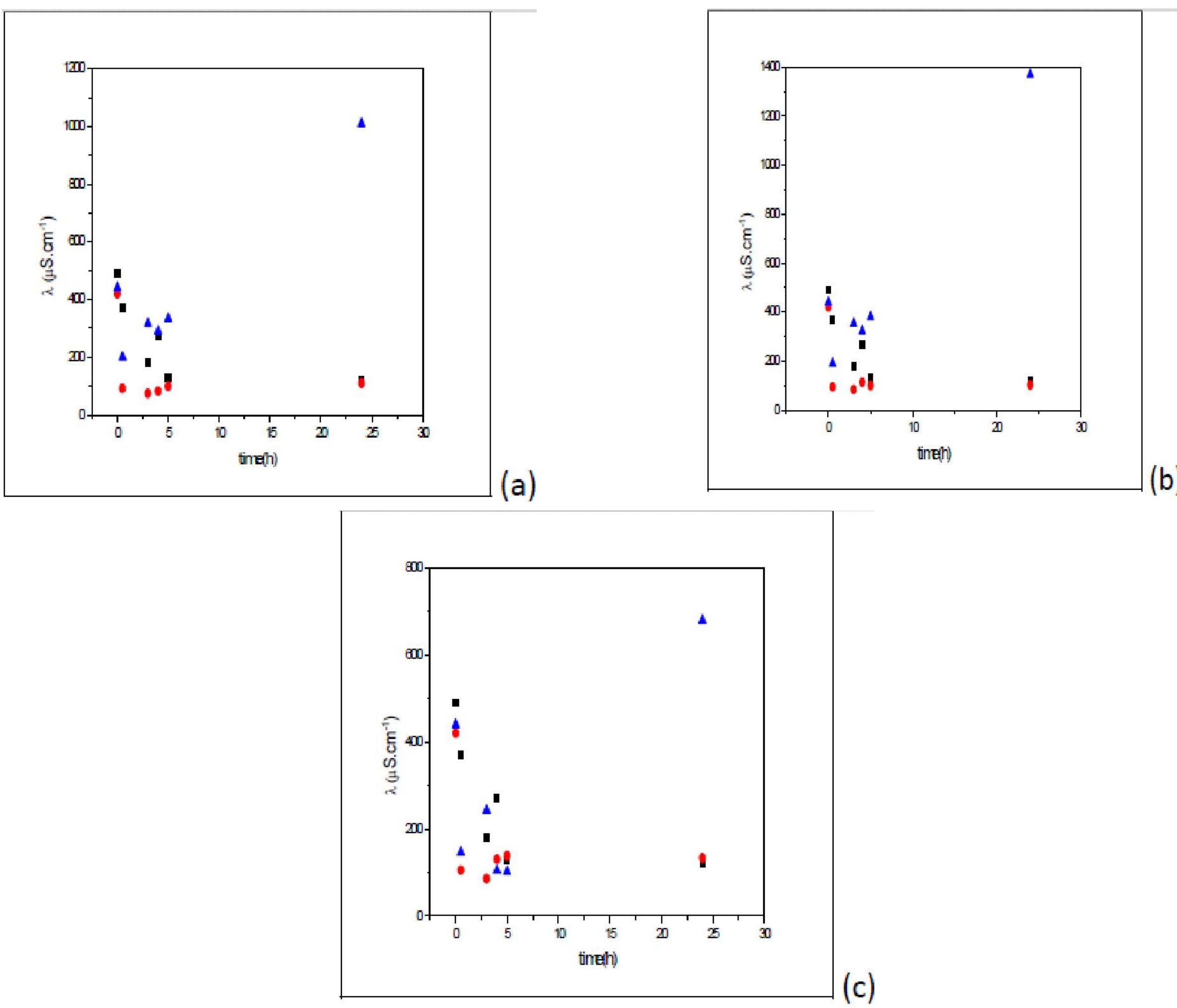
The synthetic greywater was prepared using: soap, oil and tap water in mass fraction % of: 0.068, 0.581 and 99.3. Samples of 400 mL were distributed in glass containers to carry out jar test experiments.

Jar test

A series of jar tests was carried on the samples prepared daily in the laboratory. They were coagulated at 150 rpm for 5 min, sequentially stirred and then were settled for 30 min. 95 mg/L dose of the dried traditional coagulant {Al_2 $(SO_4)_3$; $FeCl_3$ or $Fe(NH_4)$ (SO_4)}was used at pH ranging from 6.0 to 9.0. Ascorbic acid was added as an auxiliary coagulant in three distinct concentrations: 2.38; 7.18 and 11.9 mg/L, which is originally used in the experiments to enhance the coagulation process. Experiments with auxiliary coagulant were processed at pH ranging from 1.0 to 4.3.

Analysis

Raw and coagulated samples were analyzed for their conductivity, TS and turbidity contents according to Standard Methods (1998). Samples of about 4.0 mL were collected using a syringe in different times such: 0.5 h; 3; 4; 5 and 24 h.



(■Coagulant, ●Coagulant + acid; ▲ Coagulant + acid + pH-control).

Figure 1 : Conductivity of greywater treated with $Al_2(SO_4)_3$ (C = (95 mg.L^{-1}) and associated with ascorbic acid at three different concentrations as a function of time. {(a) 2.38 g.L^{-1}; (b) 7.14 g.L^{-1} e (c) 11.90 g.L^{-1}}

RESULTS AND DISCUSSION

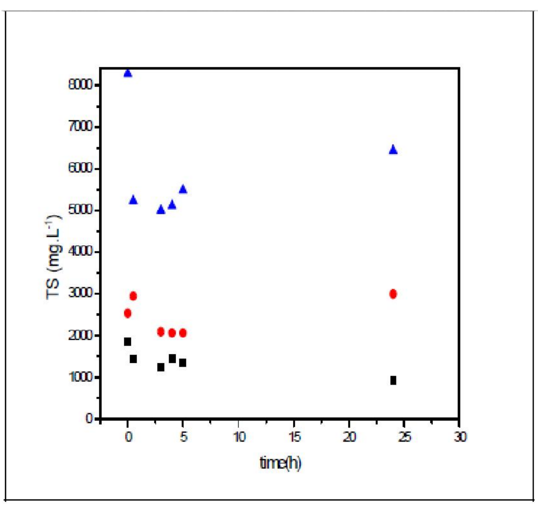
Jar test results

As already reported, only synthetic greywater with specific concentration was used in the experiments. So, conductivity, turbidity and TS concentrations were measured using three traditional coagulants associated with ascorbic acid at different concentrations.

Based on literatures reviewing[5, 13], the quality ranges of the different grey water are: pH (5.9-7.4), TSS (134-1300 mg/L) and turbidity (298 NTU). Although there are variations in grey water quality, the analysis of the grey water characteristics by different categories indicates that the kitchen grey water and the laundry grey water are higher in both organics and physical pollutants compared to the bathroom and the mixed grey water.

Figure 1 shows the behavior of greywater conductivity treated with $Al_2(SO_4)_3$ (C = (95 mg.L^{-1}) enhaced with ascorbic acid. It can be observed that there is a minimum conductivity point between 3 and 5 hours in the settling time when the process probably could be finished.

One result for TS for the same system is presented in Figure 2. For this system, all results are listed in TABLE 1. It can be seen that adding sodium hydroxide solution to keep pH in the appropriate range (pH control) leads the system to have high conductivity. It seems that the presence of ascorbic acid have not changed the grey water conductivity. Also, observing Figure 2, it is not recommended to leave the system decanting for more than seven hours.



(■Coagulant, ●Coagulant + acid; ▲ Coagulant + acid + pH-control).

Figure 2 : Total solids (TS) of greywater treated with $Al_2(SO_4)_3$ (C = (95 mg.L^{-1}) and associated with ascorbic acid at 2.38 g.L^{-1} concentration as a function of time

Overall removal calculations

The removal (*%R*) of the total contaminants or impurities during the treatment was calculated using the following equations below. *%R* values for the impurities were determined and calculated according to the variable measured as shown in Eqs. (1) and (2):

$$\%R^{Turb} = \left[(Turb_0 - Turb_t\right]/Turb_0 \quad \textbf{(1)}$$

$$\%R^{TS} = \left[(TS_0 - TS_t\right]/TS_0 \quad \textbf{(2)}$$

where, $Turb_0$ and TS_0 are initial turbidity and total solids in water, and $Turb_t$ and TS_t are the variables measured after coagulation process in the specific time. Removal efficiencies are listed in TABLES 1-6 for all experiments.

TABLES 2-6 show all the results of coagulation treatment for removal of impurities. According to them, treatment using only traditional coagulant is still seemed effective to remove impurities. The removal efficiency of TS also depended on the concentration of ascorbic acid. Results show that coagulation treatment was able to remove more than 40% of impurities from grey water. The removal efficiency was really lower when ascorbic acid concentration increased. Regarding the turbidity parameter, it was observed that removal efficiencies slightly improved with increasing dosage. However, for TS removal efficiencies were damaged by acid presence and remained unchanged when system was kept decanting all day long. This result indicates that the maximum dosage required for effective removal of these impurities from the grey water was 7.14 mg/L.

TABLE 5 shows that the results are seemed to be really similiar for removing percentage when $Fe(SO_4)_-NH_4$ is used even if acid concentration is incresead. Also, contoling pH does not cause any change in the values as a function of time.

TABLE 1 : Total solids (TS) removing for $Al_2(SO_4)_3$ and associated with ascorbic acid at three different concentrations. (legend: No aux- only traditional coagulant; No pH-c – without pH-control; pH-c – pH-control used.)

Time/h	TS removing (%)								
	2.38 mg/L			7.14 mg/L			11.9 mg/L		
	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c
0.5	23	-	37	23	-	-	23	-	-
3.0	32	17	40	32	-	-	32	-	-
4.0	21	19	38	21	-	-	21	-	-
5.0	27	19	34	27	-	-	27	-	-
24.0	50	-	22	50	-	-	50	-	-

TABLE 2 : Turbidity removing for $Al_2(SO_4)_3$ and associated with ascorbic acid at three different concentrations

Time/h	Turbidity removing (%)								
	2.38 mg/L			7.14 mg/L			11.9 mg/L		
	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c
0.5	13	73	69	13	58	69	13	-	87
3.0	-	48	75	-	80	70	-	20	49
4.0	-	80	70	-	74	72	-	4	50
5.0	-	88	76	-	78	74	-	2	53
24.0	43	29	81	43	29	76	43	59	70

TABLE 3 : Total solids (TS) removing for $FeCl_3$ and associated with ascorbic acid at three different concentrations

Time/h	TS removing (%)								
	2.38 mg/L			7.14 mg/L			11.9 mg/L		
	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c
0.5	-	-	-	-	-	-	-	-	-
3.0	17	-	-	17	-	-	17	-	-
4.0	28	17	-	28	-	-	28	-	-
5.0	38	10	-	38	-	-	38	-	-
24.0	32	-	-	32	-	-	32	-	-

TABLE 4 : Turbidity removing for $FeCl_3$ and associated with ascorbic acid at three different concentrations

Time/h	Turbidity removing (%)								
	2.38 mg/L			7.14 mg/L			11.9 mg/L		
	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c
0.5	3	7	-	3	-	16	3	-	-
3.0	-	36	-	-	9	18	-	-	10
4.0	-	30	2	-	27	17	-	-	11
5.0	-	43	14	-	33	21	-	-	10
24.0	14	-	-	14	-	-	14	-	31

The best removal efficiency was reached in the greywater when using an iron-NH_4 + acid, as presented in TABLE 6 in 2.38 mg/L of the acid after 4-5 h decanting. Therefore, turbidity could be better removed when the small concentration of ascorbic acid was employed and using 24 h decanting is not worthy.

In general, the study showed that the enhanced coagulation process alone is not able to reduce the contaminants substances to the required reuse standard, thus it needs the application of additional processes or different kind of auxiliary chemical.

TABLE 5 : Total solids (TS) removing for $Fe(SO_4)_-NH_4$ and associated with ascorbic acid at three different concentrations

Time/h	TS removing (%)								
	2.38 mg/L			7.14 mg/L			11.9 mg/L		
	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c
0.5	47	25	-	47	7	-	47	-	-
3.0	53	36	-	53	13	26	53	-	-
4.0	51	33	-	51	11	-	51	-	-
5.0	37	35	-	37	5	-	37	-	-
24.0	57	31	-	57	-	-	57	-	-

TABLE 6 : Turbidity removing for $Fe(SO_4)_-NH_4$ and associated with ascorbic acid at three different concentrations. (No pH-c: 2.3 <pH< 4.0)

Time/h	Turbidity removing (%)								
	2.38 mg/L			7.14 mg/L			11.9 mg/L		
	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c	No aux	No pH-c	pH-c
0.5	85	65	2	85	9	-	85	-	-
3.0	-	87	4	-	64	-	-	39	-
4.0	2	88	5	2	70	-	2	35	-
5.0	-	91	4	-	74	-	-	62	-
24.0	38	95	-	38	59	-	38	46	-

CONCLUSIONS

The synthetic wastewater similarly produced in Brazilian residences was treated using traditional coagulants associated with ascorbic acid. All experiments with controlled pH resulted in treated greywater with increasing in conductivity and it was found significantly high when controlled pH was used in the coagulation process.

Coagulation experiments showed that $Al_2(SO_4)_3$ resulted to higher TS and turbidity removal comparing to $FeCl_3$. The auxiliary coagulant dosage affected process efficiency.

The best removal efficiency was reached in the greywater when using an iron-NH_4 + acid in all concentrations of the acid after 4-5 h decanting. Turbidity was better removed when the small concentrations of ascorbic acid was employed. Generally, enhanced coagulation process using ascorbic acid was not sufficient to meet turbidity (< 20 mg/L) and TS (100 mg/L) limits. The highest turbidity removal (95%) was obtained at the range of 2.0–4.3 pH values.

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REFERENCES

[1] S.Meriç, M.Guida., M.Mattei, A.Anselmo, G.Melluso; Evaluation of coagulation flocculation process for S.Giovanni a Teduccio municipal wastewater treatment plant, Fresenius Envir. Bull., **11**, 906–909, **(2002a)**.

[2] S.Meriç, M.Guida, M.Mattei, A.Anselmo, G.Melluso, G.Pagano; Microbial and COD removal in a municipal wastewater treatment plant using coagulation flocculation process, J.Environ.Sci.Health, **A37(8)**, 1483–1494, **(2002b)**.

[3] S.Delgado, F.Diaz, D.Garcia, N.Otero; Behaviour of inorganic coagulants in secondary effluents from a conventional wastewater treatment plant, Filtr. Separ., **40(7)**, 42–46, **(2003)**.

[4] M.Rossini, J.G.Garrido, M.Galluzzo; Optimization of the coagulation–flocculation treatment: Influence of rapid mix parameters, Wat.Res., **33(8)**, 1817–1826 **(1999)**.

[5] H.Selçuk, D.Kaptan, S.Meriç; Coagulation of textile wastewater using alum and Fe(III) salts, Fresenius Environ. Bull., **13(10)**, 1045–1048 **(2004)**.

[6] C.Volk, K.Bell, E.Ibrahim, D.Verges, G.Amy; M.Lechevallier; Impact of enhanced and optimized coagulation on removal of organic matter and its biodegradable fraction in drinking water, Wat. Res., **34(12)**, 3247–3257 **(2000)**.

[7] L.Rizzo, V.Belgiorno, M.Gallo, C.S.Meriç; Removal of THMs precursors from a high-alkaline surface water by enhanced coagulation and behaviour of THMFP toxicity on D.magna, Desalination, **176**, 177–188 **(2005)**.

[8] B.Y.Gao, H.H.Hahn, E.Hoffmann, Evaluation of aluminium–silicate polymer composite as a coagulant for water treatment, Wat.Res., **36**, 3573–3581, **(2002a)**.

[9] B.Y.Gao, Q.Y.Yue, B.J.Wang, Y.B.Chua; Polyaluminium-silicate-chloride (PASiC) — a new type of composite inorganic polymer coagulant, Colloids and Surfaces, **229(1–3)**, 121–127 **(2003)**.

[10] B.Y.Gao, Q.Y.Y**ue**, J.Miao, Evaluation of polyaluminium ferric chloride (PAFC) as a composite coagulant for water and wastewater treatment, Wat.Sci.Tech., **47(1)**, 127–132 **(2002b)**.

[11] Standard Methods for the Examination of Water and Wastewater, 20th Edition, American Public Health Association/American water Works Association/ Water Environment Federation, Washington, DC, USA, **(1998)**.

[12] D.G.Boneberg, B.S.Revolta, S.Pimenta, Jr, M. R.Franco; Removing general organic compounds from small quantities of river water, American Journal of Environmental Engineering, **3(5)**, **(2013)**.

[13] J.S.M.Almeida, Jr, M.R.Franco; Dissolved oxygen measurements on Uberabinha River for determining the oxygenation constant, Anais do III CIMAS - São Paulo, Outubro de **(2013)**.

[14] J.S.M.Almeida, N.R.A.F.Rocha, Jr,M.R.Franco; Treating domestic greywater and expectations to be reused, American Journal of Environmental Engineering, **3(5)**, **(2013)**.