

Commercial laundry water characterization for anaerobic treatment in fluidized bed reactor

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Abstract

The laundry business is very common nowadays, and this is an important service sector. Therefore, it deserves special attention focused on their wastewater, waste disposal and treatment. The aim of this study was to characterize the wastewater from a commercial laundry during 30 days for further treatment in anaerobic fluidized bed reactor. Physicochemical analysis were performed, regarding the series nitrogen, phosphate, heavy metals, linear alkylbenzene sulfonate (LAS), volatile organic acids and alcohols. The pH was around 5.6 and COD about 4800 mg.L⁻¹. All nutrients (NO₃, NO₂, NH₄, TKN) and heavy metals were below the maximum limit in accordance with environmental legislation. The LAS was detected in all samples in the average concentration of 163.65 mg.L⁻¹. Although the characterization performed had indicated low values for many parameters, this does not eliminate the need for specific treatment before its disposal at the sewage system.

Keywords

Greywater, Legislation, Linear Alkylbenzene Sulfonate.

INTRODUCTION

Gray wastewater is defined as one with no contribution from toilets, or correspond only water from bathtubs, showers, sinks and washing machines. The total fraction of gray wastewater has been estimated in 75% of the total volume of sewage (Hansen And Kjellerup, 1994). The treatment of laundry water is currently a subject of great challenge, since the intense population growth is not accompanied by infrastructure works needed, especially sanitation. As a consequence, it sets up a precarious situation respecting population health and environmental conservation. Thus, it is extremely important to know gray wastewater, as well as, the development of economically viable and efficient technology that allow the application of treatment system wide and favorable to the sanitary conditions improvement.

METHODS

The wastewater characterization from commercial laundry was done by physicochemical analysis. This water was collected during 30 days in commercial laundry, São Carlos (SP). For this, it was standardized the washing machine, type of clothing and period of collections. The samples (1 liter) were collected after the first wash of light-colored clothes without bleach, prior to the softener addition. After collect, the samples were transferred to borosilicate glass bottle and sent immediately to the laboratory. Analyses were performed immediately after collection at the Laboratory of Biological Processes in the School of Engineering of Sao Carlos/USP. The physicochemical parameters are listed in Table 1. It was used the SPSS 17.0 statistical package for Kendall and Spearman correlations analysis between the values of COD and LAS present in water samples from commercial laundry.

Table 1. Physico-chemical parameters of water commercial laundry water

Parameters	References
pH, COD, heavy metals, sulfate, sulfite and N series	APHA (2005)
alkalinity, phosphate, fluoride, bromide	Dillalo; Albertson (1961) Ripley et al. (1986)
Linear Alkylbenzene Sulfonate (LAS)	Duarte (2006)
volatile organic acids	Moraes, et. al. (2001)
alcohols	Gas chromatography
suspended solids	Gravimetric method

RESULTS AND DISCUSSION

The LAS presence was observed in all samples, ranging from 12.24 mg.L⁻¹ to 1023.7 mg.L⁻¹ (Table 2 and Figure 1). The lowest value detected in this study was similar to that found by Gross et al. (2007), which registered 4.7 to 15.6 mg.L⁻¹ for anionic surfactants and 839 ± 47 mg.L⁻¹ COD graywater used to lettuce irrigation.

Table 2. Physicochemical parameters of water commercial laundry water

	Parameter (mg.L ⁻¹)	Value			
		Minimun	Maximun	Average	Deviation
	pH	3.32	6.85	5.63	0.95
	Total Alkalinity	0	82.15	25.89	20.22
	CDO no t filtered	622	4796	1710	968.27
	CDO filtered	415	4474	1471	915.68
	LAS	12.24	1023.7	163.65	247.86
	TSS	10	290	80	60
	FSS	10	270	10	40
	VSS	10	260	70	50
	Sulfate	1.43	102.64	21.06	19.09
	Sulfide	0.04	0.8	0.17	0.14
	Nitrate	1.03	25.68	8.37	6.77
	Nitrite	1.07	3.29	2.1	0.79
	N-ammoniacal	0.32	54.8	7	10.78
	NKT	1.2	136	32.44	26.25
	Fosfate	9.8	278.98	94.65	75.38
	Ethanol	38.87	384.59	148.62	94.56
	Volatile fatty acids	Citric	8.34	307.5	50.89
Malic		4.57	183.75	34.61	52.72
Succinic		7.39	193.75	63.47	82.99
Latic		11.78	406.75	92.23	103.39
Formic		3.23	172	15.63	35.83
Acetic		7.76	329.25	24.24	61.95
Propionic		10.66	279.75	44.61	65.91
Isobutyric		10.92	287.25	46.02	67.4
Butyric		10.93	292	121.59	140.56
Isovaleric		11.24	35.19	16.4	7.36
Valeric		10	251	40.46	85.07
Caproic		10.92	273.5	96.96	122.47
Heavy metals	Zinc	0.031	3.589	0.558	0.76
	Lead	<0.01	0,17	0.057	0.05
	Cadmium	<0.0006	0.08	0.023	0.02
	Nickel	<0.008	0.083	0.04	0.02
	Iron	0.037	0.723	0.216	0.22
	Manganese	<0.003	0.199	0.036	0.05
	Copper	<0.003	0.088	0.034	0.03
	Chrome	<0.005	0.062	0.021	0.01

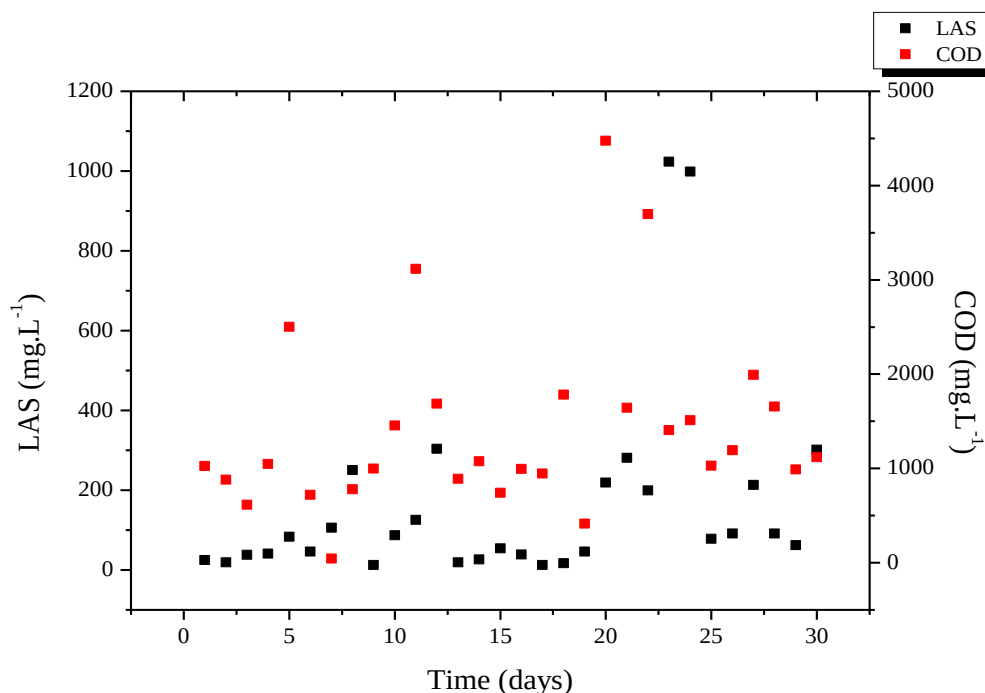


Figure 1. LAS and COD in water samples from the commercial laundry

In this study, the LAS average concentration (163.65 mg.L^{-1}) was much higher than that shown by other authors. Gross et al. (2005) found $29\text{-}60 \text{ mg.L}^{-1}$ of anionic surfactant in the wastewater and $23 \pm 4.5 \text{ mg.Kg}^{-1}$ in soil. These surfactants may be toxic to the soil and plants in these concentrations (Abu-Zreig et al., 2003).

The filtered and not filtered COD ranged from 622.25 mg.L^{-1} to $4795.80 \text{ mg.L}^{-1}$ and from 415.25 mg.L^{-1} to $4473.25 \text{ mg.L}^{-1}$, respectively (Table 2 and Figure 1). It was found that there was no pattern in relation to the effluent concentration of organic matter. Leal et al. (2010) studied biological systems for domestic graywater treatment. The authors found $43.5 \pm 6.5 \text{ mg.L}^{-1}$ anionic surfactant and $827 \pm 204 \text{ mg.L}^{-1}$ COD. The correlation coefficients of Kendall (0313, $p = 0.05$) and Spearman (0465, $p = 0.01$) indicated a positive correlation with the COD and LAS.

It was found in this study a wide VFA (volatile fatty acids) variety being the most common, propionic and isobutyric (100% of samples), lactic (96.6%), formic and acetic (93%) and malic (73.3%). The least common were caproic and succinic (16.6%), valeric (26.6%) and citric and butyric (33%). Lactic acid (13.54 mg.L^{-1} to 406.75 mg.L^{-1}) was quantitatively the most representative, followed by isobutyric (10.88 mg.L^{-1} to 287.25 mg.L^{-1}) and propionic (10.66 mg.L^{-1} to 279.75 mg.L^{-1}) respectively (Table 2). Although butyric acid has been found only in 33.3% of laundry water samples, the values were above 200 mg.L^{-1} in 40% of the samples containing this acid.

Among the alcohols analyzed only ethanol was present in 77% of samples, whose average value found was 148.62 mg.L^{-1} .

In this study, the pH average was 5.6, and ranged from 3.3 to 6.8. According to Federal Legislation CONAMA 357/2005, the proper pH value for effluent ranges from 5 to 9. The average value recorded in this study fits within this standard, although some samples showed a pH below the allowed (33.3% of samples). The São Paulo State Legislation, Decree 8.468/1976, mentions that the effluent may be released into sanitary sewer system, with treatment and pH between 5.0 and 9.0. Thus, according to this legislation, 40% of the samples had unsatisfactory pH.

The total alkalinity (25.89 mgCaCO_3) was low as can be seen in Table 2. Rose et al. (1991) reported alkalinity values ranging from 149 to 198 mgCaCO_3 in domestic greywater. Alkalinity is an

important parameter when attempting to treat graywater from anaerobic digestion, whereas lowering the pH can harm the microorganisms responsible for organic matter degradation (Eriksson et al., 2002).

Were detected low sulfate and sulfide concentrations, whose average values were 6.21 mg.L^{-1} and 0.17 mg.L^{-1} , respectively (Table 2). Casanova et al. (2001) recorded 59.59 mg.L^{-1} of sulfate in graywater. Decree 8.468/76 of São Paulo State advocates until 1000 mg.L^{-1} of sulfate. For the sulfide, CONAMA 357/05 and Decree 8.468/76 São Paulo State, allow maximum effluent release with 1.0 mg.L^{-1} . Therefore, both parameters were much lower than allowed.

Among the nitrogen compounds, nitrate had a greater contribution (8.37 mg.L^{-1}), ie, higher value than that recorded in the literature. Gerba et al. (1995) found in graywater treatment system, 1.8 to 3.0 mg.L^{-1} of nitrate. The value found for ammonia nitrogen was lower than that allowed by CONAMA Resolution 357/2005 (20 mg.L^{-1}) for effluent discharge. This standard does not include other nitrogen forms. The total nitrogen concentration was close to Christov-checked by Boal et al. (1996), 40 mg.L^{-1} in water laundry.

The phosphate was detected in 93% of samples (94.65 mg.L^{-1} in average), showing its strong presence due to the laundry water contents. The graywater contributes, in general, with 12.4% of the phosphorus load in a residence (Gray and Becker, 2002). Laundry water may have low phosphorus concentration due to the presence of phosphorus-free detergents (Li et al., 2009). However, when there are their presence, its main source is detergents containing phosphates (Eriksson et al., 2002). In places where the use of these detergents is not allowed, the phosphorus in graywater tends to be 70% lower (Otterpohl, 2001).

All metals analyzed were below the maximum permitted effluent discharge according to CONAMA 357/2005 (Table 2). In this study, zinc was the most abundant (0.56 mg.L^{-1}), followed by iron (0.22 mg.L^{-1}). Both were detected in 100% of samples. Nevertheless, the measured concentrations were below the maximum allowed, either by CONAMA 357/05 and 20/86, as, by State Decree 8.468/76, which is 5 mg.L^{-1} and 15 mg.L^{-1} for zinc and iron, respectively.

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In the present study, the average total suspended solids was 0.08 g.L^{-1} . Trujillo et al. (1998) found value of 0.16 g.L^{-1} when they studying reuse and recycling of graywater. According to Al-Jayyous (2003), graywater has a suspended solids low concentration indicating that a large portion of the contaminants is in dissolved form. Although the solids expected in the greywater is less when compared to conventional sewage, according to Gray and Becker (2002), approximately 32.7% of the solids loading of the sewage comes from graywater. Measures of solids suspended in greywater have been reported in the literature in the range of 0.017 g.L^{-1} to 0.33 g.L^{-1} , being the highest values originated from laundries and kitchens (Eriksson et al., 2002).

CONCLUSIONS

It could be concluded from this study that the commercial laundry water studied showed no own characteristic, varying the parameters measured between a water collect and another. However, the majority of these parameters was lower than recommended by Federal and State Legislation, which does not minimize the environment and public health impact. However it is not eliminate the need for special treatment before its disposal in the sewage system, since studies on the laundry water characteristics and its potential effects are scarce yet.

REFERENCES

- Abu-Zreig, M., Rudra, R.P. And Dickinson, W.T. (2003). Effect of application of surfactants on hydraulic properties of soils. *Biosystems Engineering*, **84**, 363–372.
- APHA/AWWA/Water Environment Federation. (2005) Standard Methods for the Examination of water and wastewater. 20th ed. Washington, DC, USA.
- Al-Jayyousi, O. R. (2003). Greywater reuse: towards sustainable water management. *Desalination*, **156** 181-192.
- Casanova L.M., Gerba C. P., Karpiscak M. (2001). “Chemical and Microbial Characterization of Household Graywater”. *J. Environmental Science and Health*. **A36(4)**:395-401.
- Christova-Boal, D., Eden, R. E., Mcfarlane, S. (1996). An investigation into greywater reuse for urban residential properties. *Desalination*, **106**, 391–397.
- Conselho Nacional do Meio Ambiente. CONAMA. Resolução nº20, de 18 de junho de 1986. Classificação das águas doces, salobras e salinas do território nacional.
- _____. Resolução nº357, de 17 de março de 2005. Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para o seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes, e dá outras providências. Diário Oficial da União, Brasília, 17 de março de 2005.
- Dilallo, R.; Albertson, E. (1961). Volatile acids by direct titration. *Journal WPCF*, **33**, pp. 356-365.
- Duarte, I.C.S. (2006). *Caracterização Microbiológica da Remoção e Degradação de Alquilbenzeno Linear Sulfonado (LAS) em Reatores Anaeróbios com Biofilme e Células Planctônicas*. Tese de doutorado, EESC, USP, São Carlos, São Paulo, Brasil.
- Eriksson, E.; Auffarth, K.; Henze, M.; Ledin, A. (2002) Characteristics of grey wastewater. *Urban Water*. **4(1)**, 85 – 104.
- Gerba, C. P., Straub, T. M., Rose, J. B., Karpiscak, M. M., Foster, K. E., Brittain, R. G. (1995). Water quality of graywater treatment system. *Water Research*, **31(1)**, 109–116.
- Gray, S. R.; Becker, N. S. C. (2002). Contaminant flows in urban residential water system. *Urban Water*. v. **4(4)**, p. 331-346.
- Gross, A; Azulai, N.; Oron, G.; Ronen, Z.; Arnold, M; Nejdat, A. (2005). Environmental impact and health risks associated with greywater irrigation: a case study. *Water Science & Technology*. **52(8)** pp 161–169.
- Gross, A.; Shmueli, O.; Ronen, Z.; Raveh, E. (2007). Recycled vertical flow constructed wetland (RVFCW)—a novel method of recycling greywater for irrigation in small communities and households. *Chemosphere*, **66** 916–923.
- Hansen, A. M.; Kjellerup, M., (1994). Vandbesparende foranstaltninger. Teknisk Forlag, Copenhagen, ISBN 87-571-1435-9
- Leal, L. H.; Temmink, H.; Zeeman, G.; Buisman, C.J.N. (2010). Comparison of Three Systems for Biological Greywater Treatment. *Water*, **2**, 155-169.
- Li, F.; Wichmann, K.; Otterpohl, R. (2009). Review of the technological approaches for grey water treatment and reuses. *Science of the Environment*. **409** 3439-3449.
- Moraes, E. M., Adorno M. A. T., Zaiat M. E Foresti E. (2000). *Determinação de Ácidos Voláteis por Cromatografia Gasosa em Efluentes de Reatores Anaeróbios Tratando Resíduos Líquidos e Sólidos* In: VI Oficina e Seminário Latino-Americano de Digestão Anaeróbia, 2000, Recife - PE. Anais da VI Oficina e Seminário Latino-Americano de Digestão Anaeróbia. Recife – PE. Ed. Universitária - UFPE, 2:235-238.
- Otterpohl, R.; Braun, U.; Oldenburg, M. (2003). Innovative technologies for decentralized water, wastewater and biowaste management in urban and peri-urban areas. *Water Science Technology*. **48** (11/12), 23 – 32.
- Ripley, L.F.; Royle, W.C.; Converse, J.C. (1985). Improved alkalimetric monitoring for anaerobic digestion of poultry manure. Proceed. of the 40th Industrial Waste conference, Purdue University, USA.
- São Paulo. Decreto Estadual nº 8468. Aprova o regulamento da Lei nº 997, de 31 de maio de 1976, que dispõe sobre a prevenção e o controle da poluição do meio ambiente. Diário da Oficial da União, 8 de setembro de 1976.
- Trujillo S, Hanson A, Zachritz W, Chancy R. (1998). Potential for greywater recycle and reuse in New Mexico. New Mexico. *Journal of Science* **3** 293-313.