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RESEARCH ARTICLE

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Use of organic coagulant/flocculant for treatment of effluents generated in intensive rearing of swine

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Abstract

Separation of water for reuse is essential in an effluent treatment system, especially in activities with high water consumption, such as a pig production system. The objective of this work was to evaluate the efficiency of Tanfloc SG® coagulant tannin/organic flocculant used to treat effluent generated during the intensive rearing of swine. For the evaluation, laboratory and in situ tests (field test) were performed. The laboratory tests were performed to define the concentration (1 and 16%), dosage (0, 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 milliliters of the solution), and time (24, 48, 72, and 96 hours) of coagulation/flocculation treatment of the solid portion of the effluent. The parameters pH, turbidity, oxidation reduction potential, dissolved oxygen, and electroconductivity (in microsiemens per centimeter) were evaluated using a multiparameter probe and the parameters ammonia (NH_3), nitrate (NO_3), and nitrite (NO_2) in the laboratory, in relation to the coagulation/flocculation time of the solid part of the effluent. The use of tannin as a coagulant/flocculant of plant origin in the treatment of swine effluents was effective in reducing turbidity and concentrations of ammonia, nitrite, and nitrate, and it allowed separation of the solid–liquid phase in approximately 68% as liquid phase.

KEYWORDS
coagulant/flocculant, effluent treatment, swine manure, tannin

1 | INTRODUCTION

In Brazil, water is an extremely abundant natural resource, and it is distributed throughout a 8,511,928 square kilometers (km^2) of watersheds and along the extensive coastline. The availability and distribution of this resource is quite irregular, however, with the existence of rivers with great flow, as in the Amazon region, as opposed to the scarcity within the Northeast region (Cutolo, 2009). On the other hand, the major concern in the regions of South and Southeast Brazil is water quality, as some rivers have serious pollution problems from domestic and industrial origins (Tundisi, 2008).

In Brazil, the quality of the water supply is controlled by the National Council for the Environment (CONAMA) (2005), an advisory and deliberative body of the National Environment System, through Resolution 357 of March 17, 2005, which classifies water bodies and sets water conditions and standards of effluent release. They also oversees compliance with Regulation 518, which establishes the procedures and responsibilities related to the control and monitoring of water for human consumption, where a potability standard is required

Water quality is the result of a set of physical, chemical, and biological parameters that describe its nature (Valente & Gomes, 2005). Depending on its quality, water can be used directly, or it will require treatment. Water pollution causes a number of negative impacts on the environment, potentially causing not only damage to public health, but also by undue use of water, interfering with aquatic fauna and flora and causing sedimentation and eutrophication, inducing unpleasant aesthetic aspects, and damaging the environment economically (Cutolo, 2009).

From the concept of water quality and assuming that the amount of water on the planet is the same from the most remote times, where the same water passes through several states through the hydrological cycle, there is concern about its use. It is possible to define some particularities and priorities of water consumption: (i) domestic supply; (ii) industrial supply; (iii) irrigation; (iv) animal feed; (v) preservation of flora and fauna; (vi) recreation and leisure; (vii) species breeding;

(viii) generation of electric energy; (ix) navigation; (x) landscape harmony; and (xi) dilution and transport of waste (Callisto, Gonçalves, & Moreno, 2005).

Federal Law No. 9,433 of January 8, 1997, established the granting of the right to use water resources, which aims to ensure the quantitative and qualitative control of water uses and the effective exercise of access rights to water.

In this context, putting into practice the concept of water use efficiency is fundamental to the use of water for agricultural production or for the production of animal protein. This is essential not only for the production systems and morphophysiological processes of the plants or animals, but also in production processes. An example is the production process that generates residues, as is the case in the waste generated during the rearing of pigs in confinement.

The concept of water use efficiency postulates the use of water for agricultural production or for the production of animal protein.

One of the more sustainable methods for disposing of such wastes and reducing the cost of production has been to use them as fertilizers in cropping systems, mainly because organic fertilizers provide high concentrations of nitrogen and phosphorus along with other elements that complement its effectiveness (Steiner, Czycza, Fey, Zoz, & Guimarães, 2009), resulting in improved chemical, physical, and biological characteristics of the soil (Audeh, de Lima, Cardoso, Jucksch, & Casalinho, 2011).

On the other hand, the usual practice of spreading residues from pig-rearing activities on the soil as a source of nitrogen for cropping areas can contribute to soil contamination when the quantities to be applied and the chemical composition of these wastes are not monitored.

These residues are composed of organic matter and chemical elements in a liquid medium, and it consists of feces, urine, and the water used in the animal disposal and cleaning activities. The quantities of feces and urine are affected by zootechnical factors, such as size, breed, gender, and environmental factors, such as temperature and humidity, and dietary factors, such as digestibility, fiber content, and protein (Suzuki, Fernandes, Faria, & Souza, 2014).

The total amount of manure produced by a pig varies according to its development and the production system, but presents decreasing values of 8.5–4.9% in relation to its live weight day^{-1} for the range of 15–100 kilograms (kg). Therefore, each adult pig produces on average 7–8 liters of liquid waste per day or 0.21–0.24 cubic meters (m^3) of waste per month (Klosowski, Campos, Daga, Feiden, & Câmara, 2007). During the first stage, these residues are stored in mortars or structures where they are subjected to the action of microorganisms. Afterwards, these residues can be used as organic fertilizer for the crops. However, a cubic meter of the dry matter varies between 3.8 and 6.4 kg (Cervi, Esperancini, & Bueno, 2010).

Taking as base, the total swine herd in Brazil, which is on the order of 34,500,000 head (Census, Brazilian Institute of Geography and Statistics [IBGE] 2010), and assuming that the waste production per head is 0.21 m^3 month^{-1}, the production of waste would be 7,245,000 m^3 per month with these data as a parameter and assuming that water is indispensable to this process. The water used in the swine production process becomes too polluted for other uses, either as a vehicle for the application of these wastes in agricultural areas or for the production of biogas. This creates a dilemma: the process results in the production of animal protein, but it also results in the production of a large volume of polluted water. In this sense, the possibility of reusing water in the pig production process is an alternative that needs to be explored. From this perspective, an alternative would be volume reduction by coagulation/flocculation, disinfection, and reuse of this water (liquid phase) for the cleaning of the swine production site. There are several products that can be used for this process; the most common are aluminum sulfate and ferric chloride.

The use of coagulant products of vegetable origin that are based on tannin for the coagulation treatment/flocculation in place of aluminum sulfate as a coagulant in water treatment stations has already been used on industrial clay-like wastewater destined for human consumption at chemical and petrochemical facilities in Brazil and Europe (Pedroso, Tavares, Janeiro, Silva, & Dias, 2012).

Tannins are polyhydroxyphenolic compounds that are composed of simple polyphenols, carbohydrates, amino acids, and hydroxydolodal gums (**Exhibit 1a**), which are used to transform animal hides into leather, and in the production of plastics, anticorrosives, glue, flocculant, and the like. Most tannins are found in large and small trees (Mangrich, Doumer, Mallmannn, & Wolf, 2014).

An example is Tanfloc SG® coagulant agent, which is a cationic organic polymer obtained by a process of leaching of the acacia black leguminous tree (*Acacia mearnsii* De Wild), consisting essentially of quaternary ammonium tannate (Mangrich, et al., 2014). Exhibit 1b shows the chemical structure of the quaternary ammonium tannate (Tanfloc SG®).

The tannins act in colloidal particle systems, neutralizing charges and forming bridges between these particles in the process responsible for the formation of flakes, and consequently, sediments that settle as sedimentation.

The objective of this work was to evaluate the efficiency of the organic coagulant/flocculant Tanfloc SG® from effluents generated in the intensive production of pigs.

2 | MATERIALS AND METHODS

Initially, laboratory tests were performed to define the optimum concentration range of the Tanfloc SG® organic coagulant/flocculant in powder form as well as the range of time necessary to achieve the greatest amount of coagulation/flocculation efficiency.

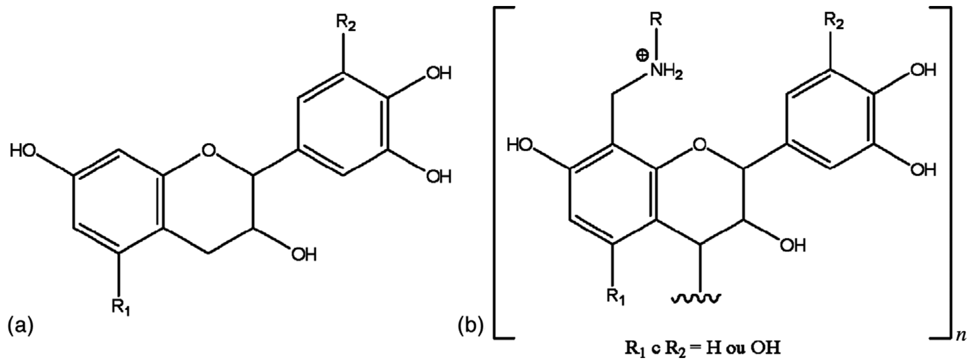

EXHIBIT 1 (a) The chemical structure of the monomers presented in the tannin, extracted of the *Acacia mearnsii* of wild: $R_1 = H$ and $R_2 = OH$ compound robinetinidol; $R_1 = OH$ and $R_2 = OH$ gallocatechin compound; $R_1 = H$ and $R_2 = H$ fisetinidol compound, and $R_1 = OH$ and $R_2 = H$ catechin compound. (b) Chemical structure of the cationic organic polymer (adapted from Mangrich et al. (2014)

The tests and all physicochemical analyses were carried out at the Laboratory of Chemical Analysis and Research (LAPAQ) at the Federal University of Santa Maria, Frederico Westphalen campus, in the municipality of Frederico Westphalen in the Brazilian State of Rio Grande Do Sul (RS). The analyses followed the procedures of the "Standard Methods for the Examination of Water and Wastewater, 22nd edition, 2012" (American Public Health Association, American Water Works Association, & Water Environmental Federation, 2012).

Two solutions were prepared for use in the laboratory tests: one at 1% concentration and the other at 16% concentration of the Tanfloc SG® product. These concentrations correspond to the minimum and maximum concentration at which the product had a total dilution in water; in other words, at concentrations above 16%, the Tanfloc SG® did not show complete solubilization. These concentrations were tested for the volumes of 0, 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 mL of the solutions, over time periods of 24, 48, 72, and 96 hours after application into the effluent. The turbidity of the effluent was the main parameter of evaluation.

As a second test, after the concentration and optimal time for coagulation/flocculation were determined, a field test was carried out in a dung pit located at the Federal University of Santa Maria, Frederico Westphalen, RS, campus. The initial stored volume and the maximum depth of the turbidity readings were estimated from the dimensions of the dung in the containment before the coagulant/flocculant was applied, and the percentage of water free of suspended solids of the effluent was estimated.

In this phase, the organic coagulant/flocculant Tanfloc SG® was applied at the dose defined in the laboratory test, followed by agitation to homogenize the product into the effluent. For this purpose, the volume of effluent in the dung pit, and thus, the amount of the coagulant/vegetable flocculant was calculated at the concentration defined in the laboratory test was calculated.

The concentrations of ammonia (NH_3), nitrate (NO_3^-), and nitrite (NO_2^-) and, in situ: the hydrogenation potential (pH, turbidity, electrical conductivity, oxidation-reduction potential (pRedox), and dissolved oxygen, were evaluated by the use of a German-made Aquaprobe branded multiparameter probe, model AP 900. The parameters evaluated in situ, and in the laboratory data were collected at periods of 24, 48, 72, and 96 hours after the application of the coagulant/flocculant.

EXHIBIT 2 Turbidity values of the supernatant treated with Tanfloc SG® tannin at 1% and 16% concentration, performed in the laboratory

	Volume added (in mL) of Tanfloc SG® product										
	Volumes (mL)										
Time (hours)	0	0.1	0.2	0.3	0.4	0.5	1.0	2.0	4.0	8.0	16.0
1% solution											
Turbidity (NTU)											
24	293	292	250	251	251	239	116	52	26	26	Fld
48	237	224	172	181	148	164	75	39	23	17.7	Fld
72	237	224	172	181	148	164	75	39	23	17.7	Fld
96	211	197	157	169	151	154	61	31	21	22	Fld
16% Solution											
Turbidity (NTU)											
24	293	26	38	32	25	fld	fld	fld	fld	fld	Fld
48	237	46	33	28	19.9	fld	fld	fld	fld	fld	Fld
72	241	42	31	31	23	fld	fld	fld	fld	fld	Fld
96	211	37	27	23	27	fld	fld	fld	fld	fld	Fld

Abbreviation: fld = Outside of the equipment's detection limit; NTU = nephelometric turbidity units.

3 | RESULTS AND DISCUSSION

The table in **Exhibit 2** shows the turbidity values of the supernatant after application of the coagulant/Tanfloc SG® tannin flocculant at concentrations of 1% and 16% at volumes 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 4.0, 8.0 and 16 mL, performed in the laboratory.

The results showed that the lower concentrations allowed researchers to determine with more precision the ideal volume of the coagulant/flocculant to achieve the most effective action in the effluent. Whereas higher concentrations interfere in measuring the turbidity by causing a great dispersion of the particles, preventing the return of the electronic impulse to the sensor. Under these circumstances,

EXHIBIT 3 Values of turbidity and volumes of supernatant of the effluent treated with different volumes of solution of the Tanfloc SG® tannin at 1% at 24, 48, 72, and 96 hours after addition of the product

	Tanfloc SG® in 1%			
	Product added volume (mL)			
Time (hours)	0[a]	2	4	8
Turbidity of the supernatant (NTU)				
24	160	31	36	20
48	101	22	23	fld
72	51	21	24	fld
96	41	24	fld	fld
Pipette volume of the supernatant (mL)				
24	39.2	27.2	14.2	18
48	25	24	33	fld
72	28.2	20	15	fld
96	29.4	12	15	fld

[a]witness fld, Out of detection limit; NTU = nephelometric turbidity units.

obtaining a reading was not possible because the conditions were outside the parameters of the equipment's detection limits.

This is explained by the Lambert–Beer law, which establishes a relationship between the absorbance of a solution and its concentration when traversed by collimated beam. This could clearly be observed in the 1% concentration of the solution at a volume of 16 milliliter (mL) compared with the inability to obtain results in the sample in which the solution concentration was 16% and the volume was only 0.5 mL.

Following this criterion and based on the table in Exhibit 2, it was observed that at a concentration of 1% of the coagulant/flocculant, the volumes of 2.0, 4.0, and 8.0 mL presented the lowest turbidity values.

The table in **Exhibit 3** presents turbidity values of the effluent supernatant at the 1% concentration of Tanfloc SG® coagulant/flocculant in volumes of 2.0, 4.0, and 8.0 mL 24, 48, 72, and 96 hours after the addition of the product.

After 48 hours, the best turbidity values were observed in the samples where volumes of 2.0 and 4.0 mL of 1% Tanfloc SG® were added. Reaffirming that, at this time, and in this concentration of the flocculant product, there was lower turbidity, and consequently, a larger volume of supernatant of 24 and 33 mL, respectively. With regard to the dosage, similar results were observed by Thakur and Choubey (2014), who, when evaluating tannin as a coagulant/flocculant to remove suspended solids in the water using the dosages of 1.0, 2.0, 3.0, 4.0, and 5.0 mL, stated that the dosage of 3.0 mL per liter (mL/L) reduced up to 91% of the turbidity.

The table in **Exhibit 4** shows the results of the physicochemical parameters performed in situ in the effluent generated by the intensive rearing of pigs.

It was verified that the average concentration of ammonia (NH_3) after 48 hours of application of the coagulant/flocculant tannin resulted in a reduction of 48.1% from an average of 361 mg/L to an average of 173.8 mg/L. The ammonia content in the liquid phase of the effluent (swine manure) after 48 hours of Tanfloc SG remained constant.

The average dissolved oxygen parameter had a higher concentration at 48 hours, correlating with the lower turbidity that occurred within the same time interval.

EXHIBIT 4 Results of the physicochemical parameters obtained in the effluent generated in the intensive breeding of pigs, in situ, using the multiparameter probe: pH, turbidity, oxidation/reduction potential (ORP), dissolved oxygen (DO); electroconductivity (EC) (μs/cm); parameters performed in the laboratory: ammonia (NH_3), nitrate (NO_3^-), and nitrite (NO_2^-)

		Physicochemical parameters evaluated							
		Multiparameter probe					Laboratory		
Evaluation time	Collection point	pH	Turbidity (NTU)	ORP (mV)	DO (mg/L)	EC (μs/cm)	NH_3(mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)
1° day "in natura"	P01	7.58	838	121,00	1.89	2495	386	32.7	6.50
	P02	7.55	820	79.70	0.83	2497	386	21.9	6.40
(24 hours)	P03	7.6	893	0.60	4.79	2489	386	44.4	6.10
	P04	7.58	881	36.20	1.36	2518	286	49.6	6.00
	Average	7.58	858	59.38	2.22	2499	361	37.2	6.25
2° day "in natura"	P01	7.07	29	180.40	5.16	2606	174	16.8	0.00
	P02	7.15	44	144.90	4.69	2581	174	5.6	0.00
(48 hours)	P03	7.16	29	141.40	4.88	2605	168	0.0	0.00
	P04	7.19	34	117.90	5.24	2617	179	0.0	0.00
	Average	7.14	34	146.15	4.99	2602	173.75	5.60	0.00
3° day "in natura"	P01	7.06	119	76.80	2.18	2617	174	13.5	0.00
	P02	7.09	127	89.00	1.30	2517	174	5.6	0.00
(72 hours)	P03	7.12	114	102.10	2.09	2537	168	0.0	0.00
	P04	7.09	132	99.30	3.74	2565	179	0.0	0.00
	Average	7.09	123	91.80	2.33	2559	173.8	4.78	0.00

The parameters, pH and electrical conductivity, presented little variation from the beginning to the end of the treatment process compared with the variation presented by turbidity. The use of tannin as a coagulant/flocculant had the characteristic of not altering the pH of the treated water, as it does not change the alkalinity of the medium and was more effective at an extensive pH range varying between 4.5 and 8.0 (Skoronski, Niero, Fernandes, Alves, & Trevisan, 2014).

The mean values of nitrate (NO_3^-) and nitrite (NO_2^-), which after 24 hours were 37.15 and 6.25 mg/L, presented concentration reduction of 84.94% and 100%, respectively, after 48 hours of application of the coagulant /flocculant. The presence of the nitrate parameter (NO_3^-) at points 01 and 02 after 48 and 72 hours of treatment (Exhibit 4) was justified because they were closer to the effluent inlet (swine manure) which was continuously contaminated.

Twenty-four hours after the addition of the TANFLOC SG® coagulant, the liquid phase's depth was evaluated by introducing a multiparameter probe into the dung pit to monitor the turbidity. Prior to the treatment, the initial depth of the effluent obtained by reading the turbidity was in the average of the points of 95 centimeters (cm). However, 24 hours after the application of the treatment, the turbidity of the liquid phase was reduced from 858 NTU (95 cm) to 34 NTU (65 cm). This was justified by the coagulation/flocculation of the solid mass contained in the effluent, promoting a drastic change in the observed turbidity values at this depth.

These data corroborated the findings of Mangrich et al. (2014), that the use of the cationic tannin in water as a coagulant has many advantages, among them the production of a sludge (sludge is considered nonhazardous under Brazilian National Standards 10.004 (2004), published by the Brazilian National Standards Organization) and its ease of elimination.

The initial volume stored, based on the dimensions of the dung pit, was estimated at 182,000 L. Considering the maximum depth of 95 cm of the turbidity tests reading before application of the coagulant/flocculant and the maximum after the application of the product of 65 cm, the purified volume was 124,000 L. This resulted in 68% of the effluent water free of suspended solids, which can be reused after disinfection, for such purposes as cleaning the pig production site.

Considering this percentage of reuse of the effluent water extended to the swine herd in Brazil (IBGE, 2010), which is on the order of 34,500,000 head, and assuming that, on average, 0.21 m^3 $month^{-1}$ of manure per head of swine (Perdomo, da Costa, Medri, & Miranda, 1999), the estimated effluent production would be approximately 7,245,000 m^3 $month^{-1}$, that is, the use of Tanfloc SG® tannin as a coagulant/flocculant would allow the reuse of approximately 4,926,600 m^3 m^{-1} of production water.

4 | CONCLUSION

The use of tannin as a coagulant /flocculant of plant origin in the treatment of swine manure effluents was effective in the reductions of turbidity, ammonia, nitrite and nitrate.

In the analyzed conditions, the use of tannin as a coagulant/flocculant in the effluent allowed separation of the solid–liquid phase in approximately 68% as liquid phase (water).

The application of tannin as a coagulant/flocculant allows the reduction of water consumption through the reuse of the water and, consequently, the reduction in the liquid volume of waste applied to the environment as organic fertilization.

REFERENCES

American Public Health Association, American Water Works Association, & Water Environmental Federation. (2012). *Standard methods for the examination of water and wastewater* (p. 107). Washington, DC: Author.

Audeh, S. J. S., de Lima, A. C. R., Cardoso, I. M., Jucksch, I., & Casalinho, H. D. (2011). Soil quality: An ethnopedological view on family farms producing organic tobacco [Qualidade do solo: Uma visão etnopedológica em propriedades agrícolas familiares produtoras de fumo orgânico]. *Brazilian Journal of Agroecology [Revista Brasileira de Agroecologia]*, *6*(3), 34–48. Retrieved from http://revistas.aba-agroecologia.org.br/index.php/rbagroecologia/article/view/9934/0

Brazilian Association of Technical Standards (ABNT). (2004). NBR 10004 - Solid Wastes – classification - ABNT. NBR 10004. https://analiticaqmcresiduos.paginas.ufsc.br/files/2014/07/Nbr-10004-2004-Classificacao-De-Residuos-Solidos.pdf

Callisto, M., & Gonçalves, J. F. Jr., & Moreno, P. (2005). Aquatic invertebrates as bioindicators [Invertebrados aquáticos como bioindicadores]. *Navigating the River from the Old Minas to the Minas Gerais [Navegando o Rio das velhas das Minas aos Gerais]*, *1*, 1–12. Retrieved from https://s3.amazonaws.com/academia.edu.documents/46265043/Invertebrados_Aquticos_como_Bioindicador20160605-11836-vgmdgy.pdf?response-content-disposition=inline%3B%20filename%3DInvertebrados_aquaticos_como_bioindicado.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20191206%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20191206T000533Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=9d6b1752c28c9a379962afa2a50fd5a8bd1560a1845af6a8857cab09d52d66cc

Census, Brazilian Institute of Geography and Statistics [IBGE] Censo, I. B. G. E (2010). Retrieved from www.ibge.gov.br

Cervi, R. G., Esperancini, M. S. T., & Bueno, O. D. C. (2010). Economic feasibility of using biogas produced in swine farm for electric power generation [Viabilidade econômica da utilização do biogás produzido em granja suinícola para geração de energia elétrica]. *Agricultural Engineering [Engenharia Agrícola]*, 831–844. Retrieved from https://repositorio.unesp.br/handle/11449/5000

National Council of Environment [Conselho Nacional do Meio Ambiente] (CONAMA). (2005). Resolution n° 357, from March 17th 2005. Brasília. Retrieved from http://www2.mma.gov.br/port/conama/legiabre.cfm?codlegi=459

Cutolo, S. A. (2009). *Wastewater Reuse and Public Health [*Reúso de águas residuárias e saúde pública*]*. São Paulo, Brazil: Annablume, FAPESP.

Klosowski, E. S., Campos, A. T., Daga, J., Feiden, A., & Câmara, R. J. (2007). Analysis of environmental adequacy and management of swine manure facilities on farms in western Paraná [Análise da adequação ambiental e manejo dos dejetos de instalações para suinocultura em propriedades na região oeste do Paraná]. *Agricultural Engineering [Engenharia Agrícola]*, *27*(3), 587–595. Retrieved from http://acervo.ufvjm.edu.br/jspui/handle/1/1191

Mangrich, A. S., Doumer, M. E., Mallmannn, A. S., & Wolf, C. R. (2014). Green chemistry in water treatment: Use of tannin-derived coagulant from Acacia mearnsii [Química verde no tratamento de águas: Uso de coagulante derivado de tanino de Acacia mearnsii]. *Virtual Journal* *of Chemistry [Revista Virtual de Química]*, *6*(1), 2–15. Retrieved from http://rvq-sub.sbq.org.br/index.php/rvq/article/view/425

Pedroso, K., Tavares, C. R. G., Janeiro, V., Silva, T. L. D., & Dias, P. Z. (2012). Evaluation of the leachate treatment from the Maringá landfill, Paraná State, by coagulation/flocculation process with Tanfloc SG® [Avaliação do tratamento do lixiviado do aterro sanitário de Maringá, Paraná, por processo de Coagulação/Floculação com Tanfloc SG®]. *Engineering and Technology Journal [Revista de Engenharia e Tecnologia]*, *4*(2), 87–98. Retrieved from https://www.revistas2.uepg.br/index.php/ret/article/view/11455/209209209428

Perdomo, C. C., da Costa, R. R. H., Medri, W., & Miranda, C. D. R. (1999). Design of treatment systems (decanter and ponds) and use of swine manure [Dimensionamento de sistemas de tratamento (decantador e lagoas) e utilização de dejetos suínos]. *Embrapa Pigs and Poultry-Technical Announcement (INFOTECA-E) [Embrapa Suínos e Aves-Comunicado Técnico (INFOTECA-E)]*. Retrieved from https://www.embrapa.br/busca-de-publicacoes/-/publicacao/436820/dimensionamento-de-sistemas-de-tratamento-decantador-e-lagoas-e-utilizacao-de-dejetos-suinos

Skoronski, E., Niero, B., Fernandes, M., Alves, M. V., & Trevisan, V. (2014). Study of the application of tannin in the treatment of water supply in the Tubarão River, in the city of Tubarão, SC [Estudo da aplicação de tanino no tratamento de água para abastecimento captada no rio Tubarão, na cidade de Tubarão, SC]. *Environment & Water—An Interdisciplinary Journal of Applied Science [Ambiente & Água-An Interdisciplinary Journal of Applied Science]*, *9*(4), 679–687. Retrieved from https://www.redalyc.org/pdf/928/92832359010.pdf

Steiner, F., Czycza, R. V., Fey, R., Zoz, T., & Guimarães, V. F. (2009). Black oat dry matter and nitrogen accumulation by organic and mineral fertilization [Acumulo de matéria seca e nitrogênio da aveia preta pela adubação orgânica e mineral]. *Global Science and Technology*, *2*(2), 55–66. Retrieved from https://rv.ifgoiano.edu.br/periodicos/index.php/gst/article/view/76

Suzuki, A. B. P., Fernandes, D. M., Faria, R. A. P., & Souza, S. N. M. (2014). Full-scale biogas production in a demonstration unit – Granja Colombari Farm [Produção de biogás em escala real em unidade demonstrativa–Unidade Granja Colombari]. *Ambiência*, *10*(1), 13–20. Retrieved from https://revistas.unicentro.br/index.php/ambiencia/article/view/1392

Thakur, S. S., & Choubey, S. (2014). Use of Tannin based natural coagulants for water treatment: An alternative to inorganic chemicals. *International Journal of ChemTech Research*, *6*(7), 3628–3634. Retrieved from https://www.researchgate.net/profile/Sonal_Choubey2/publication/278961713_Use_of_Tannin_based_natural_coagulants_for_water_treatment_An_alternative_to_inorganic_chemicals/links/5587e41b08aef58c03a066ed/Use-of-Tannin-based-natural-coagulants-for-water-treatment-An-alternative-to-inorganic-chemicals.pdf

Tundisi, J. G. (2008). Future water resources: Problems and solutions [Recursos hídricos no futuro: Problemas e soluções]. *Advanced Studies [Estudos avançados]*, *22*(63), 7–16. Retrieved from www.scielo.br/pdf/ea/v22n63/v22n63a02

Valente, O. F., & Gomes, M. A. (2005). Conservation of springs: Hydrology and management of headwaters [Conservação de nascentes: Hidrologia e manejo de bacias hidrográficas de cabeceiras]. Lush: Learn Easy [Viçosa: Aprenda Fácil].

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