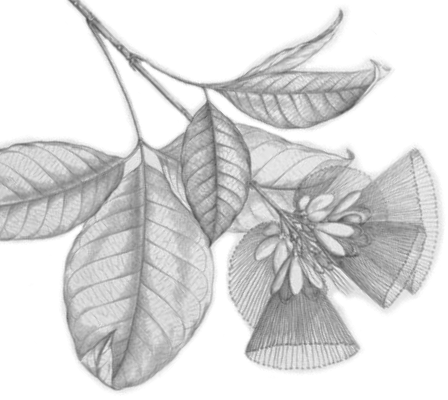

Reuse of Treated Wastewater in Metal-Mechanics Industry: A Technical-Economic Evaluation

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ABSTRACT

Metal-mechanical industries are intensive in the consumption of water and, consequently, in the wastewaters production. Thus, reuse is essential because it preserves the environmental resources, diminishing the water footprint of the obtained products. Despite the advanced techniques, the economic cost limits the wastewater treatment to the most common techniques. This study evaluated the technical potential and costs involved in the reuse of wastewater in a metal-mechanical industry. Mistakes were found in the reagents dosage, what precluded reuse of the treated wastewater. The optimum condition for coagulation/flocculation was evaluated using the bench scale jar test. The parameters of wastewater, such as turbidity, pH, alkalinity, hardness, electrical conductivity, chloride and total solids were evaluated. The ideal condition was tested at the plant and some adjustments were made. The improvements resulted in 50.96% cost reduction of wastewater treatment without new investments. Also, the treatment became faster and more efficient. The wastewater achieved the standards for reuse in toilet flushing and floor washing.

Keywords: Environmental Economics; Industrial Effluents; Wastewater Treatment; Pollution Control.

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The industrial sector is one of the largest water users, consuming about 5% to 10% of global withdrawals (Insel et al. 2017), as it needs this substance in large amounts and in various activities, from incorporation to the product until materials, equipment and facilities washing, steam generation and cooling systems.

In the metal-mechanical sector, the industrial activities have introduced metallic elements in the effluents in a much larger amount than the regenerative and self-depuration capacity of hydric bodies and soils (Silva et al. 2014). Therefore, this puts this sector as one of the big responsible for potential hazardous discharge, since it possesses large amount of wastewater to manage in a way that does not compromises the environment and society.

The efficient wastewater treatment is the key to minimize and control this impact. Is must be designed according to the industrial wastewater properties, and the final effluent reuse. However, in practical sense, it is observed a divergence between the sustainable speech and the real wastewater treatment condition. In this point, this research is important to bring up the feasibility of the wastewater treatment process only by using the improvement of the reagents species and dosage. On the other hand, wastewater reuse is seen as essential to fully meet growing urban and industrial demands and to preserve finite environmental resources. This brings several benefits, among which; improvement of agricultural production, reduction of energy consumption in relation to production, prevention of water scarcity, protection of environmental resources, environmental awareness, and others (USEPA 2012). In addition, conserving, recycling, and reusing effluents is an alternative to reduce the operational costs (WEF 2008).

In Brazil, the normative NBR 13.969 (ABNT 1997) defines standards classes for wastewater use in different ends. For this study, classes two and three are highlighted, which present as reuse standard for wastewater and floor washing only turbidity, residual chloride and fecal coliform. Thereby, it is interesting to evaluate the physicochemical standards as well, to obtain better quality, avoiding encrustation and others risks. Among of them, hardness, alkalinity, chlorides, total solids, pH, turbidity, electrical conductivity and oils and greases are focused.

Despite the existence of advanced techniques for efficient industrial effluent treatment, in practice, it is observed that a significative share of companies, covering even large-scale ones and multinationals, invest only the minimum required to achieve the quality standards determined by environmental agencies. Even if modernization results in more comfort, safety and add the sustainability concept, the economic factor is determining. The managing recommendation is to make the most, using the least possible financial resources, what means, to improve the process without adding cost.

Therefore, for this study, the physicochemical processes are used due to the high concentration of metals and oils and grease present in the effluent, highlighting the chemical precipitation (solids formation from a chemical reaction: coagulation and flocculation) as it is an efficient technique in the removal of soluble metals, of easy execution and low cost (Queissada et al. 2011), followed of sedimentation and filtration.

The coagulation includes all reactions and mechanisms involved in the chemical destabilization of the particles and in the formation of big particles. Flocculation is a process by which the destabilized particles, or the particles formed as result of destabilization, are induced to flock, forming, this way, large clusters which will be removed through sedimentation and filtration (Metcalf & Eddy 2003).

The most used coagulants are the metal salts made of aluminum or iron, the ones such as aluminum sulfate, ferric chloride, ferric sulfate, ferrous sulfate, and aluminum hydroxy chloride (polychloride) (Teh et al. 2016). When in aqueous solution, the metallic ions of iron and aluminum, positively charged, make connections to the oxygen atoms, liberating the hydrogen atoms and reducing the pH of the suspension (hydrolysis) (Kuritza 2012).

The use of polymers as flocculation auxiliaries provides smaller dosages of coagulant, smaller mold volume, cost reduction of up to 25%, among other advantages. Apart from this, the fact of utilizing less coagulant reduces the aluminum presence in the treated effluent and in the sludge that will be disposed afterwards (Rout et al. 1999). Before the great variability of available polymers, studies in laboratory scale are important to guide the decision-making process, to use a sort quantity of polymer.

In this context, this work aims to study the potential of wastewater reuse from a metal-mechanical industry and its costs involved. Thus, the proposed study becomes essential, as it discusses the difficulties encountered in the industries to the determination, implantation, and control of ideal techniques for the wastewaters treatment, considering the best cost-effective scenario.

MATERIALS AND METHODS

This research was conducted by a case study about a multinational metal-mechanical industry, located in the countryside of the Estate of São Paulo, in Brazil. To determine the potential of the reuse of industrial wastewater, the following actions were needed, namely:

- the wastewater physical and chemical characterization;
- the evaluation of the industrial wastewater treatment unit;
- the optimization of the wastewater treatment process, and;
- the economic evaluation of the wastewater treatment process.

The evaluation of the physical and chemical properties of the wastewater, before and after treatment, was based on the quality standards analysis, such as: hardness, alkalinity, chlorides, total solids, pH, turbidity, electrical conductivity and oils and greases, following the methodologies detailed in the Standard Methods for the Examination of Water and Wastewater (Rice et al. 2012), as well as in the methodology described in Chapter XIII of Adolf Lutz Institute (Zenebon et al. 2008). The quality standards for wastewater reuse were those detailed in the Brazilian resolutions CONAMA 357 (CONAMA 2005) and CONAMA 430 (CONAMA 2011).

Technical evaluation of the wastewater treatment unit was carried out considering the presence, sequence and processing capacity of the mixing and separation equipments (mixers, decanters and filters), reagent dosage (for coagulation/flocculation), as well as the process control systems (pH meter and electronic or manual dispensers).

The identification of improvements and possible adjustments in the process were done aimed to the treated wastewater achieve the reuse standards. To this purpose, were used the available information (industry's archive) on the physicochemical properties of the raw and treated wastewater (process efficiency), the current settings of the treatment unit, and the wastewater volume to be treated.

The determination of the best wastewater treatment condition, for to achieve the reuse standards, was realized by Jar Tests in laboratory scale. Thereafter, the optimal obtained condition was evaluated in industrial scale. Thus, the untreated wastewater was collected periodically in the industry and tested, according to the instructions detailed in the Procedures of Sampling and Physicochemical Analysis of Water Manual (Parron et al. 2011).

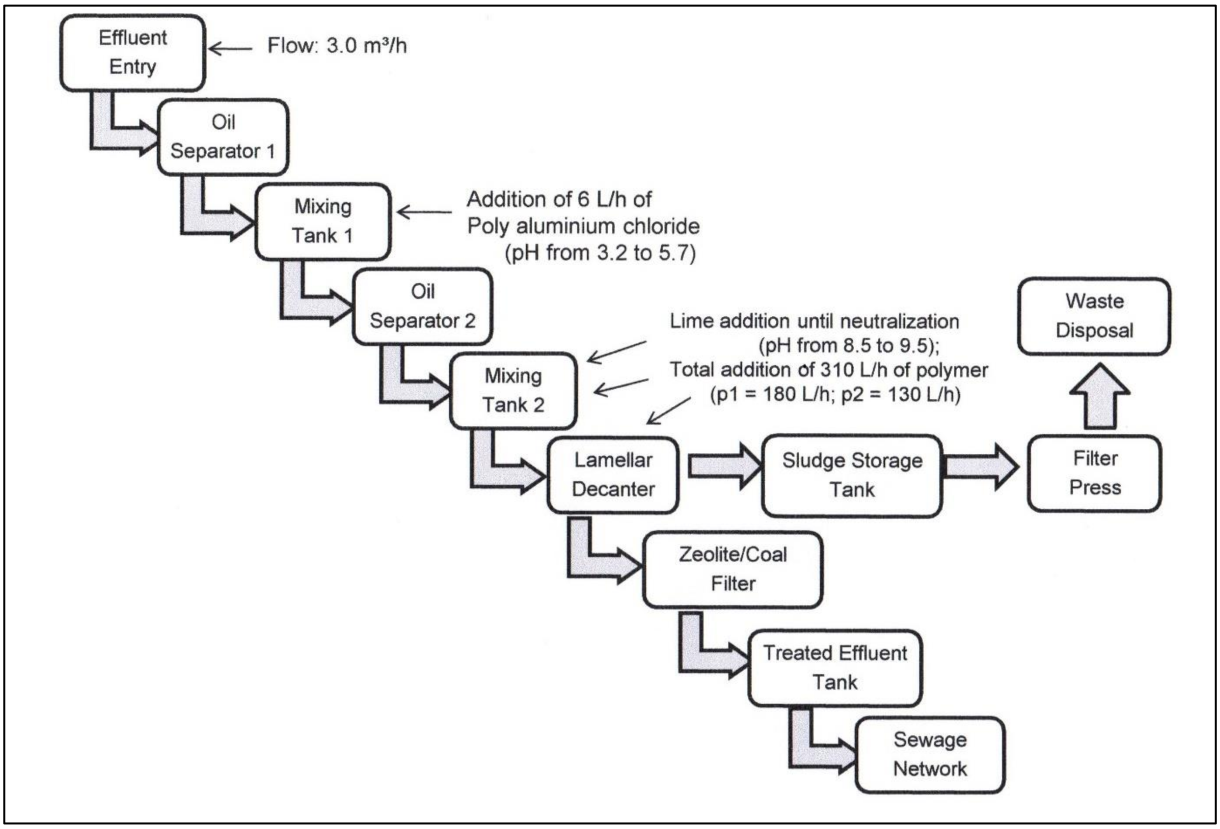
The new wastewater treatment condition was set up on the industrial treatment unit, and the efficiency monitored. Samples of treated and untreated wastewater were collected and sent to be analyzed by an independent certified laboratory.

For such study, mathematical calculations were made considering the fixed and variable costs of the wastewater treatment process, in both original and optimized conditions. Based on this data collection, the technical-economic feasibility of the proposed project was evaluated.

RESULTS AND DISCUSSION

The original wastewater treatment process in the studied industry occurs as described in Figure 1.

Figure 1. Original industrial process of the wastewater treatment.



Source: Authors.

When carefully analyzed, the industrial original condition of wastewater treatment revealed the excessive consumption of chemical reagents for the treatment. It was identified the high consume of aluminum polychloride (PAC), with the high consume of the hydrated lime. This behavior was attributed to the pH decreasing caused by the PAC.

The higher PAC addition results in decrease of wastewater pH, being necessary its correction by addition of lime. Consequently, it requires higher polymer concentration to promote de flocculation process. When pH correction is around 7.5, the sedimentation process is extremely slow, being necessary, in some cases, to pause the effluent treatment unit until decantation occurs, taking up to three hours of inoperativeness. Thus, the original process uses pH around 9.5.

To identify the optimal PAC dosage, some Jar tests were carried out, switching the reagents dosages, using hydrated lime to pH correction, and the results are presented in the Table 1.

Table 1. Jar test results utilizing the original conditions of the industry and the suggestions for the optimization of the wastewater treatment process.

Test I	PAC (mL/L)*	Polymer (mL/L)*	Initial pH	Hydrated Lime pH Correction	Initial Turbidity (NTU)	Final Turbidity (NTU)
Original Conditions	2	60	7.22	7.02	222	2.07
Suggestion 1	0.5	30	7.22	7.07	222	1.50
Suggestion 2	1	30	7.22	7.04	222	2.04
Suggestion 3	0.5	15	7.22	7.01	222	1.71
Suggestion 4	1	15	7.22	7.06	222	6.81

Source: Authors.
(*) volume of reagent per volume of effluent.

Comparing suggestions 1 and 2, and suggestions 3 and 4, with the same amount of added polymer (30 ml/L and 15 mL/L), it is noted that the higher addition of PAC results in smaller efficiency of turbidity removal. Evaluating the suggestion 2 and 4, with the same amount of PAC, it was observed that the higher polymer content results in lower wastewater turbidity. Thus, the higher consume of PAC drives to the higher polymer dosage to make efficient the wastewater treatment.

Considering the use of sodium hydroxide for pH correction (Table 2), a sensible increase in effluent treatment efficiency was observed. All suggestions, as well as the original conditions of the process hit final turbidity below the threshold established for reuse.

Table 2. Jar test results with NaOH for pH neutralization.

Test II	PAC (mL/L)*	Polymer (mL/L)*	Initial pH	Hydrated Lime pH Correction	Initial Turbidity (NTU)	Final Turbidity (NTU)
Original Conditions	2	60	6.69	7.01	253	0.41
Suggestion 1	0.5	30	6.69	7.04	253	1.53
Suggestion 2	1	30	6.69	7.05	253	0.82
Suggestion 3	0.5	15	6.69	7.10	253	1.85
Suggestion 4	1	15	6.69	7.12	253	0.88

Source: Authors.
(*) volume of reagent per volume of effluent.

Comparing the suggestions with the same polymer dosage, 1 and 2, (30 ml/L), and suggestions 3 and 4 (15 mL/L), it is observed that the PAC dosage increasing reduces final turbidity. This effect is the opposite of that observed among the outlined suggestions, with the use of lime. In a similar way, comparing the test in the original industrial conditions, turbidity was 2.07 NTU when lime was used and 0.41 NTU when NaOH was used. This evinces that lime presents adverse effect in the coagulation/flocculation process during effluent treatment.

The negative effect of lime uses in the effluent coagulation and flocculation caused surprise, as calcium is reported to be an auxiliary coagulation promoter in effluent treatment (Hägg 2015). This occurs due to the ions with multiple positive charges, such as Fe^{2+}, Fe^{3+} and Al^{3+}, interact with the negative charges of colloids present in the effluent (Hägg 2015).

However, this fact can be explained by an indirect effect of lime dosage. The higher the PAC addition, the higher is the lime addition to correct pH.

Considering the effluent coagulation/flocculation mechanism during treatment, a simpler way to describe the process would be that the PAC addition liberates the Al^{3+} aluminum ions (and ionic species, such as $Al(OH)^{2+}$ and $Al(OH)_2^{+}$. These species with positive charge interact with the negative surface of the colloids, nucleating and forming the first flocks, with positive residual charge. These flocks are adsorved by the anionic polymer, with the formation of bigger flocks, facilitating the sedimentation process.

At this point, a hypothesis to explain the negative effect of lime would be the probable ionic interaction of the Ca^{2+} ions with the negative charges of the anionic polymer, resulting in decrease of active sites on polymer surface. Mainly, because they are fed into the same mixture tank. In high lime concentration, a polymer inhibitor effect can occur (by polymer saturation), which has its flocculation efficiency diminished. This fact results the need of increasing the polymer dosage (Table 1) to obtain the desired flocculation effect.

According to the results, the negative effect over the flocculation process using NaOH was not observed, what suggests that the Na^{+} ion has less effective interaction with the anionic polymer than the Ca^{2+}. Consequently, the hydrated lime use was replaced by sodium hydroxide solution.

From these considerations, biweekly tests were started in laboratory scale, aiming the monitoring of the results in order to the implantation of better treatment condition. This assessment considered the hardness, alkalinity, chlorides level, pH, conductivity, total solids and turbidity parameters.

Among the analyzed treatment suggestions, suggestion 3 was discarded due to the inefficiency in the turbidity parameter, according to the Brazilian legislation on industrial effluent reuse. This result was already expected, as this treatment utilizes minimum aluminum polychloride concentration, substance that causes the formation of harder and heavier flocks, increasing decantation speed.

Based on the realized analyses, it was possible to observe that the nature of the raw wastewater at the entry of the process is unstable, as the results of the analyzed parameters reflect this variation daily. This is associated to the daily production dynamics of the industry including to the rework performed in some cases. This results in the washing of a larger number of machines and equipments to be necessary, generating effluents containing different concentrations of oils, grease, and soap, amongst others.

Therefore, the difficulty in maintaining the steady quality of the wastewater is observed. It is worth to note the importance of a previous study of sanitizing products inserted in the industrial production, evaluating their effects in the wastewater accordingly to its use.

The results of the parameters evaluated on the periodical tests in laboratory scale are shown in the Figures 2 to 8, discarding option 3 due to its impracticability to this study.

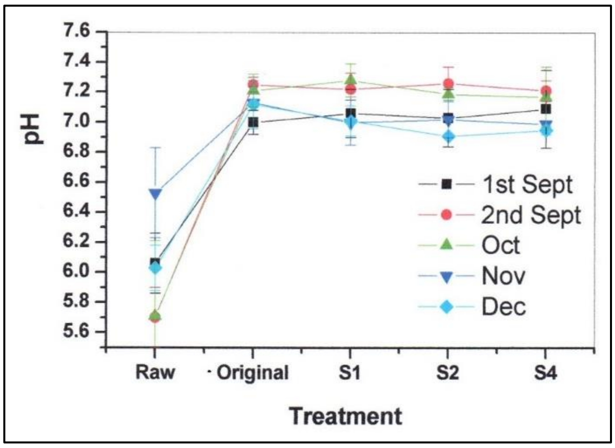
On the first sampling, in September 2017, treatment was out of determined standards, due to the improper operation of the wastewater treatment unit.

In November, there was a significant raise in the productive activity of the industry. This way, it caused the increase of the organic load present in the effluent, due to the higher use of sanitizers, oils and grease.

The sampling realized in December 2017 was also incoherent with the standards determined for treatment. The worker considerably increased the PAC (7.5 L/h) and polymer (350L/h) concentrations inserted into the process, claiming that the treatment was getting out of the physical characteristics (color, effluent transparency) frequently found. Therefore, the sampling realized in October is the most suitable for the treatment evaluation.

Figure 2 presents the final pH values obtained in the different analyses realized. Despite the inconstancy of this parameter in the raw effluent (varying from 5.5 to 6.5), similar results in all analyzed treatments were observed, between 6.8 and 7.4.

Figure 2. pH analyses of the samples collected in September to December 2017.

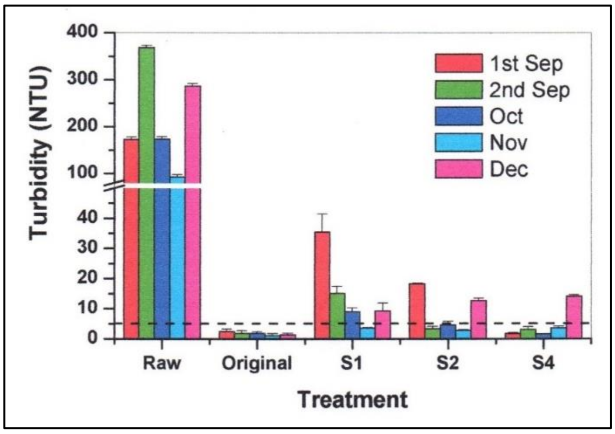


Source: Authors.

This shows that the process pH is easily controlled, once the precise dosage of sodium hydroxide solution is realized. In industrial scale, the efficient pH control is also possible, as the facility has automated reagent dosage used in the wastewater treatment, being possible the pre-determination of the pH range to be worked on.

Figure 3 presents the turbidity results of the analyzed samples. A great variation in the raw effluent during the sampling periods is observed, from 70 NTU to 360 NTU. It resulted from the varied amount of detergents, oils and greases used according to the industrial production, that reflected directly on the raw wastewater characteristics.

Figure 3. Turbidity analyses results of the samples collected in September to December 2017.



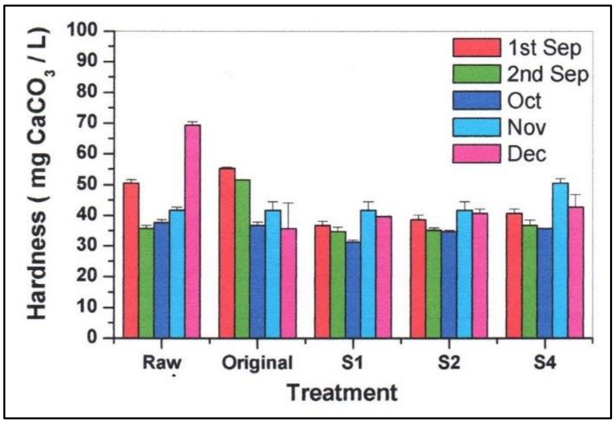
Source: Authors.

The treatment in the original conditions of the industry is shown to be efficient during all periods of analyses. Using high reagents concentrations (PAC and polymer), the flocculation and decantation processes are more efficient. However, this condition is not suitable to be used due to the high consume of reagents, reflecting an increase of the wastewater treatment costs, and generating higher amount of sludge, not environment friendly. Thus, suggestion 2 was identified as the best one, even with the variation in the effluent at the entry of the process during the months of analyses, presented similar results to those of the other treatments. Despite utilizing higher reagents concentration when compared to suggestions 1 and 4, the suggestion 2 makes the flocculation process more efficient, and, consequently, reach the required value of this parameter to the wastewater reuse.

During the sampling period from September to December the effluent was out of the treatment standards. From the results, the suggestion 4 could be considered the best condition found, as it requires low chemical reagents concentration inserted into the process, when compared to the other methodologies and treatments. However, the raw wastewater stream is not constant, and too low reagent dosage could be unappropriated to promote the efficiently treatment.

Figure 4 presents the results relating to effluent hardness. The raw wastewater has similar hardness of all those suggestions. Hardness less than 60 mg CaCO3/L is considered a soft water for potable water (Rice et al. 2012), thus it condition is applied here for wastewater hardness classification. The PAC addition can increase the hardness; at the same time, PAC is removed with the flocks by the coagulation and sedimentation process. It is observed that the higher the efficiency these processes, the lower is the final hardness. This fact is directly linked to the ability of the PAC and the anionic polymer remove metallic cations from the wastewater by sorption and flocculation.

Figure 4. Results of the Hardness analyses of the samples collected in September to December 2017.



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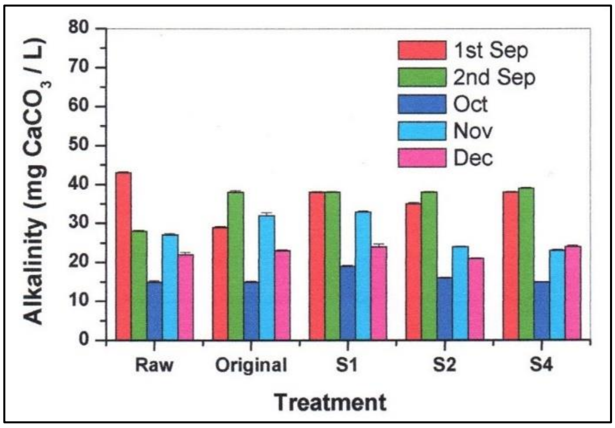
The alkalinity of the effluent has direct relation to the addition of sodium hydroxide for pH correction. It is observed that the lower the pH of the wastewater, the lower is its alkalinity and vice-versa. Figure 5 presents the results observed after the Jar test trials.

Treatment suggestion 2 was identified as the most efficient, since that even requiring a little higher addition of reagents to the process, when compared to suggestions 1 and 4, it promotes the most efficient flocculation stage, and, consequently, the effective removal of alkalinity.

The results of electrical conductivity of the different effluent treatments are presented in Figure 6. It was possible to observe that the original condition of the industry represents the highest conductivity due to the high amount of PAC inserted into the process. Suggestion 1 showed the lowest conductivity after treatment, since it is the condition which requires the least concentration of this reagent, followed by suggestion 2 and suggestion 4, respectively.

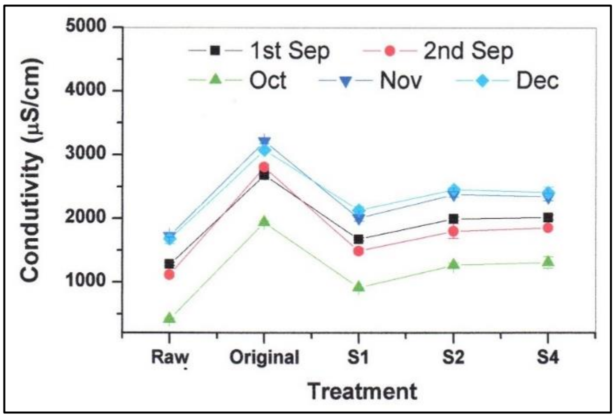
The raw effluent presents the lowest values of this parameter, as salt was not added to the process yet.

Figure 5. Alkalinity analyses results of the samples collected in September to December 2017.



Source: Authors.

Figure 6. Conductivity analyses results of the samples collected in September to December 2017.



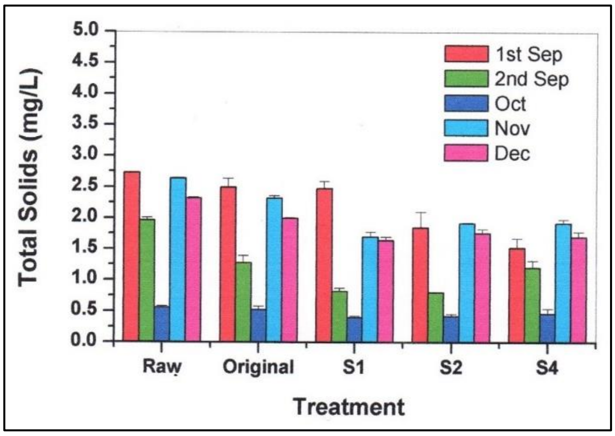
Source: Authors.

The total solids content in the analyzed samples reached similar results among them, on the different analyses days (Figure 7). It is observed that the raw effluent presents higher concentration of solids than the post-treatment effluents, due to the flocculation and sedimentation processes enables the removal of solids and substances from the wastewater.

In the analysis of this parameter, it was possible to identify that all treatments utilized present similar results, all of them being efficient for the industry process.

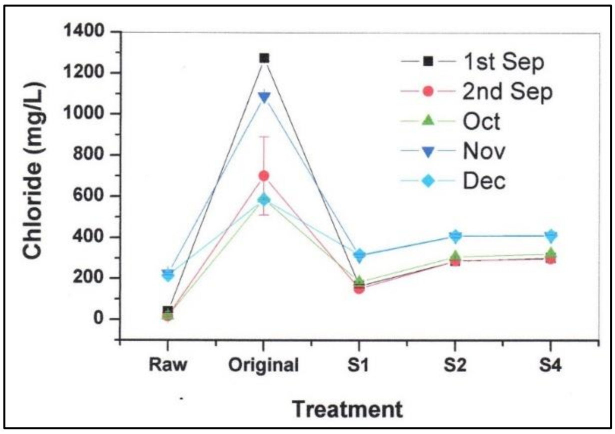
The chloride concentration present after treatment is directly linked to the PAC concentration fed to the process. This way, it is observed that in the raw effluent (Figure 8), the concentration is too low, as there are no added reagents. In the original condition of the industry, this parameter presents high values, since this condition requires excessive concentrations of PAC.

Figure 7. Total solids analyses of the samples collected in September to December 2017.



Source: Authors.

Figure 8. Chloride analyses results of the samples collected in September to December 2017.



Source: Authors.

From the results obtained in laboratory scale, the industrial scale tests were started, adjusting the parameter of treatment found in the laboratory and analyzing the behavior of the industrial plant, using sodium hydroxide for pH correction.

A comparative analysis of the results obtained for all wastewater quality parameters was carried out (Table 3). It was considered the raw effluent (without treatment), the treated wastewater conducted in the suggestions 1, 2 and 4, as well as, the wastewater treated in the industrial unit (industrial scale).

Regarding the general analysis of the parameters in all studied treatment conditions, suggestion 1 is not the most suitable to be used in the industrial unit, despite of being more efficient. This is due to the variability of the raw wastewater, that may require higher quantity of reagents for the coagulation/flocculation process. This suggestion would be the most suitable if wastewater was equalized.

Table 3. Physical and chemical characteristics of the raw wastewater, treated wastewater, and after different treatments, in December 2017.

Wastewater	Raw	Original	S1	S2	S4	IND(*)
pH	6.03 ±0.15	7.12±0.16	7.01±0.10	6.91±0.00	6.95±0.03	7.80±0.04
Turbidity (NTU)	287.00±5.00	13.8±0.46	9.28±2.56	12.75±0.75	14.05±0.61	11.40±0.5
Hardness (mg $CaCO_3$/L)	69.36±1.00	35.67±8.41	39.63±0.00	40.62±1.40	42.6±4.20	57.47±5.00
Alkalinity (mg $CaCO_3$/L)	22.0±0.6	23.0±0.2	24.0±0.7	21.0±0.1	24.0±0.2	27.0±0.2
Conductivity (µS/cm)	1679±75	3075±36	2131±56	2460±28	2410±85	3420±34
Chloride (mg/L)	216.6±5.0	587.2±8.2	319.8±4.1	410.6±11.3	414.3±6.2	774.8±23.0
Total Solids (mg/L)	2.32±0.02	2.00±0.01	1.64±0.06	1.76±0.05	1.7±0.08	2.20±0.02

Source: Authors.
(*)Wastewater produced after treatment using the industrial unit.

Comparing the original treatment condition and the treatment realized at the industry unit in the sampling day, it is verified that the excess of the reagents concentration in the process cause adverse effect in the observed parameters, not allowing its reuse.

A comparative analysis of suggestion 2 with the original condition and an industrial condition reveals that the results of the analyzed parameters are similar. As the suggestion 2 requires half the content of reagents from the original and industrial condition, it works more efficiently for this purpose.

Thus, it is essential to evaluate the chemical concentration of the reagents fed into the wastewater industrial unit. Excessive dosage can generate waste of inputs and rise of reagents expenditure, without changing positively its result.

Taking all aspects into account, the suggestion 2 was considered as the new effluent treatment condition for the studied industry, achieving the reuse parameters required for toilets flushing and floor washing.

For the economic feasibility study, the data collected in the year 2017 were considered.

Table 4 presents the established costs of the wastewater treatment process, regardless of the used methodology, considering the operating frequency of the effluent treatment unit as three times a week, for six hours a day. In this methodology, 105.000 liters are treated per month.

With the proposed methodology, there would be an increase of 38.1% in the monthly treated effluent volume, reaching 145.000 treated effluent liters monthly, in case of these production conditions in the industry require increase in this percentage.

Table 4. Established costs of effluent treatment process.

Variable:	Unitary Cost (U$)	Annual Quantity	Annual Cost (U$)
Active Carbon Filter Replacement	U$ 609,76	2	U$ 1.219,52
Filter Press Canvas Replacement	U$ 573,17	1	U$ 573,17
Energy Consumed ETE (KW h^{-1})	U$ 0,15	6480	U$ 972,00
Monthly collaborator cost	U$ 1.524,39	12	U$ 18.292,68
Annual Spending:			**U$ 21.057,37**

Source: Authors.
(*) U$1,00 = R$3,28

Considering the hypothetical treatment of 145.000 effluent liters per month, it was possible to identify the required quantity of chemical products per thousand liters of treated wastewater, according to Table 5.

Table 5. Wastewater treatment costs.

Original Conditions		
Chemical Product	**Quantity – 1.000 L**	**Amount – 1.000 L**
Aluminum polychloride (PAC)	2.97 L	U$ 5,70
Hydrated Lime	3.80 L	U$ 0,58
Sodium Hydroxide	-	-
Polymer	153.92 L	U$ 72,74
Total		**U$ 79,02**
New Methodology		
Chemical Product	**Quantity - 1 L**	**Amount - 1 L**
Aluminium Polychloride (PAC)	1.48 L	U$ 2,84
Hydrated Lime	-	-
Sodium Hydroxide	0.68 L	U$ 0,73
Polymer	74.47 L	U$ 35,18
Total		**U$ 38,75**

Source: Authors.
(*) U$1,00 = R$3,28

Considering the costs shown in the Table 5, it is verifiable that the for the current consumption of the company corresponds to 105.000 liters of treated effluent, the total cost of reagents would be of U$ 8.297,10; while the total reagents cost for the proposed methodology would be of U$ 4.068,75.

Thus, the study shows that the new determined procedure reduces up to 50.96% the wastewater treatment costs without requiring any investment by the industry. Thereby, the new condition in this study is feasible and efficient, as, beyond the economic gains, also shows environmental and social gains.

CONCLUSIONS

The proposed procedure allows industry to reuse all the effluent generated by the washing of machines and components containing oils and greases, immediately for floor and sidewalks washing and, later, with a study on the installation of pipelines for transport of the treated effluent, in toilets.

Besides environmental and social gains, as the preservation of finite resources, reduction of water pollution and environmental awareness of the involved society, this study brought significant results regarding its technical-economic feasibility. Through detailed analysis of the studied area, it was possible to reduce in 50.96% the expenses with chemical products inserted in the process, modify the effluent treatment process, and enable the new proposed procedure, without requiring any financial investment on the part of the industry.

Starting from this study, new study opportunities about the effluent treatment station automation were observed, to evaluate new equipment and analyze the economic viability for workforce reduction in this sector.

Besides that, it is observed that the industry has an artesian well, with no cost for water collection, although it has a cost established by the employee regarding the disposal of the water, regardless of its origin, according to a discriminated contract between the studied industry and Companhia de Saneamento Básico do Estado de São Paulo - SABESP. A detailed analysis applicable on this issue to verify the possibility of cost reduction concerning the new proposed methodology that enables reuse of the treated effluent.

It is worth to highlight the absence of the habit of making the effective environmental management inside the industrial sector. Even with favorable conditions and the viability of implantation of effluent reuse, obstacles that prevent its immediate start are found, as, for example, the provision of a worker for the realization of initial tests. A detailed study of the industrial administration sector would be useful to understand the difficulty found by management to speed up the implantation of an environmental project that is demonstrably feasible.

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Reutilização de Efluentes em Indústria Metal-Mecânica: Uma Avaliação Técnico-Econômica

RESUMO

As indústrias metalúrgicas são intensivas no consumo de água e, conseqüentemente, na produção de águas residuárias. Assim, a reutilização é essencial porque preserva os recursos ambientais, diminuindo a pegada de água dos produtos obtidos. Apesar das técnicas avançadas, o custo econômico limita o tratamento de águas residuais às técnicas mais comuns. Este estudo avaliou o potencial técnico e os custos envolvidos na reutilização de águas residuais em uma indústria metal-mecânica. Foram encontrados erros na dosagem de reagentes. A condição óptima para coagulação/floculação foi avaliada por Jar test. Foram avaliados os parâmetros, tais como: turbidez, pH, alcalinidade, dureza, condutividade elétrica, cloreto e sólidos totais. A condição ideal foi testada na planta e alguns ajustes foram feitos. As melhorias resultaram em 50,96% de redução de custos do tratamento de águas residuais sem novos investimentos. Além disso, o tratamento tornou-se mais rápido e eficiente. As águas residuais atingiram os padrões de reutilização em lavagem de banheiros e lavagem do piso.

Palavras-Chave: Economia Ambiental; Efluentes Industriais; Tratamento de Efluentes; Controle de Poluição.

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