Study of the Pollution Generated by Wastewater from the Refining of Vegetable Oils

Malika Kastali, Latifa Mouhir, Mohamed Chatoui, Chaymae Haddaji, Safaa Khattabi, abdelaziz Madinzi, Salah Souabi and Abdelkader Anouzla*

Laboratory of Process Engineering and Environment, Faculty of Science and technology, Mohammedia, University Hassan II of Casablanca, BP. 146, Mohammedia, Marocco

Abstract: This study concerns the assessment of the pollution generated by three industrial discharges produced by the Lesieur company in Ain Harrouda for the production of vegetable oils, such as process water (PWW), ACID wastewater (AWW), and refining wastewater. (RWW). This wastewater is heavily loaded with pollutants that could pose serious environmental problems. The concentrations of polluting matter in chemical oxygen demand (COD), Biological Oxygen Demand (BOD), and Total suspended solids (TSS), variable in time, could strongly influence the effectiveness of treatment with sludge currently used by Lesieur. In addition, process wastewater and refining wastewater are loaded with fats and oils with varied concentration between3700 and 6000 mg/l. At the same time, wastewater from leg breaking has a concentration varying between 1000 and 6000 mg/L. Additionally, leg-breaking water has a concentration of Total suspended solids (TSS) varying between 10,000 mg/L and 23,000 mg/L.

In comparison, process wastewater and refining water have concentrations (TSS) ranging between 4500 mg/L and 8000 mg/L, related to turbidity exceeding 10000 NTU. Furthermore, COD fluctuates between 700 and 3,400 mg/L and suspended matter between 500 and 8,000 mg/L with average pollution loads of 114 and 358 kg/day, respectively. Indeed, the COD/BOD5 ratio for process wastewater varies between 3 and 7. On the other hand, for basic wastewater, this ratio varies between 3 and 20, which could be due to the quality of wastewater with high polyphenol content. Indeed, refining wastewater has a COD/BOD5 ratio that varies between 2 and 4, which shows that organic matter is biodegradable compared to other types of wastewater. The phenol concentration varies over time and goes from 20 to 125 mg/L, while the surfactants have a variable concentration of 20 and 127 mg/L over time, then increases during the summer, taking into account the increase in market demand

Keyswords: Vegetable oils, Wastewater, Pollution, Biodegradable, Polyphenol.

1. INTRODUCTION

Environmental pollution by wastewater is a disruptive element for the receiving environment [1]. This pollution is mainly due to chemical, physical and biological elements exceeding the standard limit authorized by the World Health Organization (WHO) [2-3]. One of the essential sources of pollutants is the vegetable oil processing industry [4-5], a major consumer of water and, therefore, a significant producer of wastewater. In addition, it contains toxic materials such as oils, fats, polyphenols, and surfactants [6-7]. The treatment of effluent from vegetable oil refineries has been a major environmental issue in developing countries for several years [8]. In the vegetable oil production industry, wastewater mainly comes from the degumming, deacidification, deodorization, deacidification, soap fractionation, washing, and soil neutralization stages. This constitutes the main environmental concern in developing countries such as Morocco [7-9]. The presence in significant quantities of any matter foreign to the water (solid, liquid, gas) could considerably impact the environment [10-15].

Indeed, vegetable oil refining industries are ranked as one of the primary sources of environmental pollutants [16]. For example, the vegetable oil refinery uses various physical and chemical processes to provide quality oil while discharging significant amounts of wastewater [17-19]. In addition, the wastewater streams from the vegetable oil refinery without any prior treatment create environmental problems, such as a threat to aquatic life due to their high organic matter content [12, 17, 19]. Indeed, the direct discharge of this wastewater causes aquatic organisms' toxicity and photosynthetic activity deterioration [20-21], electrocoagulation [22],

In Morocco, industrial pollution, in general, has been the subject of particular attention in the national environmental protection policy. This resulted in establishing an appropriate regulatory framework, particularly through promulgating the new law 36-15 on water, which strengthened the legal framework surrounding wastewater reuse [23-24]. In addition, wastewater discharge into the natural environment must comply with the values after treatment discharge limits set by international standards relating to

*Address correspondence to this author at the Laboratory of Process Engineering and Environment, Faculty of Science and technology, Mohammedia, University Hassan II of Casablanca, BP. 146, Mohammedia, Marocco; https://orcid.org/0000-0002-6630-7342;
Tel: 00212661835108; E-mail: aanouzla@gmail.com

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discharges of spills, disposals, and direct or indirect discharges of effluents into surface water or groundwater [25-26].

The physico-chemical characteristics of wastewater largely depend on the type of oil treated, the process implemented, and the raw material used for production [27]. The effluents are rich in COD, oils and fats, sulfates, and phosphates, which leads to a significant pollutant load, both inorganic and organic. Indeed, these liquid discharges pose a significant challenge in the vegetable oil processing industry [7, 19]. As a result, studies on the treatment of oily wastewater based primarily on the diagnosis of wastewater have become increasingly important.

Many treatment technologies have been applied to treat oily wastewater, including electrocoagulation [28-30], coagulation-flocculation followed by membrane filtration [31], oxidation [32], biofilm adsorption for phenolic compounds and detergents [33-34]. Therefore, the appropriate treatment method is based on quantifying wastewater pollution. It is to highlight that the content of pollutants and wastewater flow remain essential parameters to determine the pollutant load necessary to assess the company's environmental aspects [34-35].

Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD5), and Chemical Oxygen Demand (COD) are commonly used as contamination indicators for calculating pollutant loads in characterization studies [36]. This study assessed COD's polluting loads, suspended solids, oils, and fats in the vegetable oil refinery's wastewater diagnosis. This will then facilitate the choice of a treatment technique, the design, the calculation of polluting loads, and the production of sludge to assess and prevent the impacts of these discharges on the environment. In addition, this study aimed to determine the quality of the effluents produced by the company over time about national standards.

2. MATERIAL AND METHODS

2.1. Production Process

Acidic wastewater (AWW) comes from the soap slurry splitting process. On the other hand, process wastewater (PWW) comes from all plant process facilities and equipment, especially soap and glycerine wastewater. Acidic and process wastewater is the tributaries entering the treatment plant.

The refinery uses chemical and physical methods to refine the oils (rapeseed, sunflower, soybean, palm, and hydrogenated). The refinery generates 1200 m^3 of wastewater per day, including acidic wastewater (80 - 270 $m^3.d^{-1}$) and process wastewater (570 - 1000 $m^3.d^{-1}$). Acidic wastewater comes from the process of splitting soap paste. On the other hand, process

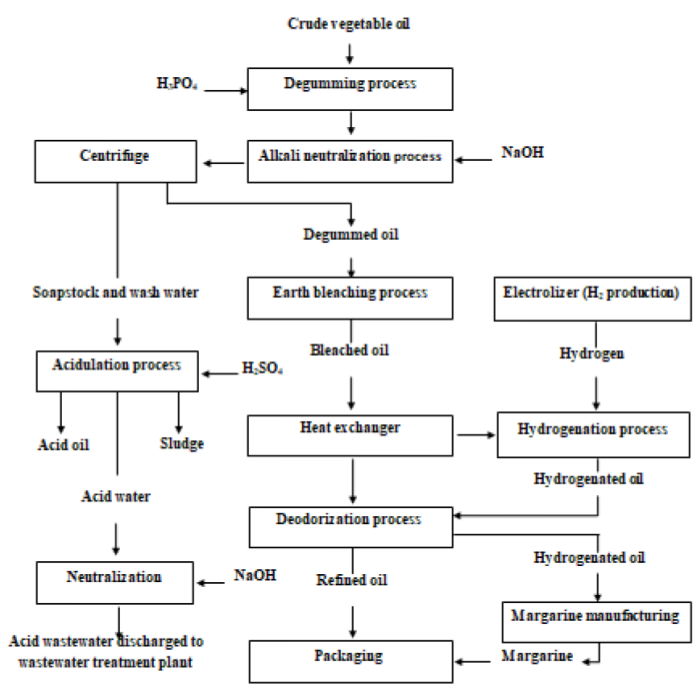

Figure 1: Processes used at the company plant.

wastewater comes from all plant process installations and equipment, particularly soap and glycerin wastewater. Acidic and process wastewaters are the influents entering the wastewater treatment plant. The acidic and processed wastewater mixture is the tributaries entering the treatment plant. Thus, the diagnosis allows the company to see very closely the possibility of carrying out at least one pretreatment to separate each of the three effluents before sending them to the activated sludge type (SBR) treatment plant.

Figure **1** shows the processes used at the Agro-industrial company plant.

2.2. Wastewater Treatment Plant

The company has built a treatment station for the waste generated during refining to protect the environment. This wastewater treatment is based on eliminating unwanted components to throw less polluting discharges into the environment. This result can be achieved by physical, chemical, and biological means.

The methods of pretreatment, coagulation-flocculation with $FeCl_3$, followed by dissolved air flotation, are the primary processes, and sequential reactor systems (SBR) as the secondary process in the wastewater treatment plant.

The organization chart of the wastewater treatment plant is shown in Figure **2**.

2.3. Method of Sampling Points

After inspection of the production facilities and processes of the company in question, two types of wastewater were sampled for characterization and carrying out the natural flotation tests :

- Process wastewater (refining and soap wastewater (PWW),
- Acidic wastewater comes from the process of splitting soap paste (AWW)
- Refining wastewater (RWW)

Wastewater was stored at 4˚C and was equilibrated to room temperature before use. Samples were taken from the company AinHarrouda Casablanca at a rate of 5 liters/hour during its operating period (8 hours / 24 hours), obtaining a composite sample of 40 liters. This makes it possible to get a representative characterization of the effluent.

The samples were stored under conditions of 4°C before being analyzed. The Standard Methods for the Examination of Wastewater procedure analyzed all models for physicochemical parameters.

2.4. Analysis of Physico-Chemical Parameters

Wastewater analysis covers the basic groups of the physico-chemical and chemical parameters defined by the current regulation on the conditions for discharging wastewater into the public sanitation system.

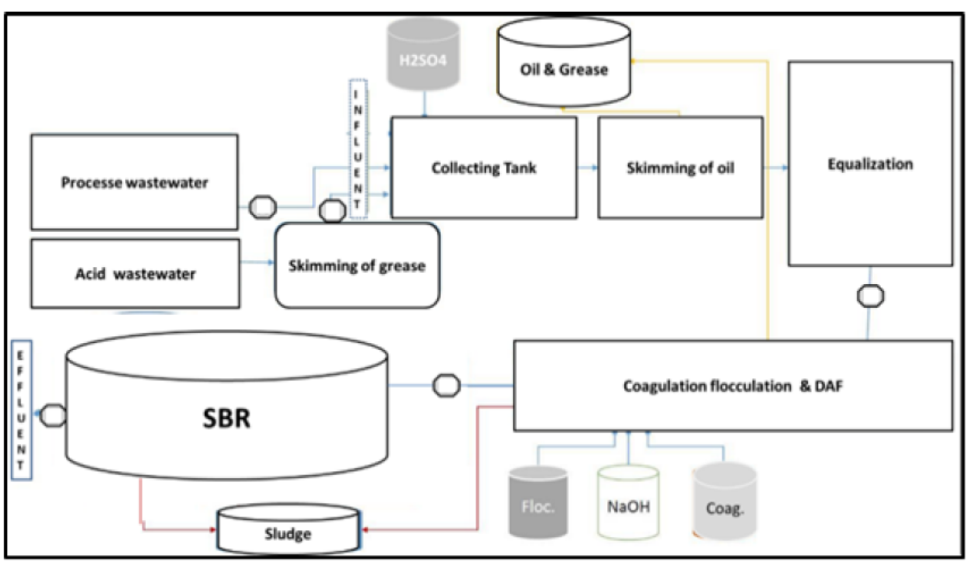

Figure 2: Agro-industrial company's wastewater treatment plant.

The pH was tracked with a pH meter "Accumet basic ab15" according to the standard NF T 90-008 February 2001 (T 90-008).

Turbidity was determined using a HACH model 2100N turbidimeter according to the NF EN ISO 7027 March 2000 standard (T 90-033). The turbidimeter used does not exceed 4000 NTU.

The total suspended matter (TSM) is determined according to NF T 90-105 January 1997 (T 90-105) protocol.

The chemical oxygen demand (COD) analysis was carried out following the NF T90-101 standard in February 2001 (T90-101).

After five days, the Biological Oxygen Demand (BOD5) was determined by the manometric method NF EN 1899 May 1998 (T90-103).

The determination of nitrates was carried out following NF EN ISO 78-90 January 1997 (T 90-045) method.

The ammoniacal nitrogen content was determined by NF T 90-015 standard in January 1997.

The total phosphorus was determined following NF T 90-023 January 1997.

The content of phenolic compounds was determined by the colorimetric method based on the Folin-Ciocalteu reagent [38].

Determination of surfactant: The determination of surfactant is based on the formation of a soluble complex in toluene between the surfactant, an anionic compound, and methyl violet, a Yucationic compound. The reading is carried out at the spectrometric wavelength of 615 nm [39].

3. RESULTS AND DISCUSSION

3.1. Physico-Chemical Characterization of Process Wastewater, Acid Wastewater, and Rafting Wastewater

Refinery wastewater comprises a complex mixture of organic and inorganic matter [7, 40]. The elimination of the polluting load by physico-chemical and biological treatment is affected by many factors, such as the physicochemical characterization of the wastewater, the nature, and the concentration of all the components. [9]. As a result, the performance of the treatment process can vary considerably.

3.2. pH Variation

Figure **3** illustrates the pH variation for the three industrial discharges chosen for the study (RWW, AWW, PWW).

These results show that the leg-breaking wastewater has an acid pH varying between 1 and 2, while the process and refining wastewater show a basic pH varying around 10. The same pH values were observed by Chatoui and *et al.* (2018) [6] and Dkhissi *et al*. (2018) [7]. This pH variation could considerably impact the treatment at the plant level, particularly in the coagulation-flocculation stage and on the biomass at the biological basin level. This shows that a buffer basin is necessary to homogenize the pH, the pollutant load and the flow rate of the wastewater received by the plant. It should be noted that the pH, the pollutant

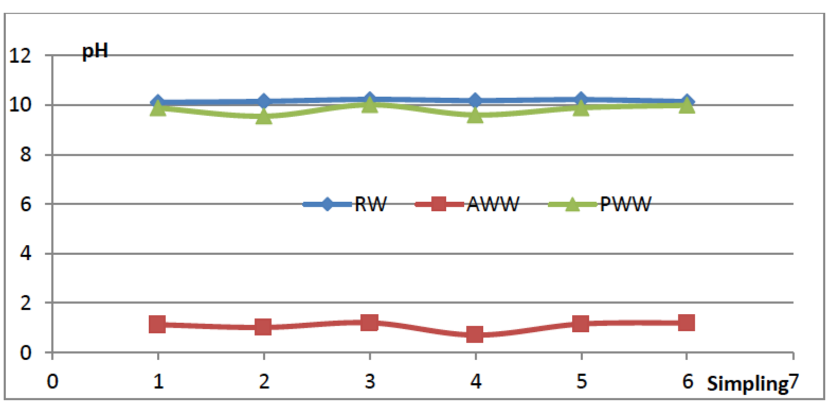

Figure 3: Variation in pH during the different sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

load and the flow rate for many industrial discharges vary over time, as shown by Chatoui *et al*. (2017) [17]. In addition, Kastali *et al*. (2021) [19] also pointed out that the pH for process and leg-breaking wastewater have pH values of basic and acid. The results of the study on vegetable oil wastewater by Anyanwu *et al*. (2019) [12] showed that the pH ranged from 0.7 to 1.23. According to the same authors, the lower pH value of acidic wastewater is related to a higher concentration of acid fat.

Anyanwu *et al*. (2019) [12] showed that industrial discharges of vegetable oils have pH values that vary between 4.9 and 5.8. pH is an important indicator of water quality as it controls several other chemical processes [7]. As part of the refining process, sulfuric acid is added to the soap slurry to aid in separating free fatty acid from the medium, a significant cause of effluent acidity [40]. On the other hand, Verla *et al.* (2014) [41] recorded a mean value varying between 4.67 and Port Harcourt, Nigeria. Adakole (2011) [42] recorded a higher mean value of 9.15 ± 0.55 in Zaria, Nigeria, while Chatoui *et al.* (2016) [6] and Kastali *et al*. (2021) [13] also recorded values greater than 10 for process wastewater and an acidic pH that varies between 1 and 2 for leg breakage while Prashant and Wagh (2020) [43] showed that the pH of discharges from vegetable oils is around 5.

3.3. Variation in Dissolved Oxygen Concentration

Figure **4** shows the evolution of the dissolved oxygen concentration during the sampling of wastewater from the three industrial discharges (process water, leg breaking water and refining water). Indeed, the O_2 concentration varies over time, from one release to another and from one sample to another.

Dissolved oxygen (DO) values ranged from 0.2 to 1.8 mg/L for process waters, while O_2 value for paw snapping ranged between 0.2 and 1 mg/L while refining wastewater presents varying concentrations between 0.6 and 1.9 mg/L. The O_2 concentration is proportional to the organic pollution in COD and BOD_5 [6, 13]. Indeed, these values show that wastewater is heavily loaded with pollutants. Atama and Mgbenka (2005) [44] showed that vegetable oil discharges have O_2 values ranging from 1.81 to 3.43 mg/L. Low O_2 concentrations are considered indicators of wastewater contamination by organic matter. Anyanwu *et al*. (2019) [12] showed that the O_2 concentration of vegetable oil discharges varies between 3.5 and 5.9mg/L. The same authors reported that dissolved oxygen concentrations below 5 mg/L could harm aquatic organisms, while the death of most fish could occur at concentrations below 2 mg/L. In addition, the diagnosis of vegetable oil wastewater (station entry) carried out by Dkhissi *et al*. (2018) [7] showed that the O_2 concentration varies between 1.3 and 2.2 mg/L, thus indicating that the O_2-poor wastewater is rich in polluting organic matter. Furthermore,

Figure **5** illustrates the variation in O_2 concentration during the different sampling campaigns for wastewater before coagulation (a) after coagulation and (b) at the level of the biological basin (c).

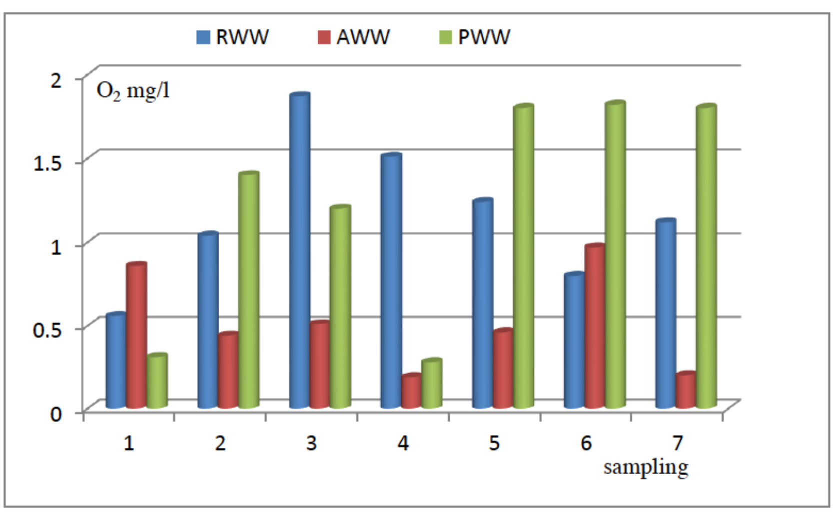

Figure 4: Variation in O_2 concentration during the different sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

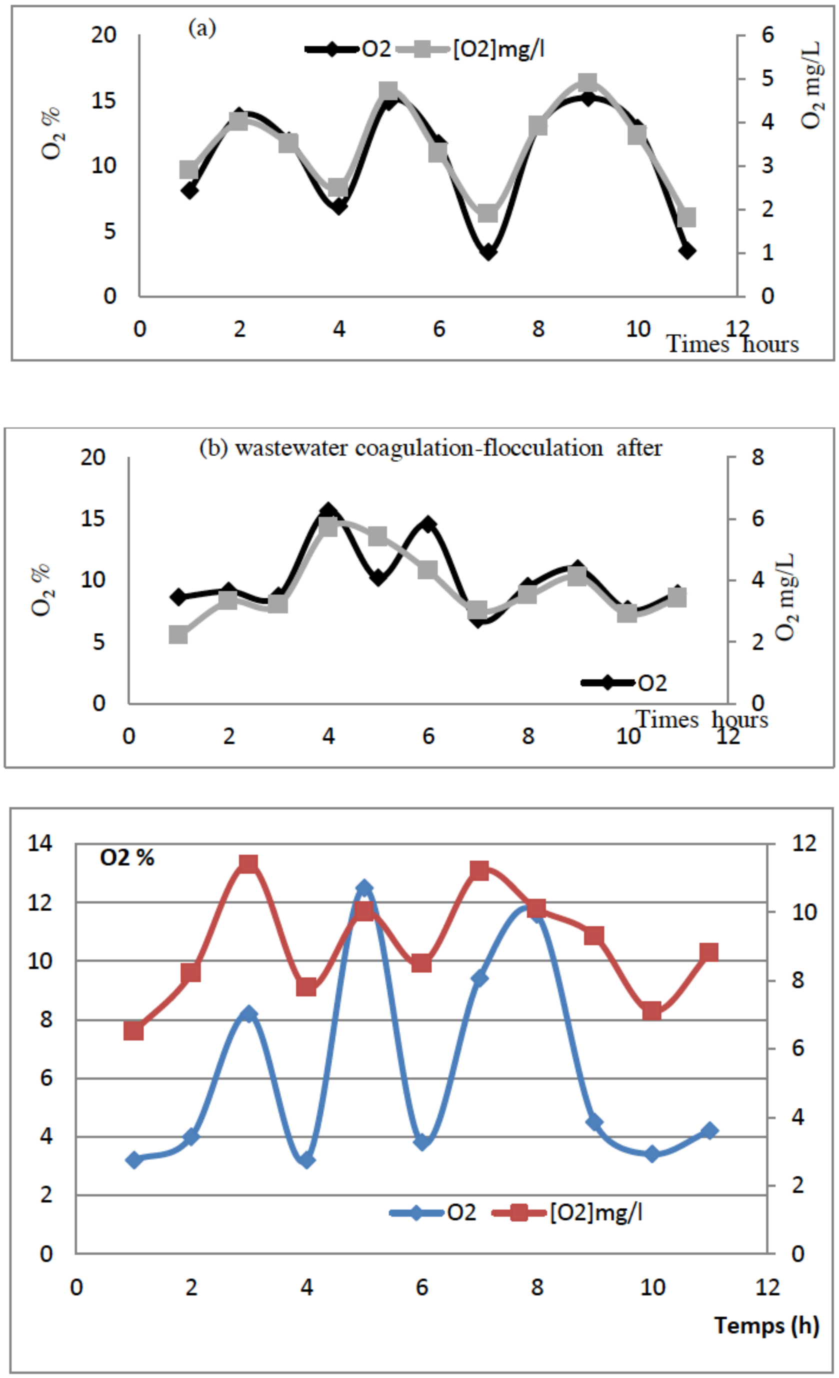

Figure 5: Variation in O_2 concentration during the different sampling campaigns.
(**a**) before coagulation, (**b**) after coagulation (**c**) at the level of the biological basin.

The variation of dissolved oxygen before and after coagulation-flocculation varies since the pollutant load received fluctuates over time. The higher the pollutant load, the lower the O_2 concentration. However, the concentration of dissolved O_2 at the level of the biological basin is a function of aeration. The latter's airing at the biological basin level (discontinue aeration) lowers the O_2 concentration.

3.4. Variation in the Concentration of Fats and Oils

Figure **6** illustrates the variation in the concentrations of oils and greases in the three types of effluent. The results show that the levels of these elements vary from one effluent to another and from one sampling campaign to another. This variation in the content of oils and fats presents a dysfunction of the wastewater treatment plant at the level of the

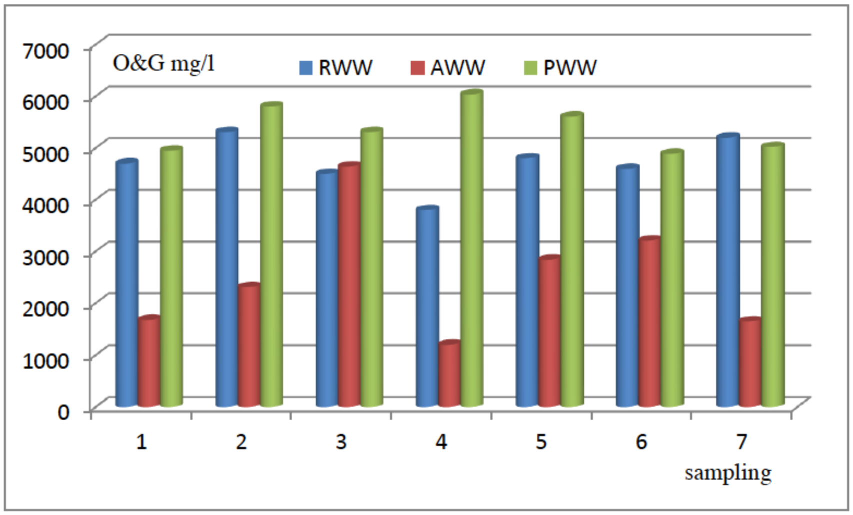

Figure 6: Variation in the concentration of oils and fats during the different sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

company's station, with a blockage of the development of biomass promoting the biodegradation of organic matter.

The physicochemical characterization of vegetable oils on three types of wastewater chosen for the study showed that the wastewater exceeds regulatory standards with very high oil and grease (O&G) loads. The effluents present variable concentrations between 5000 and 6000 mg/L for process wastewater, 3800 and 5200 mg/L for refining water, and between 1000 and 4700 for leg-breaking wastewater. Indeed, these results for refining and leg-breaking wastewater remain comparable to those found by Azbarand Yonar (2004) [45], who detected a concentration of oils and fats varying between 3600 and 3900 mg/L. However, process wastewater shows higher concentrations than those found by Azbarand Yonar (2004) [45] and Anyanwu *et al*. (2019) [12]. These effluents rich in oils and fats could completely disrupt the operation of sewerage networks by causing clogging at lower temperatures [46].

Furthermore, the results obtained for the three effluents showed concentrations lower than those El-Masry *et al*. (2004) [47] found for wastewater from vegetable oils (7535 ppm). In addition, Dkhissi *et al*. (2018) [7] showed that the Physico-chemical characterization of vegetable oil discharges (main discharge) admits a minimum concentration 504 mg/L and a maximum concentration 6542 mg/L with an average of 5495 mg /L. This remains comparable with the concentration of process water which admits as a maximum value 6000mg/L obtained during this study.

Furthermore, Anyanwu *et al*. (2019) [12] showed that the physicochemical characteristics of vegetable oil wastewater show variable concentrations of pollutants over time. It should be noted that the concentration limit for oils and greases in wastewater set by the World Bank Group (2015) varies around 10 mg/L.

3.5. TSS Variation

Figure **7** shows the Variation in TSS concentration during the 7 sampling campaigns for the three wastewater discharges.

Industrial discharges from the production of vegetable oils are heavily loaded with suspended solids for the three types of industrial wastewater (Process water, Leg breaking water, and Refining water). The three industrial discharges show SS concentrations that vary over time and from one campaign to another. Indeed, the concentration of TSS varies between 5000 and 8000 mg/L, between 11000 and 23000 mg/L, and between 4800 and 8000 mg/L, respectively, for process wastewater, leg breaking water, and refining discharges. This remains well above the concentration limit proposed by the World Bank (2015). Indeed, discharges rich in oils and fats could inhibit the development of biomass, promoting the biodegradability of organic matter at the level of the company station. It has been reported by Kastali *et al*. (2021) [13] that the reduction of fats and oils contents could be achieved by simple flotation with a yield that exceeds 80%. In addition, Anyanwu *et al*. (2019) [12]

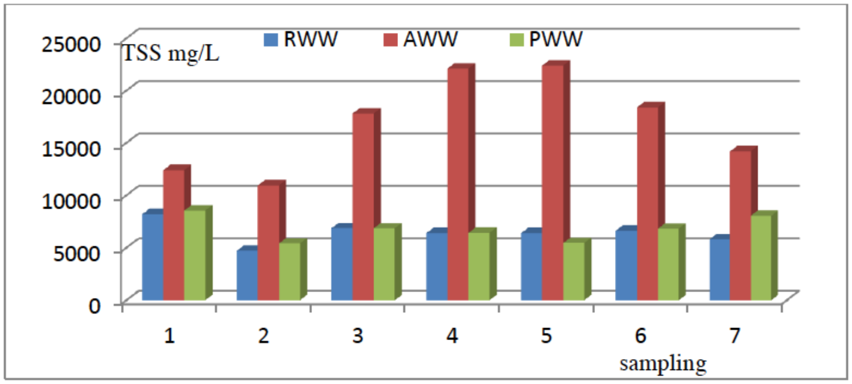

Figure 7: Variation in TSS concentration during the different sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

on wastewater from vegetable oils showed that the concentration in terms of TSS varies between 3800 and 4130 mg/L. Indeed, the discharges of leg-breaking water have a high concentration of suspended solids compared to the results obtained for processing and refining wastewater.

Furthermore, the concentrations of suspended solids for the two effluents from leg breaking and process water remain comparable. The characterization of vegetable oil discharges carried out by Dkhissi *et al*. 2018 [7] has shown that the effluent admits a minimum concentration of 5640 mg/L and 10180 mg/L as a maximum value and an average value of 7425 mg/L. This indicates that the polluting load in Kg/d remains very high, and consequently, the appearance of considerable environmental impacts. Furthermore, Azbarand Yonar (2004) [48] showed that the TSS content varies between 3800 and 4130 mg/L for vegetable oil discharges.

3.6. COD and BOD_5 Variation

Figure **8** shows the evolution of COD concentrations for five sampling campaigns. Indeed, the COD values detected vary over time and from one companion to another.

The three effluents show high concentrations, which could cause the treatment plant's malfunction at the company's level. Indeed, it should be noted that wastewater composition from the same effluent can vary considerably from one day to the following [17]. These fluctuations can be attributed to the different types of oils processed and the operating conditions [6, 13]. The characteristics of wastewater are not only influenced by raw materials and processed products but also by the water used in washing procedures during and after production. Chemical oxygen demand (COD) is a commonly used parameter to assess the oxidation potentials of organic and inorganic matter in water bodies [7]. The average COD values confirm that

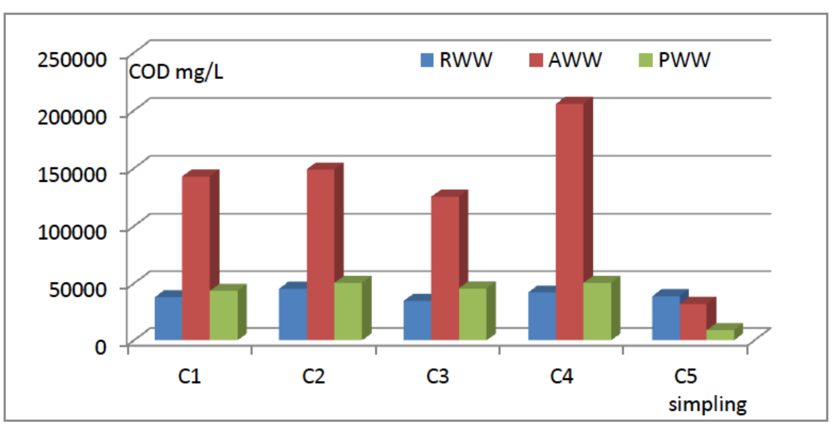

Figure 8: Variation in COD concentration during the different COD sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

the refinery wastewater has a significant organic pollutant load that varies over time. The results show that the three types of wastewater have variable concentrations over time. The highest COD values follow the same trend as DO, with lower indicator values indicating that wastewater is heavily loaded with COD-polluting organic matter.

Acidic wastewater has high COD values with a concentration that varies between 3000 and 20000 mg/L, while process water and refining wastewater show similar and varying concentrations between 1000 and 4500mg/L, which remains low compared to the value of the COD obtained for acidic wastewater COD is positively and significantly correlated with TSS and dissolved oxygen. The Variation in BOD_5 during the five sampling campaigns is illustrated in Figure **9**.

The BOD_5 values recorded in this study indicate the high pollution potential of the three effluents. For example, leg-breaking wastewater showed concentrations between 10,000 and 62,000 mg/L, refining water showed concentrations between 10,000 and 30,000 mg/L, and process water showed a value between 4,000 and 20000mg/L. However, these values remain very high and could have severe consequences for the treatment plant's operation. This agrees with the COD and BOD_5 contents found by Louhichi *et al*. (2019) [18]. Prashant and Wagh (2020) showed that vegetable oil refinery discharges produce a large amount of wastewater with high chemical oxygen demand (COD) and biological oxygen demand (BOD). COD and BOD_5 were admitted as values 22300 and 3791 mg/L, respectively. Anyanwu *et al*. (2019) [12] showed that the concentration in BOD_5 presents values between 4300 and 4700 mg/L. Indeed, the vegetable oil refinery generates two types of wastewater: acidic wastewater caused by the soap slurry splitting process.

In contrast, process wastewater is generated by all the plant's treatment facilities and equipment. This wastewater has a more or less high pollutant load (organic matter, sulfates, phosphates and chloride). According to the study by Anyanwu *et al*. (2019) [12] the values of several analytical companions showed that the highest BOD_5 concentration is around 36302 mg/L,

Generally, it can be noticed that wastewater varies in quantity and quality compared to acidic and process wastewater. These fluctuations can also be attributed to the different oil types, operating conditions, and procedures [6, 7].

3.7. Evolution of the Biodegradability of Organic Matter

Figure **10** illustrates the variation of the COD/BOD_5 ratio during five sampling campaigns. This ratio plays a critical role in evaluating the biodegradability of the wastewater of the effluent considered. Indeed, a low COD/BOD5 ratio<3 indicates the presence of a large proportion of biodegradable organic matter, making it possible to consider biological treatment alone or combined with physicochemical treatment.

Conversely, a significant value of this ratio indicates that a large part of the organic matter is not biodegradable. This leads to the conclusion that it is preferable to consider a physicochemical treatment to reduce pollution. The COD/BOD_5 ratio makes it

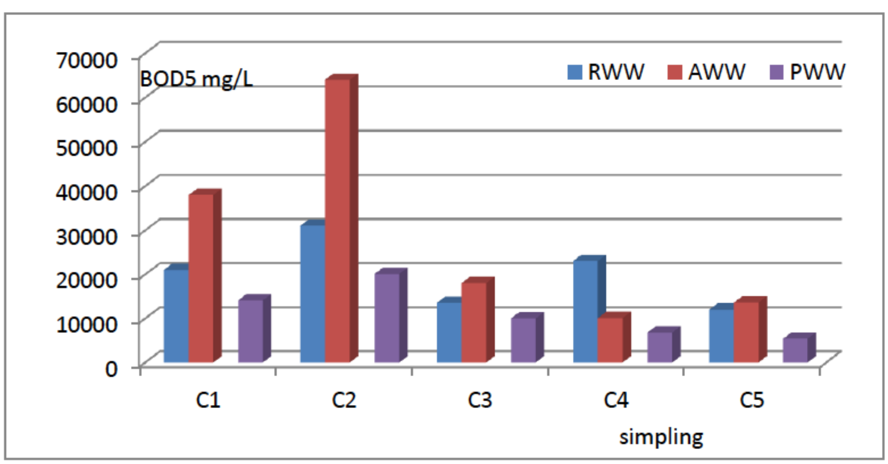

Figure 9: Variation in BOD_5 concentration during the different sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

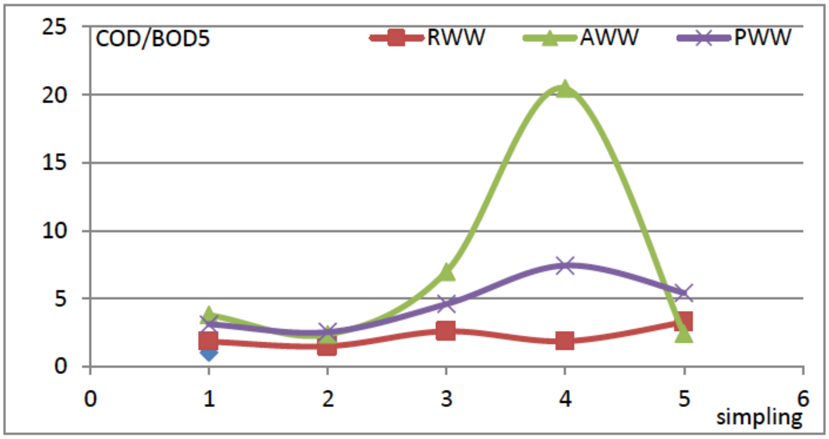

Figure 10: Variation of COD/BOD5 ratio during the different sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

possible to deduce whether wastewater discharged directly into the receiving environment could harm the environment [48]. These results show that the COD/BOD_5 biodegradability index varies from campaign to campaign. However, the effluent is not always readily biodegradable. The COD/BOD_5 ratio varies between 3 and 7 for process water and 2 and 4 for refining wastewater. This shows that refinery wastewater is rich in biodegradable organic matter compared to process water. In addition, basic wastewater has variable biodegradability over time. These results agree with Chatoui *et al*. (2016) [17], and Kastali *et al*. (2021) [19] showed that wastewater composition from the same effluent could vary considerably daily and attribute. This fluctuation is attributed to the different types of oils processed and the operating conditions and processes at the company level.

However, the COD/BOD_5 ratio value of around 20 (case of AWW acidic wastewater) showed that biological treatment alone does not lead to effective pollution elimination [13]. Indeed, the biodegradable organic matter of this wastewater is responsible for rapid bacterial growth, which could have a critical impact on the quality of natural waters [50]. Prashant and Wagh (2020) [43] showed that wastewater from the vegetable oil refinery have a biodegradability value (COD/BOD5) of around 5.9, thus showing that organic pollutants are difficult to biodegrade. In addition, Chatoui *et al*. (2016) [17] recorded a COD/BOD_5 ratio of around 3.4 in the case of overall wastewater (process water, refining water, soap factory water, etc.) received by the treatment plant of the Lesieur company. This shows that the discharges are rich in biodegradable organic matter.

Furthermore, Al-Sulaiman and Khudair (2018) [51] reported that the biological treatment of industrial effluents could be effective for a COD/BOD_5 ratio of around 1.7. This means that organic matter is biodegradable since the COD/BOD_5 ratio<3, as reported by Chatoui *et al*. (2016) [17]. This shows that biological treatment is possible since wastewater is rich in readily biodegradable organic matter. However, the vegetable oil industry effluents generally have a COD/BOD5 biodegradability index of around 5. This shows that microorganisms that promote biodegradation in the biological pond cannot quickly grow and subsequently reduce the organic pollution Activated sludge [52], and Dkhissi *et al*. (2018) [7] showed that the COD/BOD_5 ratio varies between 3.3 and 2.65, which shows that the vegetable oil effluent analyzed has average biodegradability.

Abdalla and Hammam, (2014) [52] and Anyanwu *et al*. (2019) [12] showed that the COD/BOD_5 ratio of a vegetable oil production effluent is around 5, which led to the conclusion that the effluent is rich in non-biodegradable organic matter. The COD/ BOD_5 ratio of raw and treated wastewater was calculated to assess the potential biodegradability of organic compounds in the wastewater. In addition, Al-Sulaiman and Khudair, (2018) [51] showed that for an aerobic biological treatment, the COD/BOD_5 ratio must be < 1.7. In conclusion, the biodegradability index helps predict the stability measurement of the biological degradation of organic pollutants in the environment. It is a decision aid for choosing a treatment technique [13, 17]. Furthermore, for the treatment of effluent by conventional methods such as aerobic or anaerobic digestion, the COD/BOD5 ratio must be < 1.57 [51, 53]. However, effluents from the vegetable oil industry generally have a COD/BOD_5 ratio of around 5, which could lead to the inhibition of microorganisms, promoting the biodegradation of organic matter rich in oils and fats [51, 54]. Indeed, Bouknana *et al*. (2014) [55] showed that the biodegradability of industrial effluents depends on the COD/BOD_5 ratio (Table)

Table: Biodegradability Ration COD/BOD5 and their Indication (Bouknana *et al*. 2014) [54]

COD/BOD5 Ratio	Indication
<3,33	Effluent readily biodegradable
5-1,67	Effluent medium biodegradable
>5	Effluent no biodegradable

3.8. Variation in Surfactant and Phenol Concentration

3.8.1. Variation of Surfactant

Wastewater treatment is an essential responsibility of industrial units to reduce pollutants that cause serious environmental problems. Surfactants are among these emerging contaminants. They are attractive because of their increasingly widespread domestic and industrial use. Significant production of surfactant-laden effluents accompanies this. This revealed major concerns about the impacts of surfactants on the environment, particularly wastewater treatment plants, due to disruptive biomass foams promoting biodegradation [56]. Surfactants cause foam in the biological basin, inhibiting the development of bacteria that promote the biodegradation of organic matter [13, 37]. This could strongly influence the quality of the wastewater produced. Indeed, it is necessary to specify that the company has table oils, olive oils, and different types of soaps, cosmetic products, and bleach.

Figure **11** represents the variations in surfactant concentrations during seven sampling campaigns. These results show that the three releases' surfactant content varies over time.

For samples 1 and 2, no significant difference was observed concerning the concentration of surfactants. Refined waters show the lowest values. These values vary between 3.5 and 11 mg/L. For process wastewater, the concentration of surfactants varies between 6 and 17 mg/L, while acidic waters (AWW) have varying values between 6 and 14 mg/L. The surfactant concentrations of the three discharges during the study exceeded the limit values of the standards for direct discharges. Indeed, it is necessary to optimize the treatment conditions at the level of the Lesieur company, in particular, coagulation-flocculation and aeration at the biological basin level to increase pollution reduction. These detergents cause foams at the treatment station, which can disturb the Physico-chemical and biological treatment due to the inhibition of the biomass, promoting the biodegradation of organic pollutants [6, 7]. In addition, Mousavi and Khodadoost (2019) [57] showed that detergent-rich discharges could have significant environmental impacts.

Due to the toxicity of phenolic pollutants and detergents used in developing countries, industrial

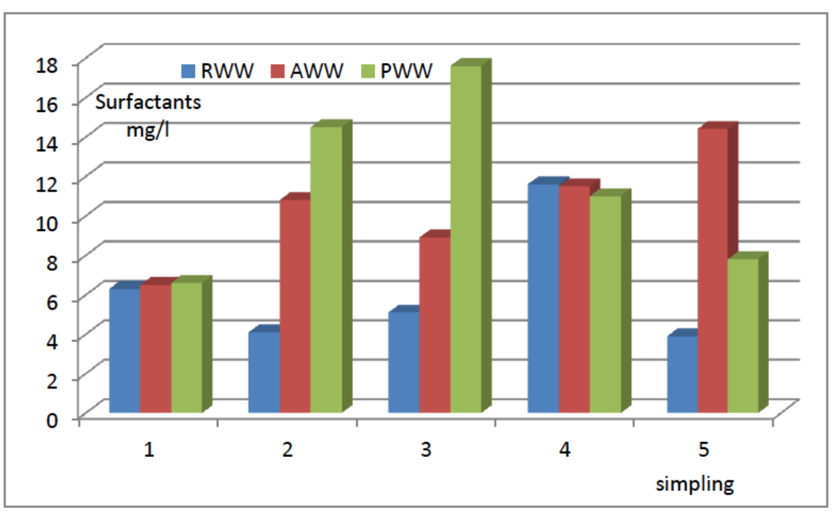

Figure 11: Variation in surfactant concentration during sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

units increasingly use high-performance techniques to comply with Moroccan legislation, including the optimal consumption of these products, awareness, prevention, and wastewater treatment. In addition, the increase in the consumption of detergents (often non-biodegradable) by the population and the industrial environment poses serious environmental problems and challenges [17, 19, 58]. Moreover, phenols and detergents significantly impact humans in the short and long term [13, 59]. Furthermore, the discharge of vegetable oils loaded with pollutants into seawater and rivers without prior treatment poses severe problems for the aquatic flora and fauna (Lika and Papadakis, 2009, Rehman *et al*., 2014) [60, 61]. The same authors showed that phenols and highly toxic and corrosive detergents are considered priority pollutants.

3.8.2. Variation in Phenol Concentration

Figure **12** illustrates the variation in phenol concentration during six sampling campaigns.

The results show that the three types of wastewater produced by the company concerned have varying concentrations of phenols. Process water offers varying levels between 36 and 60 mg/L. Refining waters have a minimum concentration of 48mg/L and a maximum of 92mg/L. Furthermore, acidic wastewater shows concentrations ranging between 20mg/L as the minimum value and 127 mg/L as the maximum value. This indicates that acid discharges (AWW) have high toxicity due to phenols having a considerable impact on the operation of the treatment plant, as Chatoui *et al*. (2016) [17]. The phenol contents for the three discharges vary from one campaign to another. Indeed, the phenol and surfactant contents remain comparable to those of Dkhissi *et al*. (2018) [7].

Furthermore, it should be noted that the wastewater produced by the company's SBR-type treatment plant has Physico-chemical characteristics that differ from country to country. The processed products and raw materials influence the physicochemical characteristics, the processes used, and the washing of waters during and after production [11, 19]. Emamjomeh*et al*. (2019) [62] showed that the phenol content of wastewater from vegetable oils has varying concentrations between 2.9 and 17.6 mg/L.

4. CONCLUSION

Wastewater from the processing of vegetable oils has a very complex chemical composition. They contain various organic and mineral compounds of very different natures and concentrations. These discharges are rich in poorly biodegradable phenolic compounds, causing a real environmental problem. In particular, the malfunction of a wastewater treatment plant. The results of the physico-chemical parameters obtained during this study constitute contamination indicators making it possible to judge the quality of the polluting materials received by the treatment plant at the company level. In addition, these parameters make it possible to assess the biodegradability of the effluents and subsequently to choose an appropriate process. for the treatment. The O_2 concentration in process wastewater, leg-breaking wastewater and refining water vary between 0.2 and 1.7 mg/L, which means that the different types of wastewater are highly loaded with pollutants that consume O_2. In addition, process

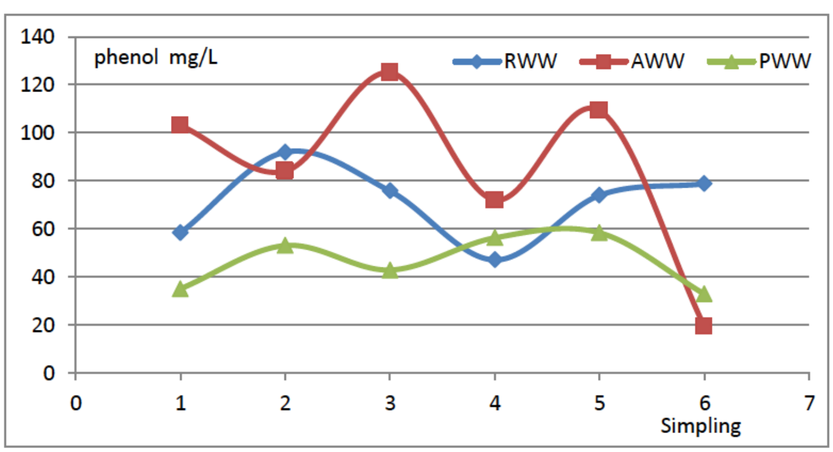

Figure 12: Variation in phenol concentration during sampling campaigns.
Refining wastewater (RWW), Process wastewater (PWW), Acidic wastewater (AWW).

wastewater and refining water are loaded with fats and oils with a concentration that varies between 3700 and 6000 mg/L while leg-breaking wastewater has a concentration ranging between 1000 and 4500 mg/L. In addition, leg-breaking water, process water, and refining water have high concentrations of TSS. COD fluctuates between 700 and 3,400 mg/L and suspended matter between 500 and 8,000 mg/L with average pollution loads of 114 and 358 kg/day, respectively. Indeed, the COD/BOD_5 ratio for process water ranges between 3 and 7. In contrast, for leg-breaking water, this ratio varies between 3 and 20, possibly due to the quality of wastewater with an acid pH. and the high polyphenol content. This may be because highly loaded wastewater with polyphenols exhibits remarkable toxicity. The phenol concentration varies between 20 and 125 mg/L, while the surfactants show a variable concentration over time. This concentration in wastewater increases during the summer, given the production of surfactants and the increase in market demand.

PWW	Process water
AWW	ACID wastewater
RWW	Refining wastewater
COD	chemical oxygen demand
BOD	Biological Oxygen Demand
O_2	Oxygen
TSM	Total suspended matter
O&G	Oil and grease
WHO	World Health Organization
TSS	Total suspended solids
SBR	Sequencing batch reactor

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