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Treatment of Tannery Effluents of Fez City by the Sequential Batch Reactor

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Abstract

The tannery effluents are characterized by a very high pollutant load, the toxicity of these effluents is mainly due to chromium and sulfides used in the tanning of animal skins. Indeed, the effluent discharge into the environment without treatment can lead to harmful or even catastrophic effects, therefore the treatment becomes indispensable.

The physicochemical characterization showed that this effluent does not meet the Moroccan standard in terms of the COD, the EC, the BOD5, the SS, the S^{2}- ions and the Cr. However, the microbiological characterization revealed a total absence of pathogenic germs.

The treatment of these effluents was by SBR which is based on treatment with aerobic activated sludge, using a medium and high load with one cycle per day. Moreover, the treatment has yielded satisfactory results by using the medium load, whose the abatement rates are 95%, 98%, 97.4%, 99.8%, 98.3% and 93.4% respectively for the EC, the COD, the BOD5, the S^{2}- ions, the SS and Cr. However, the high load revealed that the treated effluent still remains out of the Moroccan standard, despite the abatement rate which exceeds the 60%.

Keywords: Tannery, Effluent, Chromium, Treatment, SBR, organic load

1. Introduction

The tanneries or leather manufacturing industries occupy an important place in the economic sector of Morocco, view to the incomes and the number of jobs created. Despite these positive impacts, these industries have a negative image because of the pollution that results.

The toxicity of tannery effluents is mainly due to the presence of chromium. The latter has crucial risks on the environment (Sarker et al 2013), and the human health (Zhao et al, 2010; Hu et al, 2012) in the world. Indeed, 70 to 80% of leather produced internationally is made by chrome tanning (Bajza et al, 2004), and other chemical substances used at the transformation of the animal skin into leather. However, the discharge of these effluents directly into natural environments, without any treatment, can lead to harmful or even catastrophic effects.

Several processes have been studied for treating these tanneries effluents before their discharge, in order to eliminate or reduce the negative impacts of these effluents. Among them, we cite the adsorption (Kanawade, 2014), microfiltration (Ben Amari et al, 2001), coagulation-flocculation (Song et al, 2003), electrocoagulation (Shivayogimath et al, 2015), reverse osmosis (Kuppusamy et al, 2011), anaerobic biological treatment (Andualem et al, 2016), aerobic biological treatment (DIIACONI et al, 2003), biological treatment by the macrophytes (Jahan et al, 2014)... etc.

In recent decades, the sequencing batch reactor (SBR) has become the most attracted process by the experts of depollution. This system has shown a high performance of depollution on several types of effluents, namely chemical effluents, paper mill effluent, petrochemical effluents, pharmaceutical effluents, tannery effluents ... .etc (Patil et al, 2013). Thus the low operating and investment costs, and the flexibility of this process compared to other allow it to be the most recommended worldwide (Patil et al, 2013).

In this context, this study aims to characterize the effluent of a modern tannery in Fez city in Morocco and treat them by the SBR process using a medium load followed by a high load.

2. Material and Methods

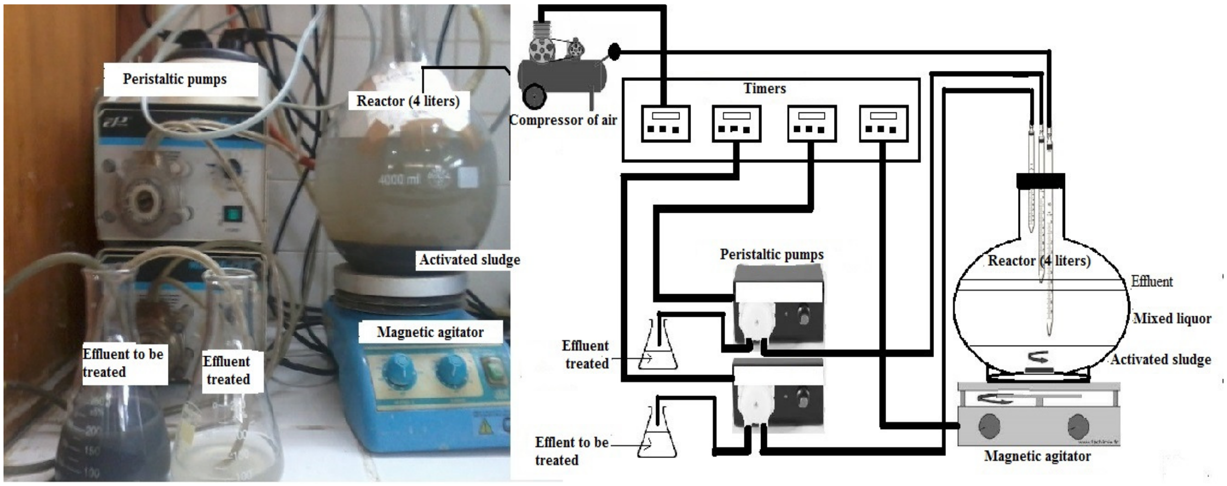
2.1 Sampling

The samples of tanneries studied were taken from a leather manufacturing industry which treats only the bovine hides, located in the industrial area Dokkarat in the Fez city in Morocco. The raw or composite effluent analyzed is composed of four effluents. These are taken directly from the fullers of different stages of the animal skin treatment, namely unhairing-liming (R1), rinsing (R2), deliming-bating (R3) and chrome tanning (R4). The samples of these effluents were collected each month starting from February 2015, according to the standard (Rodier, 2009). Then, they were transported to the laboratory separately mixed with equal quantity so as to have a composite effluent and stored at 4°C according to the standard (Rodier, 2009).

2.2 SBR Process

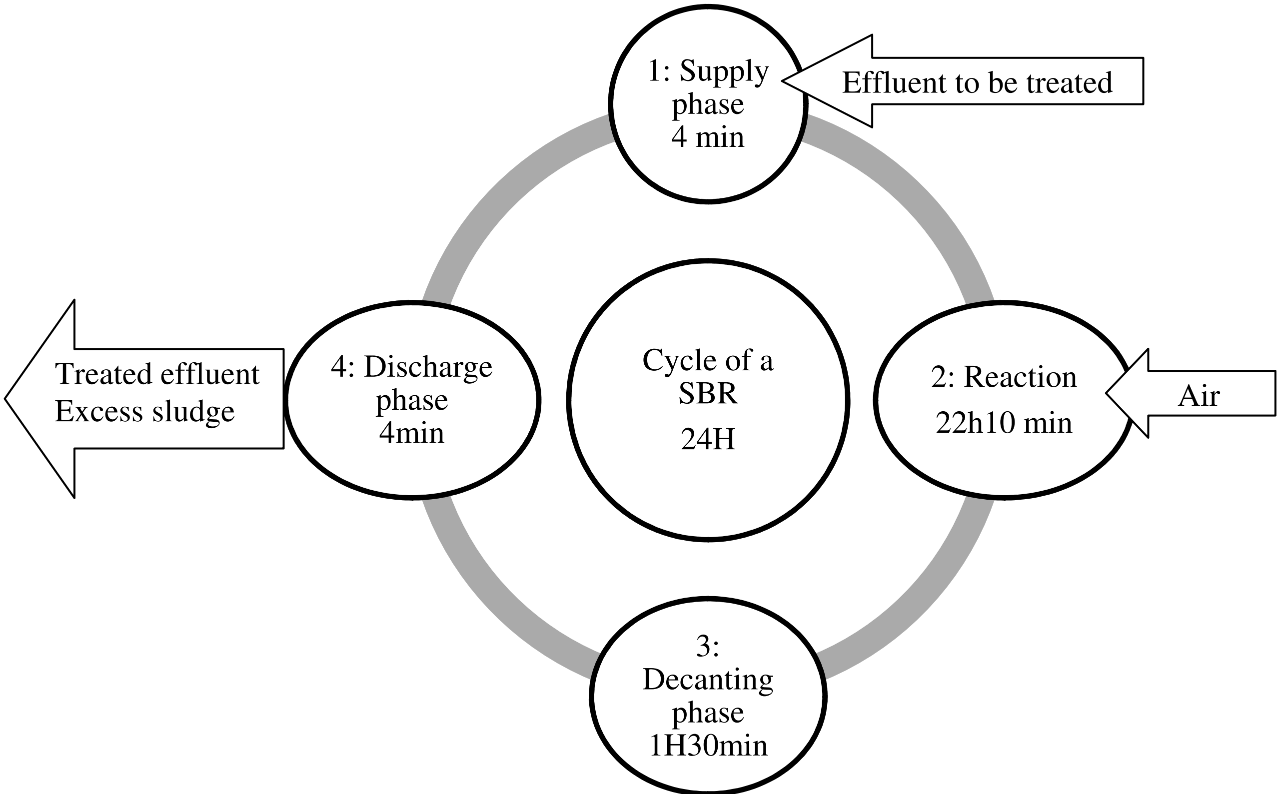
The SBR process used is a Pyrex, with a total capacity of 4 liters. The supply and withdrawal of the effluent are maintained by plastic tubes inserted into the reactor and associated with peristaltic pumps (7554-95 Master flex L/S). The aeration is made by a compressor type of snorkels TÜBAS FH 255-2050C, and the agitation was provided by a magnetic agitator (Figure 1).

Figure 1: Sequencing batch reactor (SBR)



The principle of treatment by this reactor is based on four steps: the supply of reactor by the effluent to be treated, the aerobic treatment by activated sludge, the decantation to separate the sludge from the treated effluent and finally the withdrawal of treated effluent and excess sludge if it is necessary. These four steps constitute one cycle of treatment, which lasts 24 hours in this study. Each step has a determined duration, which is ensured by the timers (Figure 2).

Figure 2: Principle of treatment by the SBR



The supply flow is calculated by using the volumetric loading studied; and the volume of the mixed liquor is estimated from the volume used of the reactor, the volume of activated sludge and the supply flow (Table 1). Moreover, the origin of the activated sludge used is the wastewater treatment plant in the Fez city in Morocco.

Table 1: Characteristics of the parameters applied to the SBR according to the applied load

	Medium load	**High load**
Volumetric load (VL) (Kg of COD.$D^{-1}.m^{-3}$)	0.7	1.5
Supply Flow (ml/d)	100	200
Volume of the mixed liquor and the actived sludge (l)	2.9	2.8
Capacity used (l)	3	3

2.3 Effluent Characterization and Treatment Effectiveness

A series of physicochemical, metallic and microbiological analyses were performed to characterize the effluent studied. Furthermore, these analyses are also carried out before and after treatment with the SBR to determine the effectiveness of treatment and specify the abatement rates for each parameter. These analyses are (Table 2):

Table 2: Physicochemical and metallic parameters performed

Parameters	**Method and references**
pH	Measured by a pH-meter, the electrode is of type X 22 Felt.
Conductivity (µS /cm)	Measured by a conductivity-meter of ORION type, where the results are obtained at 25 ° C
Dissolved O_2 (mg/l)	Measured by an oximeter type WTW OXI 315i.
Suspended solids (SS) (mg / l)	Measured according to the experimental methods described by Rodier (Rodier, 2009).
Sludge index (SI) (ml / g)	Measured according to the experimental methods described by Rodier (Rodier, 2009).
Ions ammonium (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-), sulfate (SO_4^{2-}) and orthophosphate (PO_4^{3-}) (mg / l)	Determined according to the colorimetric dosage by spectrophotometric (Rodier, 2009).
Chemical oxygen demand (COD)(mg of O_2/ l)	Measured according to AFNOR standard T90-101 (Rodier, 2009).
Biological oxygen demand (BOD_5) (mg of O_2/ l)	Determined by a type of BOD-meter Oxi Top IS6 (Rodier, 2009).
Sulphide ions (S^{2-}) (mg / l)	Determined by indirect titrimetric dosage according to standard NF-T-60-203 (Rodier, 2009).
Heavy metals (mg / l)	Measured by atomic absorption spectroscopy or ICP type Jobin Yvon Horriba.
Decoloration (%)	Measured by a spectral scanning UV spectrophotometer (Rodier, 2009).

The microbiological analyses are carried out by inoculation on the surface according to the experimental protocols described by Rodier (2009).

Table 3: Germs searched and culture medium

Germs	**Culture medium used**	**Time and temperature of incubation**
Total mesophilic aerobic	LB agar (Luria Bertani)	24 hours at 30 ° C
Facal streptococci	Slanetz and Bartley agar	24 hours at 37 ° C
Total coliforms	Desoxycholate Lactose agar	24 hours at 37 ° C
fecal coliforms	EMB agar (Eosin methylene blue)	24 hours at 44 ° C
Staphylococci	Chapman-mannitol agar	24 hours at 37 ° C

3. Results and Discussion

3.1 Effluent Characterization

3.1.1 Physicochemical Characterization

A questionnaire was conducted with the staff of the tannery in Fez before collecting the effluents, whose purpose is to determine the quantity of water, and the nature and quantity of chemicals used to transform animal skins to leather (Table 3). The animal skins treated by this company are the bovine skins only.

Table 4: Quantity of products and water used in processing of tanning for one-ton skins

Steps	products used	Quantity (kg)	Water quantity (l)
Preparation	Soap	3	2500
Soak, Depilation Liming, Fleshing	sodium hydrosulfide	12.5	20000
	sodium sulfide	35	
	Sodium carbonate	6	
	Lime	20	
Deliming, Bating, Degreasing Stripping, Tanning	Ammonium sulfate	5	2000
	Sodium metabisulphite	50	
	formic acid, sulfuric acid	56	
	Salt, Soap	140	
	Chromium	100	
	Sodium bicarbonate	12.5	
	tanning oil	6	
Retanning	Soap	0.5	4500
	formic acid	0.5	
	sodium formate,	34	
	sodium bicarbonate,	64	
	neutralization agents	73	
	Tannins, colorings	8	
Finishing	Pigments, resins, waxes	17	20
	Matting agents, agents of touch	11	
	Lacquers, thinners	26	
Total	**Chemical products**	**680 Kg**	**29 m^3**

According to table 4, we can observe that the transformation of animal skins into leather requires the different chemicals including sulfide, carbonate and sodium bicarbonate, salts and chrome ... etc. Indeed, about 680 kg of chemicals are consumed to treat one-ton of animal skins with a water capacity of 29 m^3. Therefore, these tannery industries use a very high quantity of chemicals and generate a large volume of wastewater and a large quantity of solid waste.

Table 5 presents the results of the physicochemical characterization of the tannery effluent studied. Based on these results, we can conclude that this effluent is highly loaded, and does not meet to the Moroccan standard of discharge in terms of several parameters to knowing the pH, the COD, the BOD$_5$, the electrical conductivity, the ions sulfides, the ions sulfates , the ions ammonium and the suspended solids.

Table 5: Physicochemical characterization of the tannery effluent

Parameters	Maximum value	Minimum value	Average values	Standard (State Secretariat charge of water and the environment, 2013)
pH	9.5	8.5	9 ± 0.2	5.5 - 8.5
Electric conductivity (mS / cm)	23	20	**20 ± 2**	2.7
SS (mg / l)	4500	4000	**4000 ± 100**	30
COD (mg of O_2 / l)	20135.8	14355.8	**14500 ± 250**	120
BOD$_5$ (mg of O_2 / l)	1680	1380	**1460 ± 90**	40
NH_4^+ (mg / l)	73.8	59.6	**60.6 ± 2.5**	40

Parameters	Maximum value	Minimum value	Average values	Standard (State Secretariat charge of water and the environment, 2013)
NO_3^- (mg / l)	20.6	14.7	**15.3 ± 1.5**	40
NO_2^- (mg / l)	10.8	6.8	**8.4 ± 1.6**	-
PO_4^{3-} (mg / l)	3.6	1.5	**2.8 ± 1**	2
SO_4^{2-} (mg / l)	3098.5	2397.8	**2560 ± 20**	500
S^{2-} (mg / l)	697.9	397.5	**410.6 ± 12.4**	0.5

The pH of this effluent is basic for the use of carbonate and bicarbonate of sodium, which neutralize sulphide and sulfuric acid used.

High concentrations of COD and SS were noted, with a medium of 14500 mg of O_2/l and 4000 mg/l respectively. These concentrations are probably due to the quantity of chemicals used, which achieved 680 kg per ton of treated skin (Table 4).

When the BOD_5, it is also out of the standard, which the medium concentration is 1460 mg of O_2/ l, this can be due to the hairs, the proteins, the fats eliminated during the unhairing-liming step.

Moreover, the electric conductivity largely exceeds the standard, with a medium concentration of 20 mS / cm, which it reflects the high concentration of salts used (Table 4).

As for the sulfide ions are also present with a very high concentration, which is 410.6 mg / l. The latter is higher than the Moroccan standard, which requires a concentration of sulfide ions of 0.5 mg /l only. This concentration is can be justified by the use of sulphides during the unhairing-liming step, in order to eliminate the animal skin hairs. As regards the sulfate ions, a high concentration was found, this could be justified by the use of products containing sulfates in particular chromium sulfate and sulphate ammonium...etc.

On the other hand, the orthophosphate ions are of low concentration, which is probably due to the soap used in the tanning process (Table 4).

Concerning the nitrogen forms, a high concentration of ammonium ions was recorded, which reached 60 mg / l as a medium value, this could be justified by the use of ammonium sulfate during the stage of deliming (Table 4). The low concentration of nitrate and nitrite ions is perhaps explained by the conversion of ammonium ions to nitrite ions and nitrate ions by nitrition and nitration reactions. These reactions can be performed either biologically (nitrous and nitric bacteria) or chemically, yet the low nitrite ion concentration compared to that of nitrate ions probably confirms the transformation of the ammonium ions to the nitrate ions passing by the ion nitrites which have an unstable form.

Moreover, the results have a fluctuation range for all the parameters studied. This could be justified by the non respect of quantities of products used by workers and the quality of the treated skin at each treatment. Indeed, the chemicals are used in excess in order to ensure their penetration into the animal skins (Scholz at al, 2003).

The ratio BOD_5 / COD is lower than 0.2, which that shows that the biological treatment of this effluent is impossible, but the literature has shown the possibility of treating these effluents by a biological process through several studies (DIIACONI et al 2003; Ganesh et al, 2006; Sabumo, 2016).

In fact, table 6 presents a comparison of results obtained in this study with the literature. However, the pH and the COD are generally the parameters which have to know a very important range of variation. The pH varies between 2.7 and 10, whose the acid pH is due to the sulfide and sulfuric acid used only without neutralization with sodium carbonate. When the COD values vary between 700 mg of O_2 /l and 56000 mg of O_2 /l, this could be due to the quality and nature of the treated skin and to the quantities of chemicals used.

Table 6: Comparison of the results obtained with the literature

pH	COD (mg of O_2 / l)	BOD_5 (mg of O_2 / l)	EC (mS / cm)	SS (mg / l)	Reference
2.7	56000	-	20	8860	(Shivayogimath et al, 2015)
7.5	2720	904	14566	390	(Naumczk, 2005)
3.08	2500	45	118	233	(Tiglyene et al, 2008)

pH	COD (mg of O_2 / l)	BOD_5 (mg of O_2 / l)	EC (mS / cm)	SS (mg / l)	Reference
8.3	12840	4464	42.5	21300	(Jahan et al, 2014)
7.3-10	1320-54000	840-18620	-	220-1610	(Haydar et al, 2008)
4.01	4100	2040	-	2250	(Abu Elmagd et al, 2014)
3-8	700-3400	253 ± 209	9-31	550-8000	(Aboulhassan, 2008)
9±0.2	14500±250	1460±90	20±2	4000±100	This study

3.1.2 Heavy Metals Characterization

The results of the heavy metals showed a very high concentration of chromium, whose the latter reached 920 mg/l as the average value (Table 7). This is explained by the use of chromium in the tanning step of animal skins (Table 4).

Table 7: Metallic characterization of tannery effluent

Heavy metals	Maximum value	Minimum value	Average values	Standard (State Secretariat charge of water and the environment, 2013)
Cr (mg / l)	1020.6	846.8	**920 ± 20.04**	**0.5**
Al (mg / l)	7.8	1.8	**5.44 ± 0.6**	**10**
Fe (mg / l)	5.2	0.5	**3.9 ± 0.4**	**5**
Ni (mg / l)	1.5	0.01	**0.44 ± 0.06**	**5**
Cd (mg / l)	0.5	0.01	**0.2 ± 0.07**	**0.2**

This chromium value obtained resembles that of other studies (Haydar et al, 2008; Abu Elmagd et al, 2014), and more important relative than other works (Sabumon, 2016 ; Haydar et al, 2008), it is probably due to the quantity of chromium used, the tanning time and the time of sampling. In addition, the direct discharge of this effluent ; containing the chromium, in the environment allowed to this metal to undergo the oxidation reactions in order to be transformed into Cr (VI) (Bartlett et al, 1979), this form that is highly toxic and carcinogenic (Zhang et al, 2001).

3.1.3 Microbiological Characterization

The microbiological analyses showed a low concentration of the total aerobic mesophilic flora (FMAT), which the average value is 100 CFU (Unite Formant Colonie)/ ml, as well a total absence of pathogens germs, in particular, the *facal streptococci*, the *staphylococci* and the fecal coliforms. This could be explained by the high concentration of salts that inhibit the bacterial growth (Rene et al, 2008), and by the toxicity of chromium which is present with a very high concentration. However, we can conclude that the germs found (MTAF) are halophilic and they resist high concentrations of chromium.

3.1.4 Performance of the Treatment with SBR

In order to ensure the good performance of the SBR process. The latter has been controlled by some parameters, including the suspended solids (SS), the sludge index (SI), the dissolved oxygen and the pH of the mixed liquor. The results of these parameters are in the optimum state (Table 8).

Table 8: Results of SS, SI and the pH of the mixed liquor

	Medium load	High load	Optimum
SS (g / l)	5 ± 0.9	5.4 ± 0.6	3-6 g / L
SI (ml / g)	96 ± 4.8	100 ± 5	50-150 ml / g
pH of the mixed liquor	7.39 ± 0.1	7.59 ± 0.2	6-8

The table 8 shows that the pH of the SBR reactor is between 6 and 8 for the two load studied, this indicates that is optimum for the bacterial growth (Acharya et al, 2008). As well, the SS concentration in the reactor is between 3 and 6 g /l for the two loads too, then it is higher than the concentration 2 mg /l which is unfavorable for a biological treatment (Arica et al, 2001). On the other hand, the sludge index is 96 ± 4.8 and 100 ± 5 ml/g for a medium load and a high load respectively, so it is between 50 and 150 ml /g. This showed that the decantation is will be good and satisfactory, therefore no bulking phenomenon.

Figure 3: Evolution of dissolved oxygen during the treatment cycle

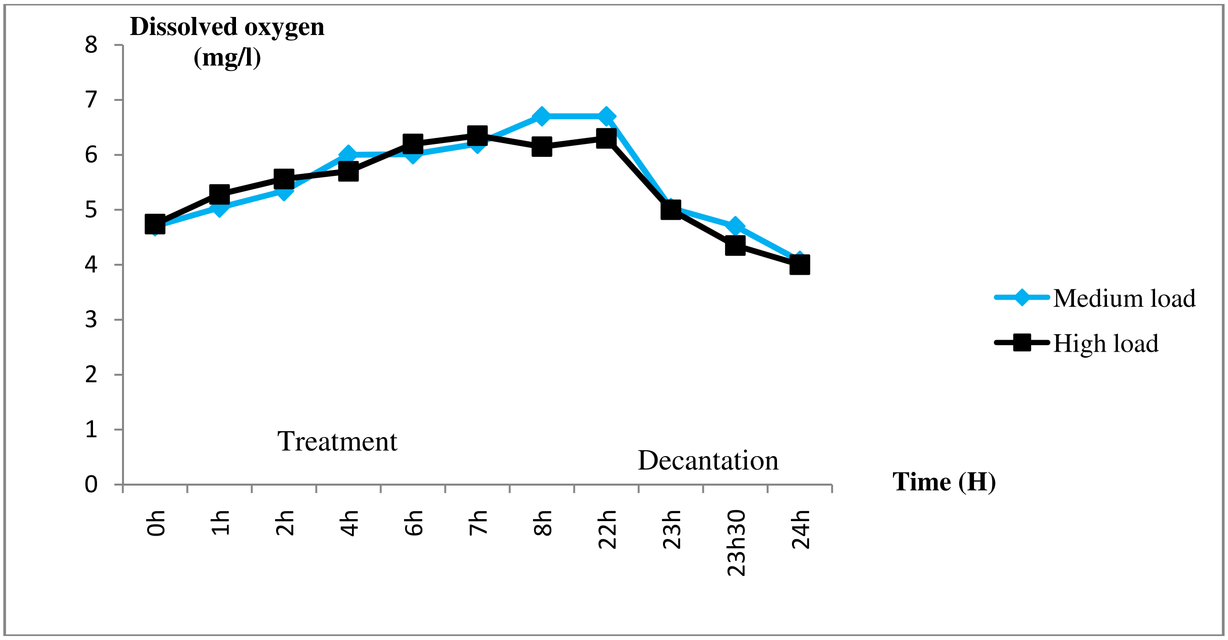


Figure 3 presents the evolution of the concentration of dissolved oxygen during the treatment cycle. For the two loads applied, the dissolved oxygen concentration is between 4 and 6 mg/l, in which there is an increase during the aeration or treatment phase and a decrease in the decantation phase. The decrease is explained by the air supply during the decantation phase, while the increase is possible due to endogenous respiration and the biodegradation of the polluting substances, these results are consistent with those found by Lefebvre (2005) et Faouzi (2012).

Table 9: Results of physicochemical analyses for two loads applied after month of treatment

Parameters	**Medium load**			**High load**			**Standard (State Secretariat charge of water and the environment, 2013)**
	Enter SBR	**Output SBR**	**(%)**	**Enter SBR**	**Output SBR**	**Abatement rate (%)**	
pH	7.64	7.79	-	7.73	7.89	-	6.5-8.5
EC (mS / cm)	22	1.1	**95**	23	3.5	**84.9**	2.7
SS (mg / l)	5200	90	**98.3**	6000	230	**96.2**	30
COD (mg of O_2 /l)	5912	120	**98**	6000	321	**94.7**	120
BOD_5 (mg of O_2 / l)	1500	39	**97.4**	1550	60	**96.1**	40
NH_4^+ (mg / l)	38.56	0.32	**99.2**	40.86	0.97	**97.6**	40
NO_3^- (mg / l)	26.3	0.86	**96.7**	28.67	1.56	**94.6**	40
PO_4^{3-}(mg / l)	3.14	0.21	**93.3**	2.89	0.9	**68.8**	2
SO_4^{2-}(mg / l)	2062	280.6	**86.4**	2598.4	496.7	**80.9**	500
S^{2-} (mg / l)	170.4	0.42	**99.8**	185.6	2.15	**98.8**	0.5

About table 9, we observe a slight increase in the pH for both loads. This increase was accompanied by a decrease of nitrate. This could be justified by the liberation of the OH group in the external environment during the denitrification (Cassellas et al, 2002).These results match those found by Faouzi (2012) et Elfadel (2012).

A reduction was revealed for the other parameters studied, with important abatement rates using a medium load as well as a high load.

The chemical oxygen demand (COD):

As regards a medium load, we obtained a reduction of 98% for COD with an average concentration (120 mg of O_2/l) which meets with the Moroccan standard of rejection. This abatement rate of COD is the same found by Moletta (1999), Corthando (2004) et Torrijos (1998), and who mentioned that the SBR system can remove 98% of the polluting load.

As for a high load, the COD abatement rate is 94.7% with a medium concentration of 321 mg of O_2/l, which is still greater than the standard. On the other hand. That abatement rate is higher than that found in literature (Ganesh et al, 2006). This difference could be attributed to the duration of the treatment cycle, hence our cycle lasted 24 H while this author (Ganesh et al, 2006) used only 12h as the treatment cycle.

These abatement rates of COD obtained by using a medium load and a high load, are higher than those found by the physicochemical methods including electrocoagulation (91%) (Shivayogimath et al, 2015), chemical coagulation (85-88%) (Song et al, 2003), and adsorption on activated carbon (71%) (Kanawade, 2014), then we can conclude that our SBR system more efficient and could replace these expensive techniques.

The biological oxygen demand (BOD_5):

The abatement rate of BOD_5 obtained ; using a medium load ; is 97.4% with an average concentration of 39 mg of O_2/ l, which corresponds to the Moroccan standard of rejection. Concerning the treatment by applying a high load, we obtained an abatement rate of 96.1% with an average concentration of 60 mg of O_2/ l, which is higher than the standard. In fact, these abatement rates correspond to those found by CPHEEO (2012), who found the removal rates ranging between 89 and 98% of BOD_5. However, they are higher than those found by Sundara Kumar (2010). This difference could be due to the nature of raw effluent and the duration of the treatment cycle.

The electrical conductivity (EC):

As regards the electric conductivity, the medium concentration (1.1 mS / cm) largely meets the Standard, with a removal rate of 95% by using an average load. Furthermore, we obtained an abatement rate of 84.9% with an average concentration (3.5 mS / cm) which is greater than the standard by applying a high load. As result, we obtained the important abatement rate by our biological process, whereas the chemical coagulation increases the concentration of the electrical conductivity by adding the coagulant (Tchamango et al, 2016), which ensures the efficiency of our system.

The suspended solids (SS):

When the suspended solids, we found the high abatement rate of 98.3% and 96.2% respectively for medium load and a high load. Despite these high removal rates, the average concentrations for medium and high load do not meet to the Moroccan standard. These abatement rates obtained are consistent with those found by CPHEEO (2012), who reported that the SBR process eliminates 85 to 97% of SS. In fact, our abatement rates found are higher compared to those found by Lefebvre (2005) et Faouzi (2012).

Indeed, the high abatement rates of COD, BOD_5, the EC and the SS obtained by applying a medium load or high load, would be related to the formation of decantable bacteria flocs or bioflocs matching to aggregates of bioflocullated microbes consisting of microbes, of inert particles, biodegradable particles and extracellular polymers. These bioflocs will contribute to the sludge settling and facilitate the solid / liquid separation. In the same way, they will absorb the organic compounds and therefore contribute to an increase in the performance of the SBR process in terms of COD and BOD_5 removal.

The nitrogen compounds:

Regarding the nitrogen forms, the abatement rate of ammonium ions and nitrate ions are very high by applying a medium load and a high load, which we obtained 99.2% and 96.7% respectively for ammonium ions and nitrate ions using a mediumload. When a high load, the removal rate is 97.6% and 94.6% for ammonium ions and nitrate ions respectively. However, our abatement rates are higher than those found by others Lefebvre (2005), Faouzi (2012) et Ganesh (2006). This difference could be related to the duration of the treatment cycle. Indeed, these important abatement rates can be explained by the extended aeration, which promotes the oxidation of the ammonium ion to nitrite ion and nitrate ion by the nitrification reaction.

This biological process is provided by nitrifying microorganisms (*Nitrosomonas, Nitrobacter, Nitrosolobus*, etc ....) into the sludge. In addition, during the decanting phase, an important part of nitrogen is removed by these organisms to ensure their clean metabolism, while another part of nitrogen is removed as nitrogen gas by facultative anaerobic flora such as *Pseudomonas denitrificans*. This denitrification requires a carbon source which can come either from the effluent to be treated (exogenous denitrification) (Metcalf, 1991) or a carbon source associated with the denitrifiers microorganisms (endogenous denitrification) (Christensen et al, 1978). Moreover, we had a denitrification in the aerobic thing that remains better compared to the anoxic in terms of the cost of a treatment plant and treatment of nitrogen-rich effluent.

The orthophosphates ions:

When the orthophosphate ions, a removal rate of 93.3% was obtained using a medium load, this is consistent with that found by other Lefebvre (2004). While a high load, we a obtained 68.8% as abatement rate. This result corresponds to that found by others, who found the removal rates of 57 to 69% of orthophosphate ions.

In fact, these removal rates could be related to the assimilation of orthophosphate by the sludge microorganisms (Lefebre et al, 2005; Sundara Kumar et al, 2010). Yet, an important dephosphatation requires the extension of the decanting phase (anaerobic), with prolongation of the aeration phase (Tsuneda et al, 2006). In addition, the average concentrations obtained by applying a medium load or a high load, respond to the Moroccan standard.

The sulfates and sulfides:

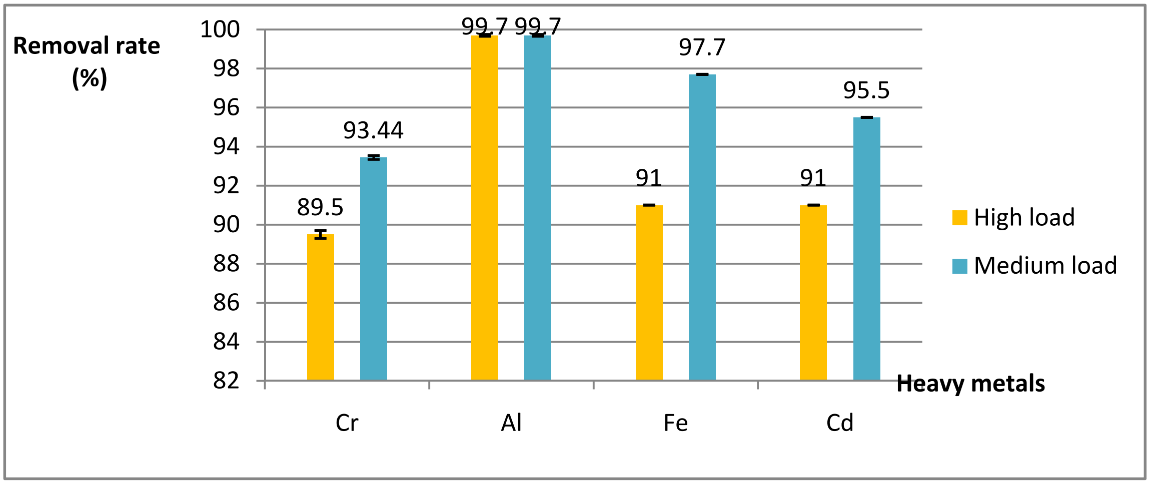
Concerning sulfates and sulphides, the reduction rates are 86.4% and 99.8% respectively for the SO_4^{2-} ions and S^{2-} ions by applying a medium load. When a high load, we obtained the following abatement rates: 80.9% and 98.8% for the SO_4^{2-} ions and S^{2-}ions respectively. These removal rates are higher than those found by chemical processes (Omor et al, 2017). Moreover, this reduction of sulfates and sulfides is probably due to the oxidation reaction of these ions by aerobic microorganisms or by anaerobic chemotrophic microorganisms including *Thiobacillus, Pseudomonas*. Indeed, these microorganisms use the inorganic carbon as a carbon and energy source for the oxidation of reduced mineral compounds (Widdel, 1988). Some microorganisms are oxidized sulphides to sulfates, while others are reduced sulfates to sulphides. The sulfates can be assimilated by the microorganisms, whose the transporter affinity for sulfate varies with their extracellular concentration (The affinity is greater at low concentration) (Boshoff, 2004).

In addition, the average concentrations of sulfates and sulfides meet the discharge standard when using a medium load, while that of sulphides is still greater than the rejection standard when applying a high load.

The Heavy metals:

As regards the removal rate of chromium (Figure 4), we obtained a very high abatement rate of 93.44% by applying a medium load, while a removal rate of 89.5% by applying a high load. Despite these abatement rates, the medium concentrations are slightly higher than the Moroccan standard. Indeed, these abatement rates are higher compared to those found by Sundara Kumar (2010) et Ansari (2007).

Figure 4: Abatement rate of heavy metals in medium and high load



This reduction could be related to the biosorption or bioaccumulation of this metal by the microorganism. As a result, the accumulation can be performed either by complexation, coordination, ion exchange, chelation, or adsorption (Kang et al, 2007).

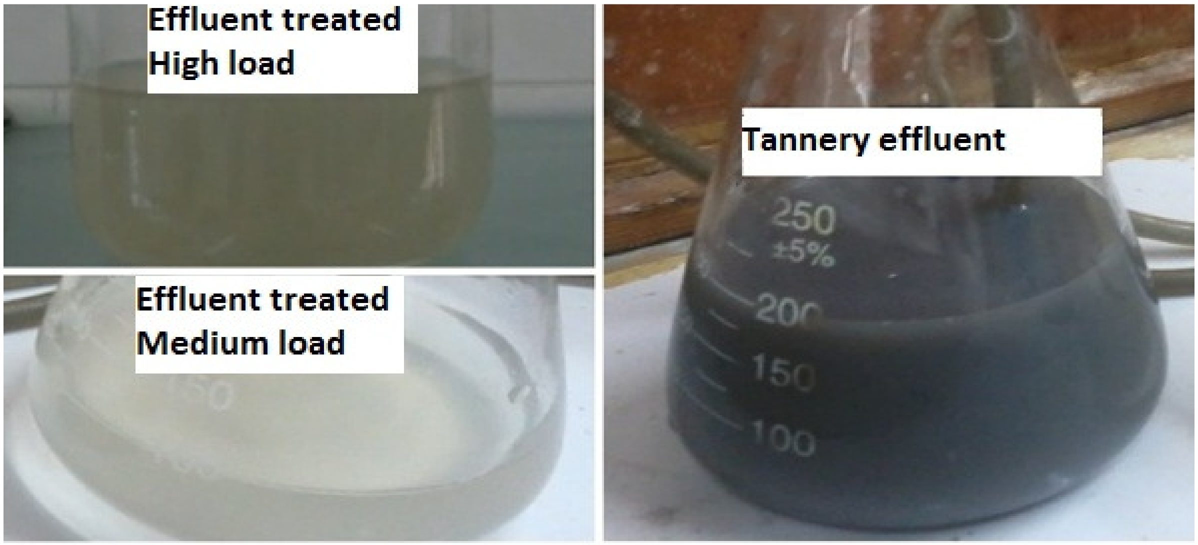
In particular, the walls and the envelopes of the bacteria and the fungi are the structures responsible for biosorption because they contain charged groups. Recently, several studies on the biosorption of heavy metals using the bacteria, the fungi, and the yeasts were developed (Jacques et al, 2007). Particularly, the bacteria *Bacillus licheniformis*, isolated from Hunan Province, in China, was used to trap the Cr (VI) at aqueous solutions (Jacques et al, 2007).

Discoloration:

After a spectral scanning, our effluent was strongly absorbed in 436 nm. This wavelength is comparable to that found by others (Aboulhassan, 2008; Tchamango et al, 2016).The color rate (Figure 5) obtained reached 93% and 88.5% respectively for a medium and a high load. These abatement rates are higher than those found by Song (2003) et Tchamango (2016) who used the chemical processes.

The color rates increases in parallel with the decrease of COD and SS for the two loads, this could be attributed to the performance of the sludge and their adaption with our effluent.

Figure 5: Color removal of the tannery effluent after processing by the SBR system for both loads



Conlusion

The physicochemical characterization and metallic of the tannery effluent of the Fez city revealed that this effluent does not meet the Moroccan standard of discharge in terms of the COD, the SS, the EC, the BOD_5, the SO_4^{2-} and S^{2-} ions, and the Cr. In fact, this characterization showed the toxicity of this effluent for the environment and the human health.

In the other hand, the treatment of tannery effluent by the biological process SBR ; by applying the medium and the high load ; showed a very important abatement for all the parameters studied with the medium than at the high load. Moreover, the important abatement rates were detected by the medium load, which we obtained 95%, 98%, 97.4%, 99.2%, 86.4%, 99.8%, 98.3 % and 93.4% respectively for the EC, COD, BOD_5, NH_4^+, the SO_4^{2-}, the S^{2-}, the SS and the chromium. Regarding the high load, we also obtained a very high abatements rate but the average concentrations of effluent treated ; for the majority of the parameters ; remain higher than the Moroccan standard of rejection.

Indeed, in order to complete this study and optimize the results obtained, it is necessary to study a low load or to couple this system with another chemical or physical system or to precede the pretreatment.

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