POLLUTION CHARACTERIZATION OF WASTE WATER OF AN INDUSTRIAL ZONE EXAMPLE OF A DAIRY WATER CLARIFICATION

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ABSTRACT

The objective of this study is the estimation of the polluting load generated by domestic effluents added to those of various industries in one of the most important industrial zone in Africa. Analysis of waste water showed strong and irregular pollution which is prejudicial for the aquatic receiving medium (river, sea). This pollution is confirmed among others by COD/BOD ratio which may attain the value of 1.8. Pre-treatment by coagulation floculation of waste water used in a dairy belonging to this industrial zone showed a considerable reduction of the initial pollution by a systematic decreasing of pollution parameters. Aluminium sulphates and iron chloride tested in this experience have reduced considerably all the studied parameters; the organic charge has received a very significant reduction up to 99%.

The discharge of treated effluent in the surrounding river or its use for recycling aims is then possible for this industry. However, the formed sludge can be the subject of a suitable treatment for possible agricultural, avicolous valorisation or other.

Keywords: characterization, clarification, coagulation, dairy, industrial, waste water

INTRODUCTION

The use and management of water is an acute problem for many countries in which annual rainfall is insufficient for a suitable socio-economic development. For Algeria, this problem is accentuated by its increasing industrialization, which requires a lot of water. For these reasons of lack and management of water, the Algerian water authority (Public institution production, management and distribution of water) can not provide regularly the same volume of water especially in drought periods. Therefore restrictions are sometimes imposed. To overcome this deficit in water, some companies have made their own wells. This inbalance between the offer and demand of water is aggravated by the no use of waste water by the majority of enterprises. These discharges cause a luckless pollution to the receiver environment (river, sea). In this study, the industrial zone of El-Hadjar of the littoral city in Annaba is chosen as the place of investigation, as it is known to be the biggest and the most diverse industrial pole in Africa.

The objective of this study is to evaluate on the one hand the pollution degree of the water discharge of this industrial zone by the analysis of various parameters which characterize waste water (Boeglin, 1999) and on the other hand, propose an example of pre-treatment of waste water of an industrial dairy that is adapted to the possibilities of the enterprise while preserving the criteria and norms of industrial spill (Boutin, 2001). Many authors agree to purify dairy discharges by a biological treatment because the nature of the spill is mainly organic (Moletta & Torrijos, 1999a ; Walker, 2001).

In this study, a physico-chemical type of pre-treatment (coagulation-flocculation-sedimentation) is tried for exploratory purposes. For this, three coagulants have been tested, aluminium sulphate, iron sulphate and ferric chloride with a synthesis adjuvant flocculation (poly electrolyte). The comparison of analysis of parameters pollution before and after pre-treatment of waste water will validate the adopted process of coagulation flocculation.

DATA CONCERNING THE INDUSTRIAL ZONE

Presentation of the industrial zone

The industrial zone of El-Hadjar is located along the north-east of Algerian coast, a few metres altitude over sea level and 10 km south of the city and seaport of Annaba. It is bypassed to the east by Seybouse Wadi, north west by the Meboudja Wadi and south by El-Rassoul Wadi. In this zone there is the small town of El-Hadjar with 35 000 inhabitants for a surface area of 62 km^2. The choice of site was motivated primarily by its proximity to the national highway leading to different localities, cities and production sectors. These sectors include a diverse group of private and state companies which are active in steel, cement, paper, plastics, food, *etc*…The industrial dairy is located 6 km south of the city on a terrain of 5 ha. It is chosen as the study zone, because this is the only company that dumps a load especially organic in common receptors, the wady of Meboudja then Seybouse. The irrigated perimeter of the "Bounamoussa" and the Algerian water authority, permit, by their proximity, to give an important contribution of water for human, industrial consumption and for agriculture.

Consumer and discharge of waste water

Given the immensity of the industrial zone and the massive and unceasing settlement of enterprises , establishment of a reliable census in regard to consumption and destination of water is not always obvious. However, Table 1 provided by the Algerian water authority (ADE, 2004) relates the volumes of water affected to the most important activities of sectors. It should be noted that these volumes are indicative and that many companies have made their own wells as is the case for the dairy industries. It can be noted also that for the small town of El-Hadjar, the average consumption of drinking water is about 100 litres per capita per day and that the distribution is discontinuous. The absence of reliable census of the overall consumption of water in this zone affects the knowledge of the volume of discharge. It must also be added that apart from big enterprises, many small companies recently installed are not connected to the drain. For the dairy, the ignorance of the volume of discharge is linked mainly to the irregularity in production of different workshops. Similarly, the flow rate of discharge at each workshop is not known because of obstruction of some drains. It is known however that 3.6 litres of waste water are poured for the production of one litre of milk

(Sachon, 1980). Based on this data and the average volume of production of the main workshops of milk and cheese (200 000 litres per day), the daily average of waste water is approximately 720 000 litres. The constitution of the industrial zone discharge is complex since it consists of urban effluent of the city of El-Hadjar, as well as water used by different companies. These waters contain suspended solids, oils and grease, mineral and organic dissolved matter, *etc*….

TABLE 1

Volume of Distributed Water by the Algerian Water Authority to Some Sectors of the Industrial Zone of El-Hadjar

Sector	Volume ($m^3.y^{-1}$)
El-Hadjar City	1 607 068
Steel (raw water)	6 752 027
Steel (treated water)	1 543 135
University services	277 619
Dairy	342 000

MATERIALS AND METHODS

Sampling

Because of the complexity, the multiplicity and diversity of discharges, it is difficult to make a judicious choice of sampling points. However, recognition of the net discharge of waste water allowed opting for three important levies points namely: a discharge of industrial dairy and two domestic and urban discharges from the city of El-Hadjar and its industrial fabric. These three privileged levies points are defined and symbolized by P1, P2, P3 in Figure 1 (CNERU, 1980). P1 corresponds to the domestic waste water of the entire industrial zone levied at last drain of the main collector which is about ten meters from the Meboudja wady. Sampling schedules have been possible from 6 to 16 h (almost flow is null from 17 h). Taking sediment was inevitable even during working hours. The recognition of the net showed several clogged drains so, only the partially filtered water can pass, which can change the character of existing water. P2 corresponds to the industrial waste water from the dairy taken in the last drain of the factory. The hourly sampling was realized from 6 to 24 hours, the water flow was important during the production (9 h to 16 h), the water level has exceeded the level of exit conduct probably caused by the blockage of some drains of workshops in the factory. At the beginning (5 h) and after the end of workstation (21 h), the water flow was low and water is clear. P3 corresponds to the urban waste water (including the municipal slaughterhouse) collected from the Meboudja wadi. The sampling schedule was possible 6 to 24 hours; despite a discontinued alimentation in the city with drinking water.

Broadly speaking, the levy of these three points, planned initially for a consecutive period of 24 h have been shortened to fewer hours when conditions did not allow a proper sampling. The reasons are related mainly to the low flow of discharge from certain hours or to unavoidable taking in some sediment samples even during working hours. In order to quantify and to characterize the degree of pollution of these discharges, a sampling campaign and measurements took place on March 26th 2004 which corresponds with a day of full activity. To control and confirm the repeatability of all measurements, other punctual levies which are corresponding to main collectors were taken whenever it was necessary throughout the year 2004 until June 2005.

For measurements of pH, dissolved oxygen, the samples were realized throughout the day at suitable times and specific to each sampling point. For the temperature, BOD, COD, the total dry matters (TDM), suspended solids matters (SSM) and sedimentation, the samples were promptly effectuated at the time the most representative for each of these parameters; the common schedules of levies are 8 h to BOD, COD and 15 h for SSM, TDM. For the coagulation-flocculation pre-treatment of dairy waters at point P2, the levy has been made during the same campaign on March 26, 2004, on an average sample of 50 litres, representing 24 hours of waste water discharge. All the aqueous samples are made possible through a standard manual sampler of 1 litre; the depth of the test taken was about 50 cm.

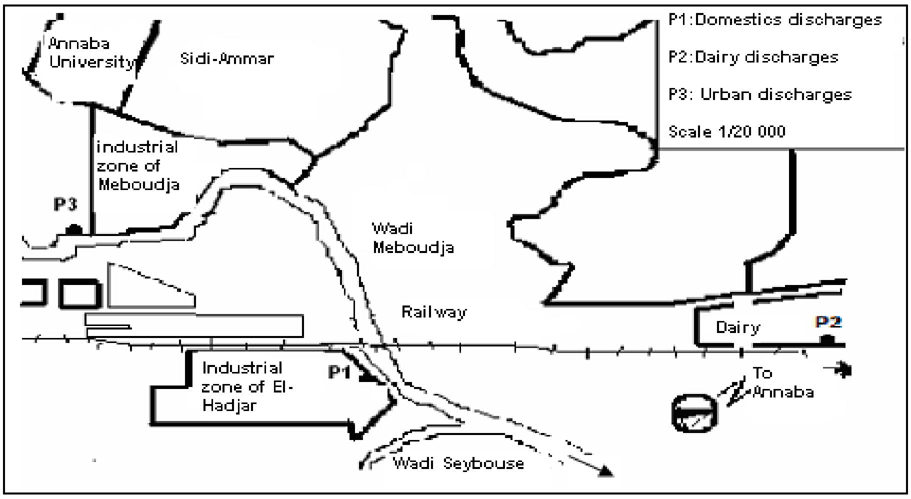

Figure 1. Location map of samples points of the industrial zone.

Analysis methodology

The organic load of discharge water and their fast biodegradation, all the parameters that may be affected have been analysed as soon as possible in accordance with standard analysis methods (AFNOR, 1986 ; Rodier, 1996). The total dry matters (TDM), dissolved

(DM) and suspended solid matter (SSM) are determined for the three levies; desiccation of samples at 105 °C allows by a difference weighing of initial and final masses to determine TDM which represents the sum of MD and SSM. The combustion of these same samples in an oven (Cyol.0251) previously heated at 600 °C can find the organic part and to deduct the studied portion of dry mineral matter. The analysis of these parameters with those of sedimentation, BOD for 5 days, the COD were made using the methods described by the French norm (AFNOR, 1986). Dissolved oxygen, pH and temperature were analysed on site using a multi-parameter portable analyzer (Consort C535, Belgium).

For testing coagulation-flocculation, the followed experimental protocol is jar test and it is the oldest, cheapest, simplest and, therefore, the most used (Bouyer and al., 2005**)**. This protocol consists in introducing in each beaker of a flocculator (Velp-Scientifica.C6F), 1L of water to be treated with increasing doses of coagulant and a flocculent. The purpose of these tests is to find the necessary and sufficient concentration of coagulant for a maximum clarification. The three tested coagulants are: $Al_2(SO_4)_3.18H_2O$, $Fe_2(SO_4)_3.18H_2O$, $FeCl_3.6H_2O$ prepared at a concentration of 2% ; Al^{3+} and Fe^{3+} being the coagulants agents. These coagulants were matched separately to a unique and constant concentration of adjuvant flocculation (polyelectrolyte SP6, KemWater, Helsingborg, Sweden) 1 $mg.L^{-1}$. The tests were conducted with a high speed fluctuator (200 $rounds.min^{-1}$) for 2 minutes after adding the coagulant and at slower speed (40 $rounds.min^{-1}$) for 17 minutes after adding the flocculent. At this stage, a minimum of 30 minutes for decanting is necessary for proper separation of the two phases (Bob & Walker, 2001). To justify the obtained results, a sample of water without adding products has been treated under the same operating conditions. The clarified samples are characterized again to evaluate the effectiveness of pre-treatment which was appreciated by analytically monitoring the reduction rate of all studied parameters.

The choice of parameters studied in this clarification, took into account the impact of constituents of used coagulants, the important turbidity linked to the initial organic load of water (BDO_5, CDO) and phosphorus as an eutrophying composed. The turbidity of the discharge or its degree of transparency was measured through a turbidimeter (Phywe System2100N GMBH, Germany). The sulphates, chlorides, phosphorus, aluminium and iron were measured, respectively, according to the French norm (AFNOR, 1986). An atomic absorption spectrometer (Perkin. Elmer 3110) was used for the two latter elements. All characterization analysis realised on an average of 4 tests per parameters, give an average error of ± 2% for the spectroscopic parameters and ± 6% for other parameters.

RESULTS AND DISCUSSION

Characterization of the industrial zone waters

pH and temperature

The average values of pH for waste water of different sampling points are between 6 and 8 (Figure 2). Exceptionally for the dairy, there are, occasionally, extreme values of 3 and 10 in pH units. These values are linked to an overdose of acido-basic in cleaning products (Merin *et al*., 2002), an insufficient rinsing of production equipment and natural bacterial acidification of milk and whey. This range of pH is prejudicial to the environment and the cement net. According to Meinck *et al*. (1977), it will also have luckless consequences on aquatic flora in which a growth pH is between 6.0 and 7.2. The temperature is between 20.0 and 23.5°C for the P1, 21,4 and 30.0°C for P2 and 21.0 to 25.8°C for P3. These values of temperature meet the Algerian norm of industrial discharge which is 30 °C (JORA, 2006). However, at the end of the workstation the dairy presents a temperature of 32°C, which is due to the warm water used in washing production equipments. This temperature accelerates the process of acidification by fermentation of the lactose into lactic acid and promotes the formation of an important bacterial biomass. The high temperature slows the aquatic life; the vital activities of many organisms is greatly affected (Meinck *et al*., 1977; Sachon, 1980).

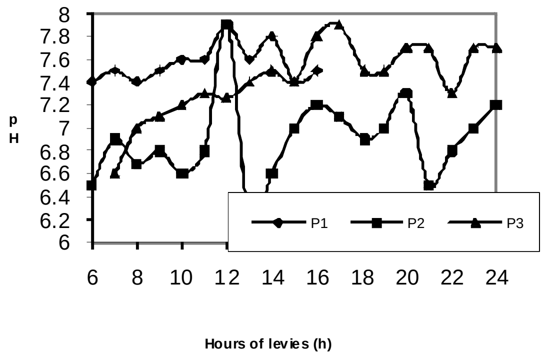

Figure 2. Average evolution of water pH at levies points.

Dry matter and sedimentation

Table 2 shows that for the sampling point P1, SSM are 280 mg.L^{-1}, annealed losses are around to 46 %; the dissolved matters are 657 mg.L^{-1}; a loss of 34 % at 600 °C indicates a preponderance of minerals *versus* the dissolved organic matters. For the P2 the content of SSM is 598 mg.L^{-1} with about 95 % of losses at 600°C, which would explain the excess of organic matter justified by the nature of dairy discharges. For P3, the obtained values show a high content of soluble inorganic (~50%) and organic matter (~50%). As the sedimentation of SSM, which are all above the norm of Algeria (30 mg.L^{-1}), it is after 2 hours from 3.8m L.L^{-1} for P1, 12m L.L^{-1} for P2 and 0.7m L.L^{-1} for P3 (Figure 3). Sedimentation is fast, 50 to 80 % of SSM are deposited between 15 and 30 min; settling of fine particles is observed after 2 hours. The presence of these SSM in the various discharges may significantly compromise the functioning of the sewerage by frequent blockage at the level of drains; on the other hand it can cause nuisances such as deposits of mud and silt in aquatic receivers; these sludge are luckless to maintaining equilibrium and the life of the ecosystem (Meinck *et al*., 1977; Sachon, 1980 ; Badia Gondard, 1996).

TABLE 2

Averages of Dry Matter from Levies Points

Dries matter	DM ($mg.L^{-1}$)			SSM ($mg.L^{-1}$)			TDM ($mg.L^{-1}$)		
	P1	P2	P3	P1	P2	P3	P1	P2	P3
Dry residue at 105°C (total)	657	1492	1205	280	598	87	937	2090	1292
Dry residue (mineral)	434	827	660	151	30	19	585	857	679
Losses at 600°C (organic)	223	664	545	129	568	68	352	1233	613

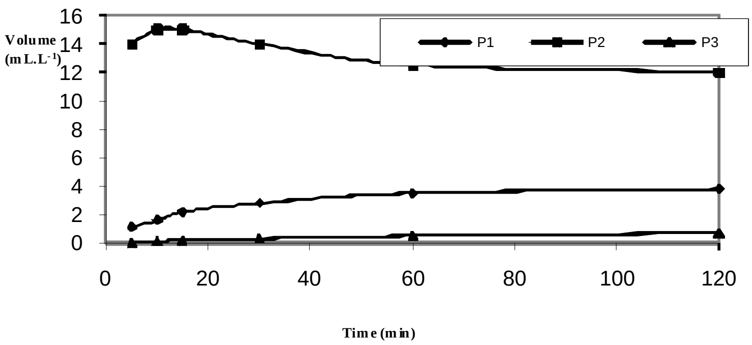

Figure 3. Average sedimentation of levies.

Dissolved oxygen

The analysis of dissolved oxygen showed the irregular tenor, and they range from 1.6 to 8.3 $mg.L^{-1}$ (Figure 4). The sudden increase of oxygen observed in P2 and P3 is probably linked to an arrival of cleaning water, rich in dissolved oxygen. This increase is very significant for the dairy levies. Point P1 shows for domestic water a strong drop of dissolved oxygen from 4.7 to 1.6 $mg.L^{-1}$, characterizing an arrival of waste water that is rich with dissolved organic matter. In all cases, the obtained tenor of oxygen may fall as soon as the degradation of organic matter and the multiplication of aerobic micro-organisms has began. Concentration of dissolved oxygen between 2.5 to 3 $mg.L^{-1}$ is detrimental to the life of fish (Meinck *et al.*, 1977).

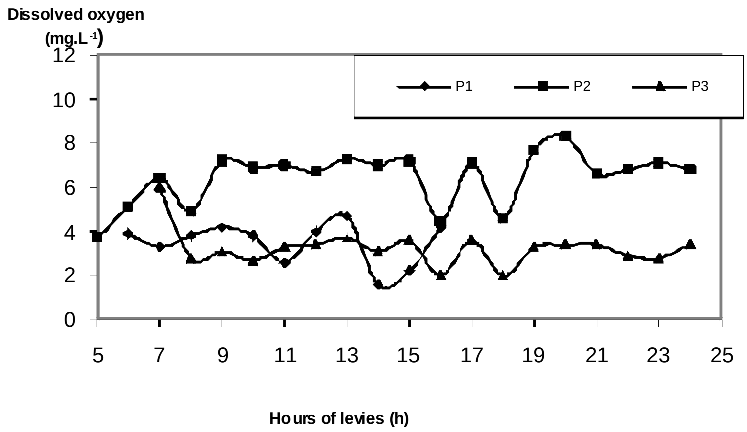

Figure 4. Average evolution of water's dissolved oxygen in levies points.

Biological and chemical demand of oxygen (BOD and COD)

For the sampling point P1, the analysis results (Figure 5 and Table 3) show a heavy load expressed in BOD and COD. It is noteworthy that the found values are high compared with domestic waste water of industrial zones in Algeria and can be classified as an urban type of waste water heavily polluted. In addition, the determination of COD and BO_5D on a composite sample after 2 h of sedimentation shows a purification effect around 27% (COD) and 25% (BOD). For point P2, the BOD and COD values are significant for organic load which is the most important compared to P1 and P3. The reduction of this load of sediment after 2 h gave 49% (COD) and 26 % (BOD). The ratio COD/ BOD is 1,81, it indicates a high pollution load. This ratio is comparable with those of the majority of dairy industries in which the relationships are between 1.5 and 2; the production of dairy products influence the evolution of these ratio (Sachon, 1980; Moletta & Torrijos, 1999b). For P3, the slaughterhouse discharge is the principal cause of the rise of the organic load; reduction of COD and BOD after 2 h of sedimentation are low, 8 % and 3 %. These poor results are probably related to the water discharge and blood forming a colloidal organic mixture which can be difficulty decantable.

Clarification pre-treatment by coagulation-flocculation

For this study, the pre-treatment of dairy waste water by a physico-chemical process was opted for: coagulation-flocculation, as the matrix of this discharge is easier to identify than for the points P1 and P3. On the other hand, the pollution load expressed by the ratio COD/BOD is the most important. The clarification pre-treatment proposed aims to reduce the pollution load in accordance with the Algerians norms of industrial discharge and taking into account the possibilities and interests of the company.

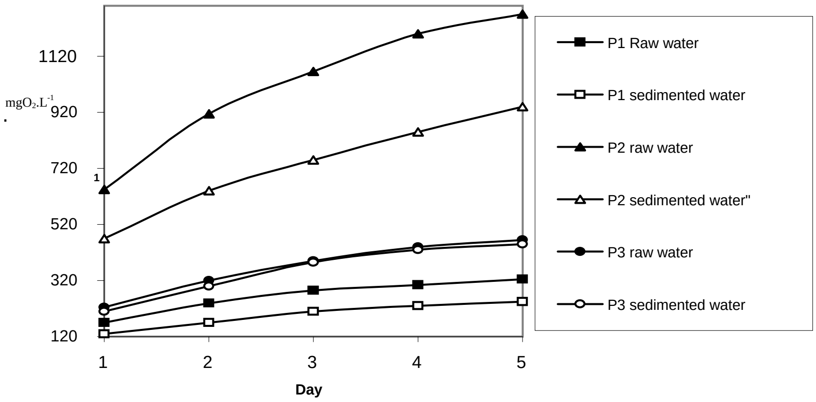

Figure 5. BOD meter of raw and sedimented levies.

TABLE 3

Average Expression of Organic Load from Sedimented (PS) and Raw Water Levies (PB)

Levies points	P1		P2		P3	
	PB	PS	PB	PS	PB	PS
COD ($mg.L^{-1}$)	520	390	2300	1180	760	700
BOD ($mg.L^{-1}$)	325	245	1270	940	465	450
COD/BOD	1,60	1,55	1,81	1,25	1,63	1,55

The regrouped results in Figure 6 show that the employed coagulants give a clarifying efficiency of waste water of about 99 %. The optimal concentrations of coagulant are 200 $mg.L^{-1}$ for the ferric chloride (0.74 mmol $Fe^{3+}.L^{-1}$), 400 $mg.L^{-1}$ for the ferric sulphate (0.41 mmol $Fe^{3+}.L^{-1}$), 600 $mg.L^{-1}$ for aluminium sulphate (0.45 mmol $Al^{3+}.L^{-1}$). Ferric sulphate seems to be the most effective in reducing the initial turbidity. However, this coagulant induces a coloration of water by iron. Therefore the aluminium sulphate is a better coagulant and would be adopted in this study. For all these experiments, the volume of sludge is between 200 and 250 $mL.L^{-1}$ after 30 minutes of settling. It is obvious that the high volume of mud contains a decantable colloidal and particulate fraction removed from the waste water of the dairy, including organic matter, phosphorus, but also a quantity of chemical reagents (precipitates of coagulants, reagents disinfection). Contrary to the urban and industrial sludge, dairy sludge is devoid of toxic substances (Vidou, 1984). Indeed, this type of mud instead of being incinerated or land filled, could be valorised and used for agricultural purposes. However, the high concentration of bacteria in this sludge limits its application in soils, thus the interest of refinement (Hansen *et al*., 1994). In this respect, it should be noted that the successful impact of liming of the treated effluent, increases the pH and inhibits the fermentation of sludge (Guettier *et al*., 1994). On the other hand all the curves in Figure 6, have the same appearance: they have an ascending part which corresponds to the coagulation and the formation of flocs (clarification). Once the optimum is reached, there is a descending part which corresponds to the destabilization of formed flocs with an increase in turbidity. Kemira Kemi, 1990 precise that the effectiveness of coagulation is obtained from pH 5 to 9 for ferric sulphate and 4.5 to 9.0 for aluminium sulphate. This idea with chemical equations (1 and 2) can help to explain the shape of curves.

$$Al_2(SO_4)_3,18\ H_2O \xrightarrow[H_2O]{} 2Al^{3+} + 3SO_4^{2-} \text{ then } Al^{3+} + 3H_2O \longrightarrow Al(OH)_3 + 3H^+ \quad (1)$$

$$FeCl_3 \xrightarrow[H_2O]{} Fe^{3+} + 3Cl^- \text{ then } Fe^{3+} + 3Cl^- + 3H_2O \longrightarrow Fe(OH)_3 + 3H^+ + 3Cl^- \quad (2)$$

Indeed, in their ascending parts, measured pH range from 7.0 to 5.7 (optimum). These pH are suitable for the formation of insoluble aluminium and iron hydroxide ($Al(OH)_3$), ($Fe(OH)_3$). These hydroxides form flocs which by decanting helps to clarify more the waste water (scanning effect). The use of acidic salts, the increasing concentration of coagulant above the optimum shifts significantly the pH to acid values. The measured pH fall to 2,8 for ferric sulphate and ferric chloride. According to the solubility diagram of aluminium and iron which depends on the pH, these metal forms exist at pH values measured in this descending part of the curve; the hydroxides forms of these metals and their precipitates start to form from a pH of 4 (Cathalifaud *et al*., 1997). Thus it can be said that the increasing concentration of coagulant beyond the optimum promotes the phenomenon of restabilisation of colloids by adsorption and neutralization of the charges. The overdose of coagulant, which is a source of cations, may result in too important adsorption of cation and reverse the charge of particles, which becomes positive. The particles would restabilise and turbidity tends to increase (Amirtharajah & O'Melia, 1990; Dentel, 1988). At the interface solid / liquid the colloidal particles or electric double layer, the repulsion forces between particles would be considerably increased while the Vander Waals forces of attraction are affected (Randtke, 1988). On the other hand, the second imprisonment phenomenon of the negative colloidal particles in the positive precipitated or positive flocs of hydroxide metal can't be realized (Chowdhury & Amy, 1991). The pH medium becomes highly acidic. Under these conditions, salts and coagulants' solubility is very high. In addition, Amirtharajah and O'Melia (1990), showed that a high concentration of polymers can restabilize the colloids. That is why the employed flocculent has been introduced with coagulants at feeble and constant concentration (1ppm). This discussion of restabilisation phenomenon of the colloids supports the lower efficiency obtained at the highest concentrations of coagulant (beyond the optimum). The drop in pH of the medium (from 6.8 to 7.1) and consumption of alkalinity (from 210 to 220 mg $CaCO_3.L^{-1}$) by the coagulants are related. In effect, during the introduction of coagulants, the pH of the medium decreases to attain at the optimal concentrations, an average value of (5.1). Adding coagulant drops pH to an average value of 2.8 (beyond 1 mmol.L^{-1} Al^{3+} or Fe^{3+}). The fall of pH translates the loss of alkalinity (Julien, 1983; Tseng *et al*., 2000). According to classical data, alkalinity decrease indicates that 1 mg.L^{-1} of alum reacts with 0.5 mg $CaCO_3.L^{-1}$. For these tests, alkalinity and pH decrease depending on the addition of coagulant. At the optimum clarification and beyond, there is a residual alkalinity from 5 to 10 mg $CaCO_3.L^{-1}$ whatever for adding of Al^{3+} or Fe^{3+}. Tseng (2000) found that demand for aluminium sulphate used to reduce the turbidity of a natural water increased proportionately with the concentration of alkalinity and that, beyond the critical concentration of clarification, persists the residual alkalinity which maintains the equilibrium of calcium carbonate of water. This explanation is in the same direction as that found and given by reactions (3), (4), and (5).

$$Me^{3+} + 3H_2O \longrightarrow \underline{Me(OH)_3} \downarrow + 3H^+ \quad (3)$$

The pH is very important in the coagulation process; the alkalinity has a buffering effect and does not react directly with the coagulant (Me^{3+}):

$$3\,HCO_3^- + 3H^+ \longrightarrow 3H_2CO_3 \quad (4)$$

$$Me^{3+} + 3\,HCO_3^- + 3H_2O \longrightarrow Me(OH)_3 + \underline{3H_2CO_3} \downarrow \quad (5)$$

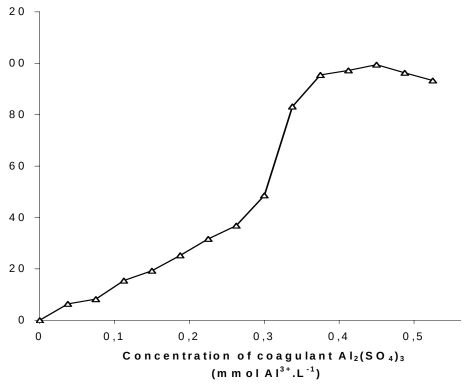

Figure 6a.

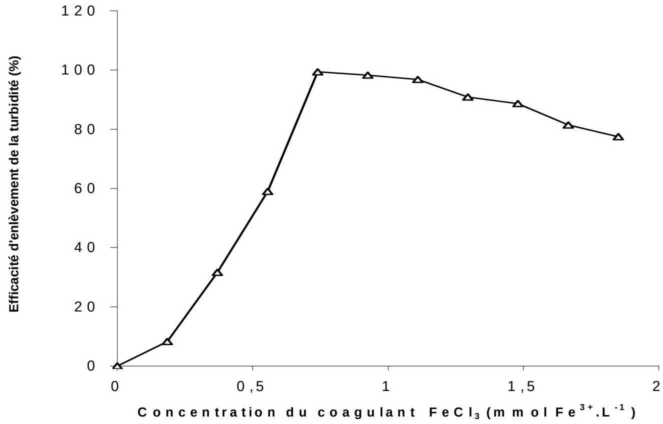

Figure 6b.

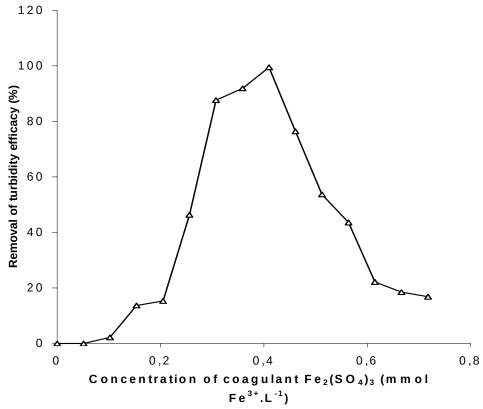

Figure 6 c.

Figure 6. Effectiveness of tested coagulants in relation to the turbidity parameter.

TABLE 4

Results of Physico-Chemical Analyses of Clarified Water

Element	Waste water	Clarified water 0,45 mmol $Al^{3+}.L^{-1}$	Clarified water 0,74 mmol $Fe^{3+}.L^{-1}$	Algerian norm of industrial discharge
Iron ($mg.L^{-1}$)	0.39	0.43	1.65	5
Aluminium ($mg.L^{-1}$)	0.10	1.37	0.19	5
Chlorides ($mg.L^{-1}$)	1598	1538	1762	1200
Sulphates ($mg.L^{-1}$)	118	393	169	1000
Phosphorus($mg.L^{-1}$)	36,3	9,3	12,4	10
BOD ($mgO_2.L^{-1}$)	1270	8	6	40
COD ($mgO_2.L^{-1}$)	2300	39	37	120
Turbidity (UTN)	1037	5,6	6,3	-

Analysis of clarified water

In this evaluating study of the effectiveness of the pre-treatment, the tests are oriented on aluminium sulphate and ferric chloride for their frequent employment in water treatment. The overall comparison of analytical results of clarified and waste water for the chosen parameters and the used coagulants for this purpose, show that, apart phosphorus, which gets an interesting reduction of approximately 70 %, all other studied metallic or minerals elements get an increase (Table 4). Their concentration stays below the Algerian norms of industrial discharge (JORA, 2006). Finally, comparing the organic load with reference to BOD and COD only, there is a very significant reduction (about 99 %) which is comparable with the final turbidity of the consumption water. This considerable reduction of organic matter with this type of coagulants and many others, is well confirmed on some urban and industrial waste water (Randtke, 1988; Robert & Sheldon, 1996; Zoubilis & Traskas, 2005). The reduction of this organic and mineral matter from waste water passes in general by widely studied mechanisms and cited by various references, which are trapping, adsorption, neutralization / destabilization of charges and complexation / precipitation (Amirtharajah & Mills, 1982; Rahni & Legube, 1995).

CONCLUSION

This work was given to evaluate the degree of pollution generated by the effluent waste water from the industrial zone of El-Hadjar and to propose a clarification pre-treatment by coagulation-flocculation to a dairy. The characterization results of discharges show a significant pollution load expressed in particular by the BOD, COD among other parameters. The chosen pre-treatment of clarification showed that the three tested coagulants give an efficiency of clarifying waste water of about 99 %, compared to the parameter of the turbidity generally taken as a reference in this type of test. But the aluminium sulphate gives the best result because of its frequent use in water treatment and the low concentration needed (0,45 mmol $Al^{3+}.L^{-1}$).

A techno-economic study would be desirable to validate the use of one or other coagulants. However, the volume of 200 to 250 $mL.L^{-1}$ of formed sludge as a result of this pre-treatment, raises a problem concerning the use and performance of this process. This concern would require an indispensable physico-chemical and bacteriological knowledge and appropriate treatment before suggesting any possibility of valorisation and application of this sludge in agriculture, energy recovery or otherwise. The overall comparison of analysis results of clarified and waste water for the chosen parameters and the used coagulants to this effect has shown a good reduction of the initial pollution. The best results were obtained for phosphorus ~ 70 % and 99 % for BOD and COD. Finally, in accordance with the existing Algerian norms, it can be deduced that the obtained clarified water is very acceptable for an industrial use in respect to all the analyzed parameters. This example of pre-treatment could then be tested again and, why not, be extrapolated to the entire industrial zone. For a refining treatment, it would be necessary to go through a biological treatment which will complete the essential step of the proposed coagulation-flocculation pre-treatment.

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