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# The physico-chemical treatment by coagulation-flocculation releases of slaughterhouse wastewater in the city of Rabat (Morocco)

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**ABSTRACT**

*Water is an essential element in the food industry. The resulting wastewater is often returned to the natural environment without treatment; this can be a major source of pollution to the environment. Among these food processing industries, there are slaughterhouses that are classified as dangerous, unhealthy and uncomfortable so treatment of their discharges is required prior to discharge. This work is primarily to recommend a suitable physical-chemical treatment flocculation by coagulation using ferric chloride ($FeCl_3$) as a chemical coagulant. The Jar-test tests were used to find the optimal conditions that reduce suspended solids. The results obtained after decantation show a degree of removal of suspended solids of about 98%. The resulting experimental equation for the correlation between the time of settling and the height of the sedimentation column was validated according to the law of Kynch.*

**Keywords**: Waste water, physical-chemical treatment, settling, JAR Test, Kynch law.

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## INTRODUCTION

In recent years, the red meat slaughterhouse sector has experienced great expansion in the world. All conditions are met to allow this industry to continue its development. However, this industry is among the most polluting because of the large amounts of waste water. The effluents of these slaughterhouses are characteristic and require appropriate treatment (separation of solid waste and fat, specific treatments).

The use of physicochemical processes such as the process of coagulation-flocculation for removal of suspended matter and color, primarily provided by the organic materials with insoluble forms seems to be the most suitable [1]. In this study, we followed the treatment efficiency of the slaughterhouse rejected by the coagulation-flocculation process followed by settling in determining the optimal dose of coagulant $FeCl_3$. Process modeling of settling was established by the method of Kynch.

## MATERIALS AND METHODS

### *Site study*

The city of Rabat, capital of the kingdom, is a coastal city situated on the left bank of the estuary of the Bouregreg, extended over an area of 118.5 $km^2$ [1]. It has a municipal slaughterhouse whose opening date is 1956, covers an area of 1800 $m^2$, it is part of traditional municipal slaughterhouses, it is located in one of the neighborhoods (Yacoub Al Mansour district) Top capital (Figure 1). According to statistical data of 2014, the production of red meat is 787,835 tons, 82% of sheep origin, 16% of origin cattle and goats 2 % original. Discharges from wastewater is quite loaded by solid waste , grease materials , with plenty of organic matter ( debris rumen) and a relatively high concentration of the blood of slaughtered animals [3].


**Figure 1: Block diagram of the slaughterhouse in the city of Rabat**

***Sample***

To characterize wastewater from slaughterhouse, the sample was taken at the global rejection of the slaughterhouse Yacoub Al Mansour (Figure.2).

This release includes:

The blood diluted with soil washing water during slaughter operation

The bellies of the wash water and the content of stomachs during the evisceration operation,

The waters of the great cleaning rooms at the end of the slaughtering operation.

**Figure 2: Total rejection of the slaughterhouse Yacoub Al Mansour**

***Characterization of releases***

Wastewater Rabat slaughterhouse were characterized by different physicochemical parameters (T °C, pH, Conductivity, Suspended Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand). The pH and temperature were determined by a pH meter 206 Lutron provided with a probe measuring the temperature. The electrical conductivity was measured by a type of conductivity meter WTW LF90, while turbidity was measured by a turbidimeter HACH 21009. The SS (suspended solids) are determined by filtration filter. COD is determined by the oxidation in an acid medium by excess potassium dichromate at a temperature of 148 °C oxidizable material under the conditions of the assay in the presence of silver sulfate as a catalyst and mercury sulfate [4] and $BOD_5$ is determined by the breathing method using a meter-mark BOD WTW OxiTop, according to DIN described by technique[5].

***JAR-Test***

Coagulation-Flocculation is a physico-chemical method of treating sewage, water. It consists of a row of beakers aligned in an apparatus for stirring at the same speed. The coagulant used is ferric chloride ($FeCl_3$) at increasing concentrations (0.1g, 0.2g, 0.4g, 0.5g and 0.6g) per liter. Coagulation is done at a speed of 120 rev / min for 30

seconds, and thenreducesthis stirring at 40 revolutions/min for 20 minutes to flocculation [6]. Two hours after stopping the stirring, the supernatant samples were analyzed. Similarly, several tests were conducted at different concentrations of coagulant which aims to determine the optimum dose of coagulant (Figure 3).

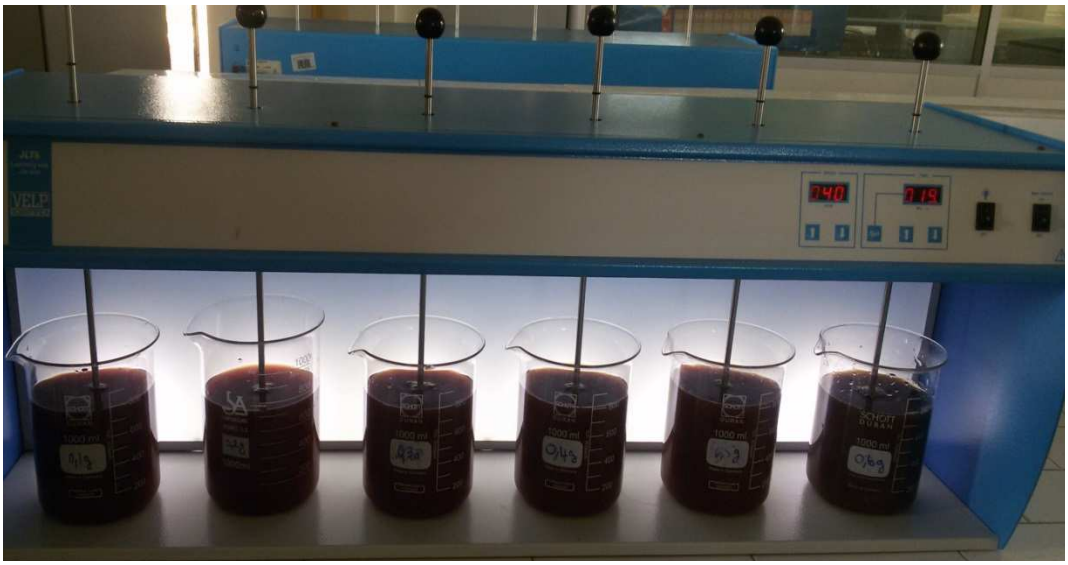

**Figure 3: Jar- test performed by the $FeCl_3$ coagulant for waste water slaughterhouse**

***Settling***

One goal of settling tests was determined the relationship that connects the sedimentation rate and the local solid concentration at the interface. After coagulation-flocculation test, suspended solids agglomerate and fall rate varies during the settling on the assumption of Kynch. This speed depends only on the initial concentration. Settling is characterized by a sharp interface between the sludge blanket and the clarified water [7].

## RESULTS AND DISCUSSION

***Treatment by JAR test***

The experimental tests of coagulation-flocculation allow the decrease in turbidity, which is due to the presence of suspended solids. The assessment of the abundance of these materials measuring the degree of turbidity. Turbidity measurements of the supernatant thus have an interest in monitoring the treatment. These measurements show that the turbidity varies with the concentration of $FeCl_3$ (Figure.4). It is optimal and order 11 NTU at a concentration of 0.5 g/L of $FeCl_3$ with a better yield of settling the order of 98% (Table 1).

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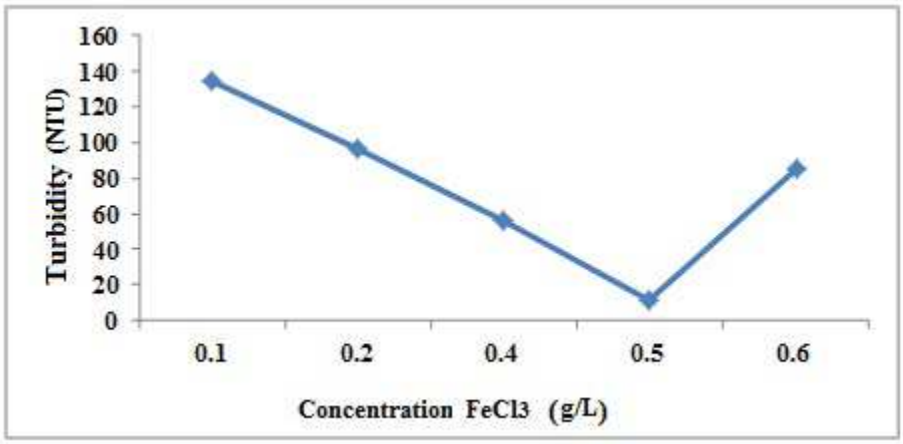


**Figure 4: Change in turbidity as a function of the concentration of the coagulant (Ferric chloride $FeCl_3$, 6 H2O)**

A decrease in pH in the concentration 0.5 g/L (Figure 5), it is in the range of Moroccan standards of water quality for irrigation and in the meantime indirect discharge limits (Table1).

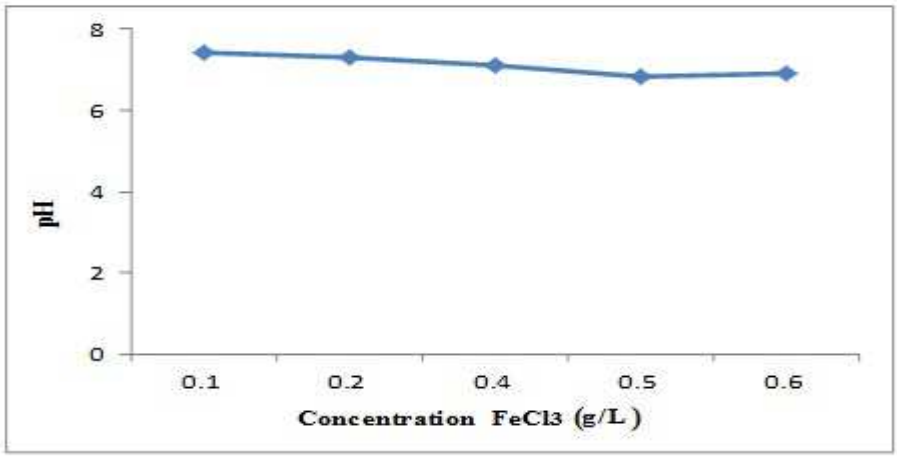


**Figure 5: pH Variation of the concentration of the coagulant (Ferric chloride $FeCl_3$,6H2O)**

The conductivity has been an increase in the concentration of 0.6 g / L which is due to the presence of chloride ions from the coagulant $FeCl_3$ (Figure 6). Comparing the values of electrical conductivity in treated wastewater with the standards of quality of water intended for irrigation can be deduced that the waste water is acceptable for crop irrigation. Similarly, these values remain below the limit value (2700 microseconds / cm) for direct discharge into the receiving environment[8].

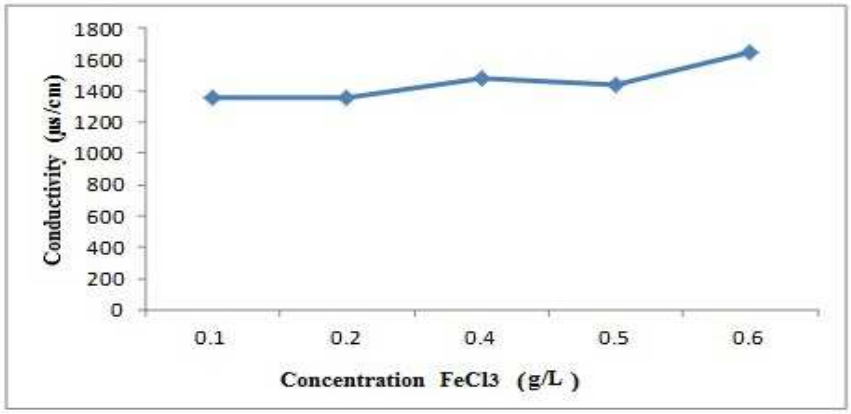


**Figure 6: Change in conductivity depending on the concentration of the coagulant (Ferric chloride $FeCl_3$, 6H2O)**

Analysis of the results of MES, studied shows that wastewater is characterized by a concentration often linked to heavy load of organic and inorganic materials. TSS values after treatment with Jar Test acceptable standards of water for irrigation (2000 mg / l)[8].

The analysis of raw sewage shows high levels of $BOD_5$ and COD: this water so can not be released into the environment without any treatment. After physicochemical treatment by coagulation flocculation, the wastewater undergoes a significant reduction in COD who spent 1500 mg / l to 790 mg / l and $BOD_5$ which declined by 580 mg / l to 310 mg /l, these values are consistent with the value set by Moroccan standards of indirect discharge. The purifying performance of $BOD_5$ is 46% and the COD is 47% (Table 1).

**Table 1: Physico-chemical characterization of wastewater Rabat slaughterhouse before and after the test JAR test and indirect discharge standards (waste water) or water for crop irrigation [8]**

| Parametre | Before | After | Indirect discharge standards | Water for crop irrigation |
|---|---|---|---|---|
| T°C | 16.8 | 18,4 | 30°C | 35°C |
| pH | 7,76 | 6,52 | 6,5-8,51 | 6,5-8,51 |
| Turbidity (NTU) | 622 | 11 | - | - |
| Electrical conductivity(µs/cm) | 1296 | 1442 | - | 8,7 ms/Cm |
| $BOD_5$ (mg/l) | 580 | 310 | 500 mg/l | - |
| COD (mg/l) | 1500 | 790 | 1000 mg/l | - |
| MES (mg/l) | 960 | 620 | 600 mg/l | 2000 mg/l |

***Settling***

The characteristics of Kynch or concentration law must propagate either from the origin of the plot in relation to a time of height, or tangentially from the place of the compression or suspension of sediments [9 -13].

In our work, the study of the settling was conducted by monitoring the fluid / mud interface. The descent of this interface over time to distinguish four different zones. From these areas, Kynch could draw a curve that determines the settling velocity. The accuracy of our figures is justified by the correlation coefficients (R) as estimates will be adjusted based on the least square method. Monitoring the height of liquid / slurry with time allowed to draw the following curve (Figure 7).

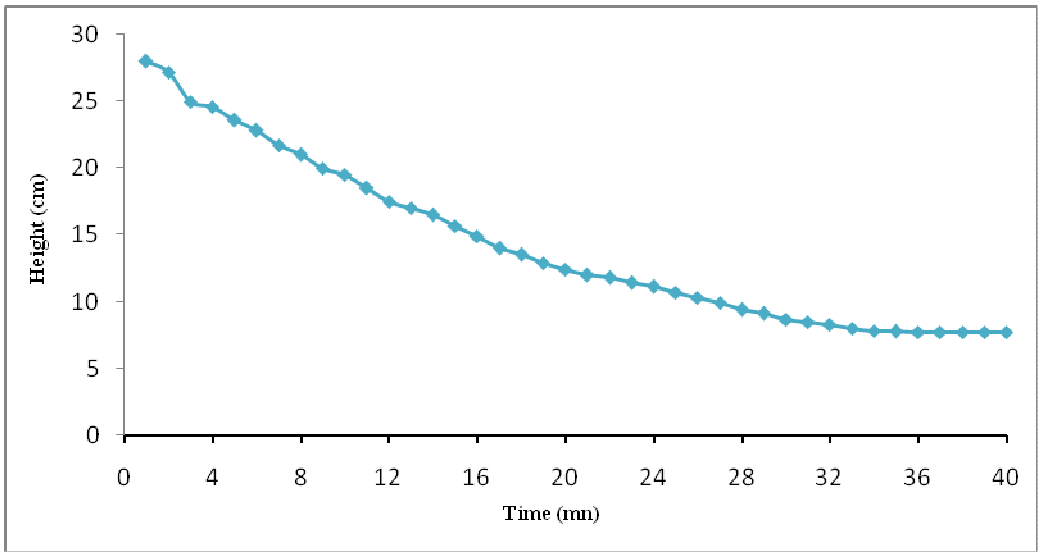


**Figure 7: Experimental curve after settling JAR test treatment Kynch**

The curve is characterized by a portion in the form of arch (Figure 8A) and another linear portion (Figure 8B). The first part is approximated by an exponential function and the second part by a linear function.

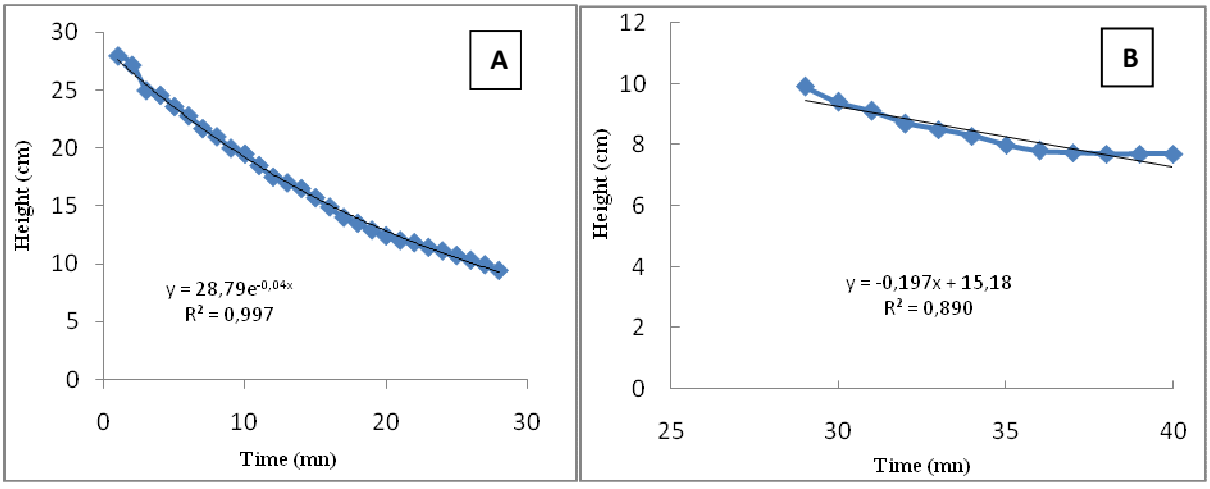


**Figure 8: Exponential part (A) and linear Part (B) of the curve Kynch**

By the method of least squares, the straight portion admits as function Hi = -at + b and vaulted portion admits the function Hi = $\lambda e^{-\alpha.t}$ + h∞, h∞ represents the height when t (time) goes to infinity at the end of the settling .The accuracy of our calculations is justified by calculating the correlation coefficient for the linear part as to the part in vault.

The equation of the linear portion is hi = + 15.189 -0, 1974.t with a correlation coefficient of R = 94% and the equation of the arch portion is hi = 28,792.e $^{-0,04t}$ with a coefficient of correlation R = 99%.

We find a match between the two curves: theoretical and the experimental (Figure9).

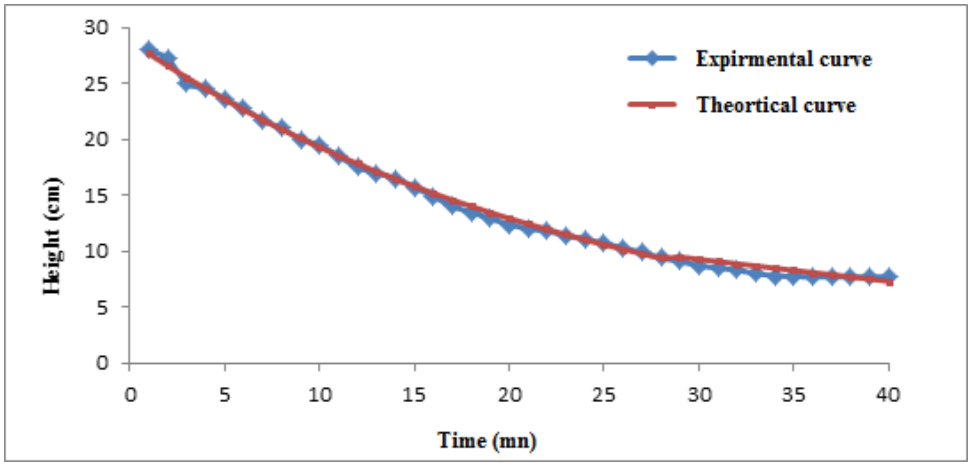


**Figure 9: Height versus time "Experimental and theoretical"**

The approximation is clearly visible after juxtaposition of both theoretical and experimental curves representing the heights versus time. Thus, it was possible to verify experimentally the fundamental assumption of Kynch. The operation of the settling curve enables the calculation on the one hand the decantation speed and on the other hand, concentrations.

## CONCLUSION

Assessing the degree of organic pollution allowed us to define the quality of wastewater Rabat slaughterhouse. The physicochemical characterization of these waters showed a neutral pH, conductivity variable, a very significant decrease in turbidity and suspended solids that can be mineralized with COD/$BOD_5$ in the order of 2.5 which indicates that wastewater discharged are biodegradable. To improve the quality of discharged water, sewage treatment plants should be installed to reduce the degree of local pollution and allow water reuse for irrigation of gardens and agricultural fields.

The wastewater from slaughterhouse by coagulation-flocculation followed by decantation yielded a clarified supernatant liquid, using ferric chloride $FeCl_3$ as chemical coagulant; performance decanting can reach 98%.

The increasing of the concentration of the coagulant causes a supernatant volume decrease and an increase in mud volume.

Monitoring the evolution of the liquid / slurry over time and operation of the settling curve (height versus time) to determine the settling velocity of a particle and concentration. Thus the law of Kynch has been verified experimentally.

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