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CHARACTERIZATION AND METHODS OF TREATING WASTE WATER FROM THE CITY OF TIFLET

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ABSTRACT

Over the last few decades, the standard of living and particularly the health conditions of the population of the town of Tiflet has undergone a major transformation contributing significantly to an unprecedented population explosion. This conversion to urbanization has not been without negative impact on the environment, due to the disposal of colossal quantities of untreated waste water in Oued Tiflet and its use in agriculture. In this context, and in order to preserve the city's environment, the search for a wastewater treatment process has become a major concern.

The objective of this work is to evaluate the pollution rate of the city's wastewater by elaborating specific bacteriological and physico-chemical parameters. Our results showed that these parameters are far from complying with the standards set by the public authorities in terms of irrigation and discharge of wastewater into the natural environment.

Moreover, this study shows that the coagulation-flocculation treatment process using FeCl3 allows a better efficiency in terms of turbidity (99.39%) and BOD5 (66.95%) abatement after a settling that follows Kynch's law. However, the biological treatment allows to reach respectively 47.95 % of turbidity and 61.5 % of BOD_5.

Key words: Biological, wastewater, environment, Jar Test, Tiflet, treatment

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1. INTRODUCTION

In recent decades and thanks to the health progress that has benefited from the development of science and technology in the world, the world's population has grown strongly, increasing three times more than the world population observed in the year 1950. Today, more than seven billion people live on earth, millions of them, live in areas that do not exceed 1000 km², which has created an explosion of urbanization. Today, any urban environment where a population is concentrated has multiple primary needs, among them water, which is defined as an indispensable element of life. Global water use has increased six fold over the last 100 years and continues to grow progressively by about 1% by an ," reports the United Nations World Water Development Report 2018 [1].

The very high consumption of water by cities in turn leads to a very high production of wastewater, 50% to 80% of drinking water is recirculated in liquid sewers. Morocco, like any other country in the world, is subject to the phenomenon of population growth, with an overall growth rate of 2% since 1960 and an urbanization rate of 60.3%. Millions of cubic meters of water are consumed per day and millions of cubic meters of wastewater are discharged into nature every day. This causes several nuisances and harmful consequences on the environmental state of Moroccan cities. In 2005 Morocco launched the National Sanitation Plan in which it set several objectives to be achieved by 2020, firstly, to treat 60% of wastewater discharged into rivers or the sea. In this sense, the bacteriological and physicochemical characterization of wastewater from the city of Tiflet, which does not have a wastewater treatment plant, is being studied in order to assess its impact on the receiving environment (Oued Tiflet) [2] [3] [4].

2. MATERIALS AND METHODS

2.1. Study Site

The wastewater under study comes from the city of Tiflet, which is located 56 km from Rabat, the capital of Morocco, and is part of the Rabat-Salé-Kenitra region. The city is characterized by a population of 86709 inhabitants over an area of 12 km². The first economic activity of the city is agriculture with an agricultural area of 67 ha. (Figure 1) [5].

The city is characterized by a water source, Oued Tiflet, which is not used as a source of drinking water but as a source of irrigation water for all the residents of the Oued, however it is defined as the final receiving environment for the wastewater discharged from the city [6].

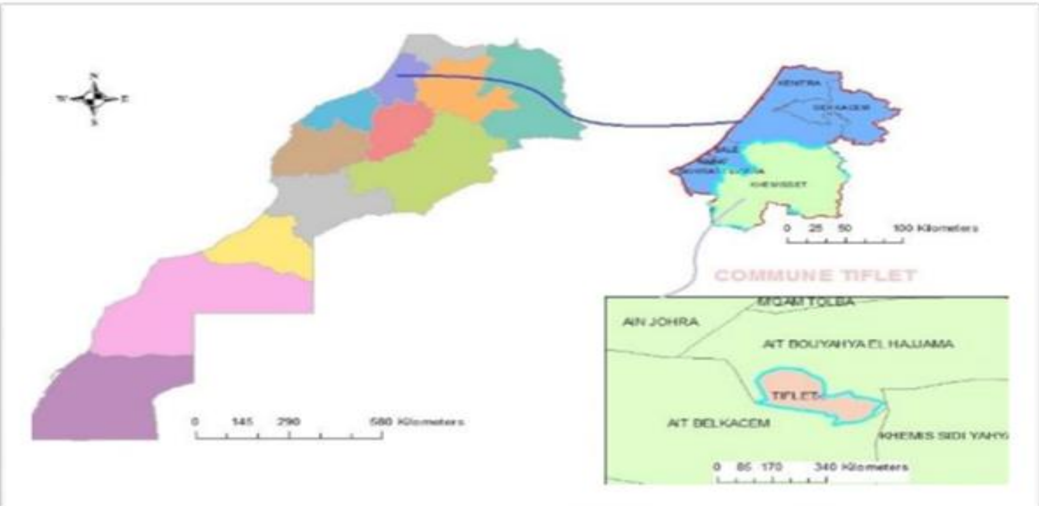


Figure 1 Geographical location of the town of Tiflet

2.2. Presentation of Rejects

Sampling was carried out from three discharges that bring together all of the city's wastewater that is discharged without any treatment into Oued Tiflet (Figure 2).

Table 1 Geographical coordinates of wastewater discharges from the town of Tiflet

	X	Y	Location in the city
Rejection 1	416689.08	366290.44	Near the weekly Souk
Rejection 2	415973.52	367170.07	Near the nursery
Rejection 3	414690.11	367949.54	Near Errahma cemetery

Figure 2 Geographical location of the waste water of the town of Tiflet

2.3. Methods of Wastewater Analysis

In order to identify the typology of the waste water of the town of Tiflet and to determine its quality, we carried out physicochemical and bacteriological analyses.

The pH and temperature were determined by a 206 Lutron pH meter equipped with a temperature probe. Electrical conductivity was measured using a WTW LF90 conductivity meter and turbidity was determined by a 2100p portable turbidimeter.

Suspended solids (SS) are determined by filtering a volume of water through a GF/C membrane filter (125 microns). The mineral matter was calculated as the difference of the total matter after calcination of the sample in porcelain capsules at 550°C for 3 hours. The total material was measured by evaporating the sample in porcelain capsules at 105°C. [7]

Microbiological analyses were limited to the determination of fecal pollution indicators, fecal coliforms and fecal streptococci, using the MPN Most Probable Number method. [7]

2.4. Processing Methods: Jar Test

Based on the principle of flocculation coagulation, which is based on the physico-chemical treatment of wastewater and the decanting of colloidal matter, the Jar Test presents a practical laboratory scale model that helps to determine the appropriate concentration noted, the optimal dose of coagulant to treat the wastewater sample.

At the scale of our laboratory we have chosen Ferric Chloride ($FeCl_3$) as coagulant. The wastewater sample chosen is a mixture of the three discharges from the town of Tiflet (R1, R2 and R3). The coagulant is mixed with the sample for 15 s with a stirring speed of 120 rpm, then flocculation for 20 min at a speed of 40 rpm, and settling for 30 min.

2.5 Biological Treatment

In order to degrade the organic matter contained in the wastewater and measure it from BOD5in mgO2/l, aerobic biological treatment is used, based on continuous agitation in the open air. The principle is used to regularly measure the physico-chemical parameters (pH, Conductivity, Turbidity, Temperature, dissolved oxygen, BOD5 at the beginning and end of the treatment).

In a flat-bottomed flask, a volume of the wastewater (mixture of R1, R2 and R3) to be treated is added, with continuous stirring, however the variation of the physico-chemical parameters as a function of time is monitored in an ambient temperature of 19°C (laboratory temperature).

3. RESULTS AND DISCUSSION

3.1. Bacteriological Quality

The concentration of fecal pollution indicators, fecal coliforms and fecal streptococci is not very variable from one discharge to another, the maximum value of CF is observed in discharge 2 (11 1011 CF/100 ml), however the minimum is observed in discharge 1 (21.105 CF/100 ml), while the maximum value of SF is recorded in

discharge 3 (16.106 SF/100 ml) and the minimum is recorded in discharge 1 (11.104 SF/100 ml).(Figure 3) The CF/SF ratio shows a value greater than 4 for Releases 1 and 2, confirming that the source of pollution is exclusively human, other than Release 3 which is characterized by an uncertain source of pollution (CF/SF=1.31). [8]

According to the quality standards for water intended for irrigation, this waste water is not suitable for direct use in irrigation and is pre-treated. [9]

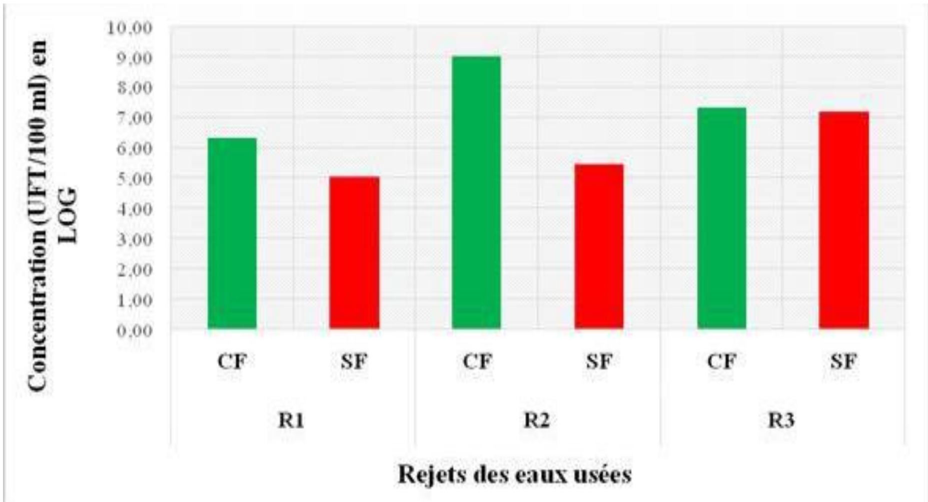


Figure 3 Bacteriological characteristics of the wastewater from the town of Tiflet

3.2. Physicochemical Quality

The temperature noted at the level of wastewater discharges from the town of Tiflet varies between 15°C and 16.6°C (Table 4) and does not exceed the limit value for direct discharges into receiving environments and water intended for irrigation. These results are lower than those observed in the city of Salé and the region of Chaouia in Morocco, Ouargla and Biskra in Algeria and Senegal. [9] [10] [11] [12] [13] [14] [15]

The pH recorded in the three wastewater discharges from the town of Tiflet varies between 7.13 and 7.93 (Table 2), which qualifies it as neutral. This result is similar to that found in different Moroccan regions such as Salé, Chaouia, Ouarzazate, Oujda, Kenitra and other regions in Algeria and Senegal. The measured pH values are acceptable according to the Moroccan standards determining the quality of wastewater intended for irrigation [9] [11] [12] [13] [14] [15] [16] [17] [18].

The average dissolved oxygen concentration in the wastewater of the town of Tiflet is 6.17 mg/l (Table 2),

Generally, when the level of dissolved O2 in the water rises, the efficiency of the biological treatment becomes more important due to the aerobic microorganisms contained in the wastewater. The result shows that the concentration of dissolved O2 in the wastewater of the town of Tiflet is three times higher than that recorded in Salé and Senegal. [11] [15]

The average turbidity observed at the three wastewater discharges from the town of Tiflet is 292 NTU (Table 2). This value is equivalent to that reported for the wastewater from the town of Salé. [11]

The calculation result of suspended solids in the wastewater of the city of Tiflet is 282 mg/l on average (Table 2), which is half the TSS concentration recorded in Salé, Chaouia in Morocco and Senegal, in contrast to Algeria which has a very high TSS concentration in Ouargla.

The observed TSS values exceed the specific discharge limit values applicable to discharges of waste water from urban agglomerations and water intended for irrigation. [9] [10]

The measured electrical conductivity shows a strong mineralization of the wastewater from the town of Tiflet, with the highest value being 3,446 mS/cm and the lowest being 3,363 mS/cm (Table 2). This is expressed by the mixture of domestic and industrial wastewater from the textile factories located in the centre of the city and the food and aeronautical industries located in the Ain Johra industrial park, which are connected directly to the liquid sewerage network, R2 and R3 successively.

The measured electrical conductivity is almost similar to that recorded in Salé and Chaouia but is very much higher than the conductivity recorded in Senegal and Algeria. The conductivity found does not exceed the limit values set by the Moroccan standard for water intended for irrigation.

The biological oxygen demand (BOD5) varies from 240 mgO2/l observed in discharge 1 to 840 mgO2/l observed in discharge 3 (Table 4). The chemical oxygen demand (COD) varies from 360 mgO2/l observed in discharge 1 to 1176 mgO2/l observed in discharge 3 (Table 2).

The average BOD5 and COD measured at Tiflet is higher than that recorded at Salé and Chaouia and lower than that recorded at Ouargla in Algeria.

The results show that the BOD_5 and COD of the wastewater from the town of Tiflet exceed the specific discharge limit values applicable to wastewater discharges from urban agglomerations. [9]

The biodegradability report (COD/BOD_5) shows that the wastewater from the town of Tiflet is biodegradable.

According to the results of the calculation of the organic matter obtained, it can be seen that its concentration fluctuates between 325 mg/l examined at discharge 1 and 882.5 mg/l examined at discharge 3. While the minimum concentration of mineral matter recorded is 950 mg/l observed in Reject 1 and the maximum is 1140 mg/l observed in Reject 2 (Table 2).

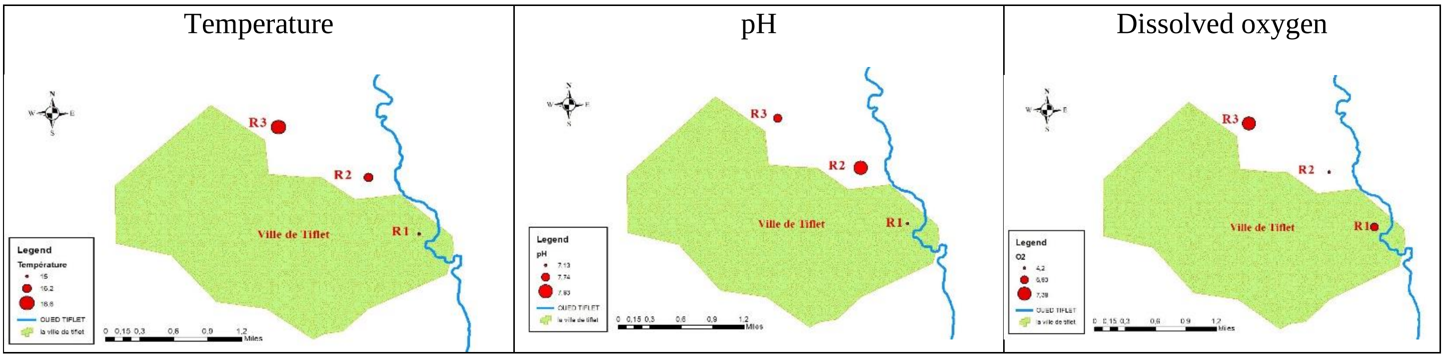
Table 2 Comparison of the physico-chemical characteristics of Tiflet wastewater to Moroccan standards and different study areas in Africa

	Moroccan Standard (EU) [10]	**Moroccan Standard (irrigation) [9]**	**Tiflet (this study) Min - max**	**Morocco Sale [11]**	**Morocco Chaouia [12]**	**Yacoundé Cameroun [19]**	**Sénégal [15]**	**Ouargla Algérie [13]**
Temperature (°C)	30	35	15 - 16,6	18,5	23		27,65	19,45
pH	6 - 9	6,5 - 8,4	7,13 - 7,47	7,86	7,6	7,11	7,25	7
Dissolved oxygen (mg/l)	-	-	4,2 - 7,38	3.31			2,67	
Turbidity (NTU)	-	-	152 - 367	331			Import -ante	
MES	150	100	204 - 327	500	417		340	1113,5
Electrical conductivity (ms/cm)	-	12	2,26 - 3,45	2,218	2,97	0,181	0,058	0,027
DBO_5 (mgO_2/l)	120	-	240 - 840	340	367,33	17,56		511,42
COD (mgO_2/l)	250	-	360 - 1176	576				597,85
Organic matter (mg/l)	-	-	325 - 882,5	-				
Matière minérale (mg/l)	-	-	950 - 1140	-				

3.3. Presentations of the Results on ArcGIS

In order to facilitate the reading and interpretation of the measurement results of the parameters obtained, they are displayed in the form of maps prepared on ArcGIS.

According to Figure 4, it can be seen that the pollution rate of the three wastewater discharges from the town of Tiflet does not vary greatly from one discharge to another, yet discharge 1 is always present the least concentrated part, due to the number of population connected to this collector, which is considered low compared to the other collectors that are connected to the textile and food manufacturing plants in addition to the number of population.



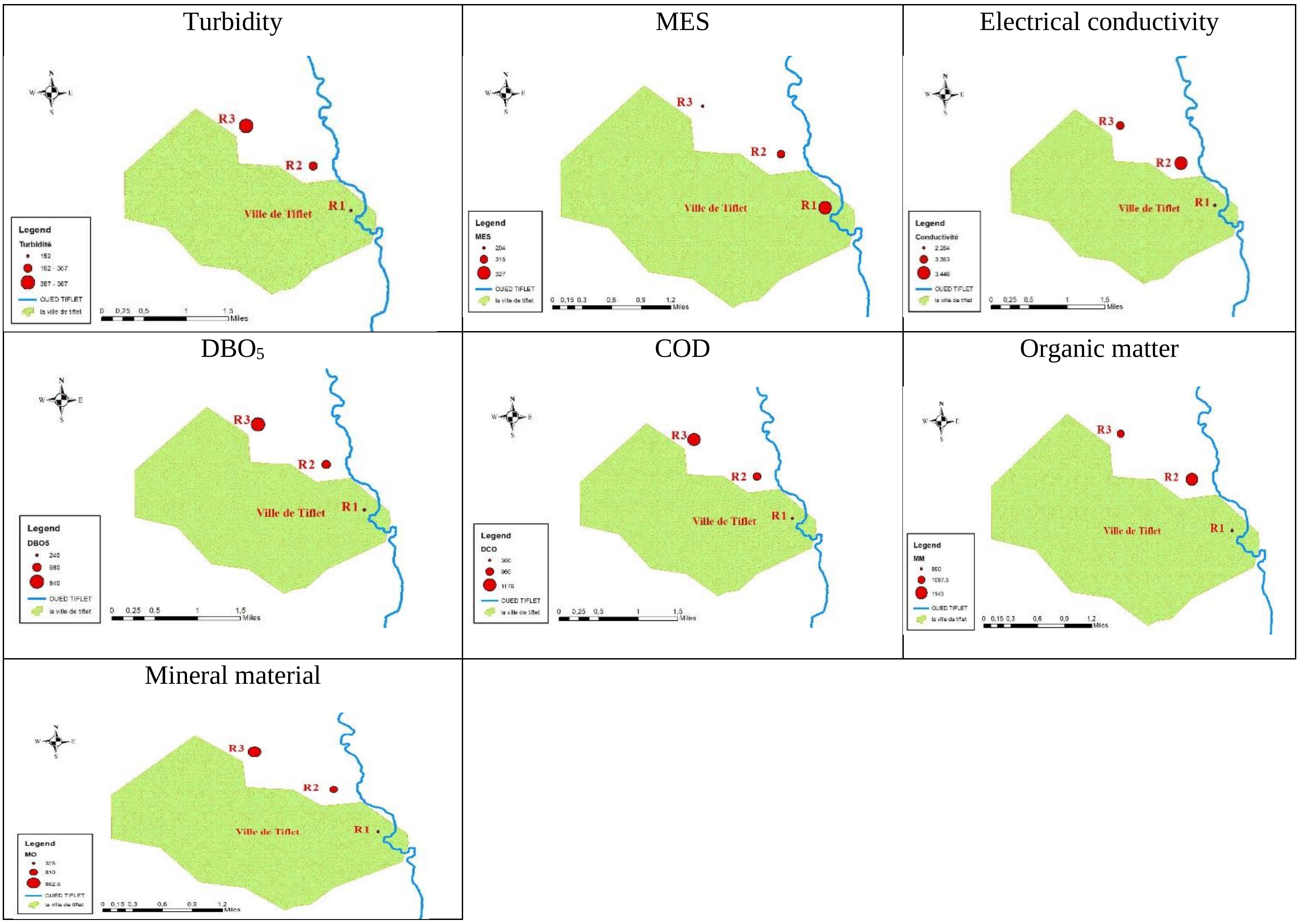


Figure 4 Physico-chemical characteristics of the wastewater of the town of Tiflet by ArcGIS

3.4. Treatment by Jar Test

After decanting for 30 min the results of the Jar test, pH, turbidity and conductivity, are shown in Table 3.

Table 3 Results of physico-chemical parameters after Jar Test

Beaker (FeCl3 in g/l) / **Settings**	**Control - (0 g/l)**	**(0,2 g/l)**	**(0,6 g/l)**	**0,8 g/l)**	**(1g/l)**	**1,2 g/l)**
Turbidity (NTU)	292	50,8	7,26	2,59	1,77	8,71
Conductivity (ms/cm)	3,024	3,14	3,174	3,196	3,22	3,25
pH	7,6	6,86	6,31	6,05	5,83	5,46
T (°C)	15,93	17,2	17,3	17,3	17,2	17,3

The pH values and turbidity decrease significantly due to the acidity of the coagulant (FeCl3) and its effectiveness in coagulating and agglomerating the non-settling colloidal material in the wastewater in the form of flocs. From Figure 5 it can be deduced that the optimum dose of coagulant for a better treatment efficiency, which is indicated by the lower turbidity, is 1 g/l of (FeCl3).

However, it can be seen that the conductivity gradually increases as a function of the concentration of added coagulant, which is explained by the accumulation of chloride ions from coagulant in the wastewater, while the dissolved oxygen which rises as the turbidity decreases, 9.25 mg/l of dissolved O2 in the least turbid beaker.

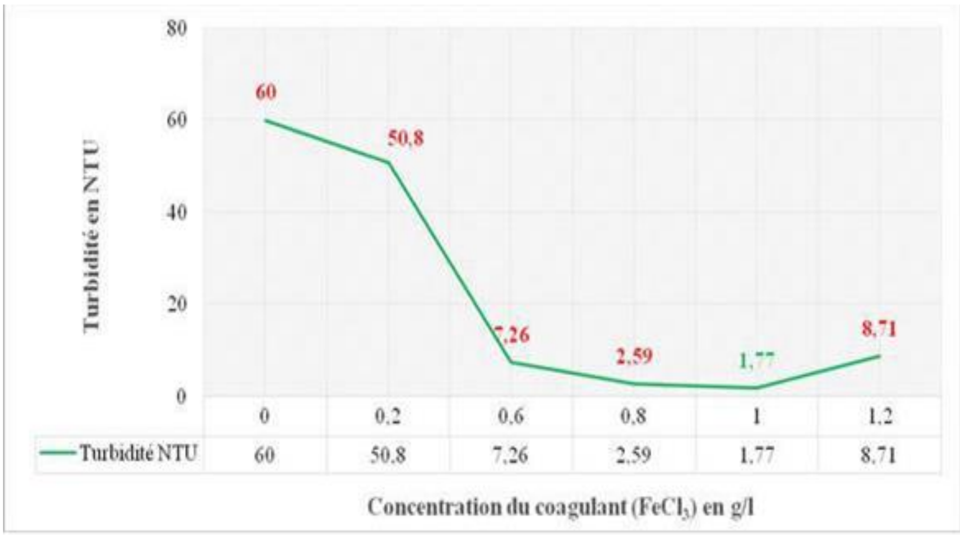


Figure 5 Variation of turbidity after settling as a function of the concentration of added coagulant

3.5. Settling (Kynch Curve)

After the increase of flocs after coagulation and flocculation by Jar test using FeCl3, settling is started in a 1 litre test tube. The colloidal material becomes heavier and begins to settle in a piston.

Kynch's hypothesis or concentration law the falling velocity of a particle depends on the initial particle concentration C, where it spreads from the origin (surface), as a function of height over a given time regularly, or tangentially from the point of sediment compression.

In our work, we studied the settling of the particles by following the Liquid/Mud interface, noting the volume of the sludge every minute. The monitoring of this settling as a function of time allowed us to differentiate four different phases, from which the Kynch curve was drawn to determine the sedimentation rate. (Figure 6)

The first phase from A to B is the clearest surface, however it is the coalescence phase of the substances or flakes. The second phase from B to C is a rectilinear part that is approximated by a linear function determining a constant falling speed (slope of the straight line) in a tube of given dimensions.

The third phase from C to D is a part in the form of an upwardly concave vault and is approximated by an exponential function, this phase corresponds to a progressive slowing down of the falling speed of the particles. The last phase has a compression phase. [20] [21] [22] [23] [24] [25]

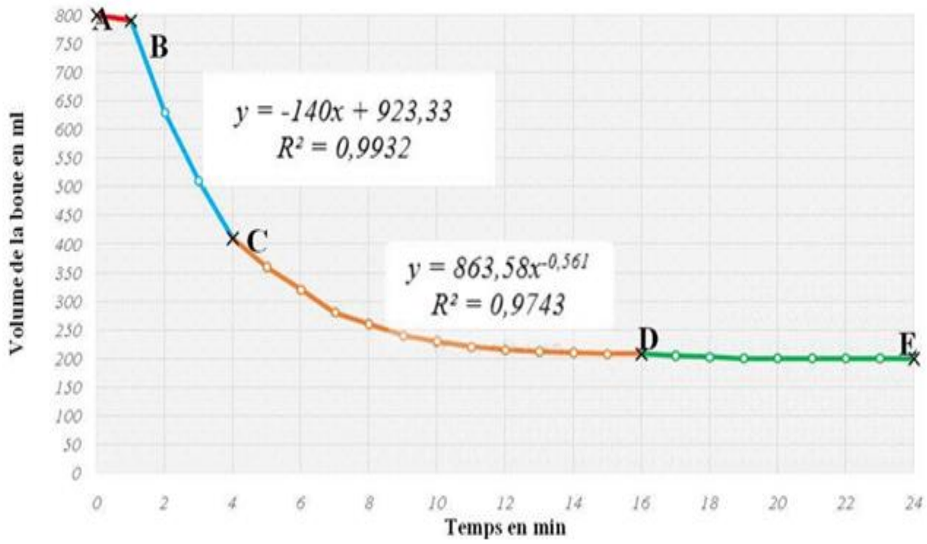


Figure 6 Experimental decantation curve of wastewater mixture R1, R2 and R3 after Jar Test treatment (Kynch curve)

Kynch's theory is applicable to the BC and CD phases which cover the settling range of flocculated particles. Based on the method of least squares, the linear section BC admits as function (1) Hi = a.t + b and the section with a concave upward vault admits the function (2) Hi = $c.t^d$.

It is determined that the correlation coefficient exceeds 99% at the linear portion and 97% at the exponential portion (Table 4).

Table 4 Kynch Equations after Jar Treatment Test and Settling

	Linear part	Exponential part
Equation :	$Hi = -140t + 923{,}33$	$Hi = 863{,}58\ t^{-0{,}561}$
Correlation in % :	99,32	97,43

According to the Kynch curve, we can see that the muddy medium has two different zones:

Area [BOC] where the concentration and falling velocity are uniform and maintain its initial concentration and velocity;

Median zone [COD] where the sludge concentration gradually increases from C to D, yet the rate of fall decreases. (Figure 7).

The average concentration at point M, Equation (3), of the CD:

$$C_M = C_0 \times \frac{H_0}{H_M}$$

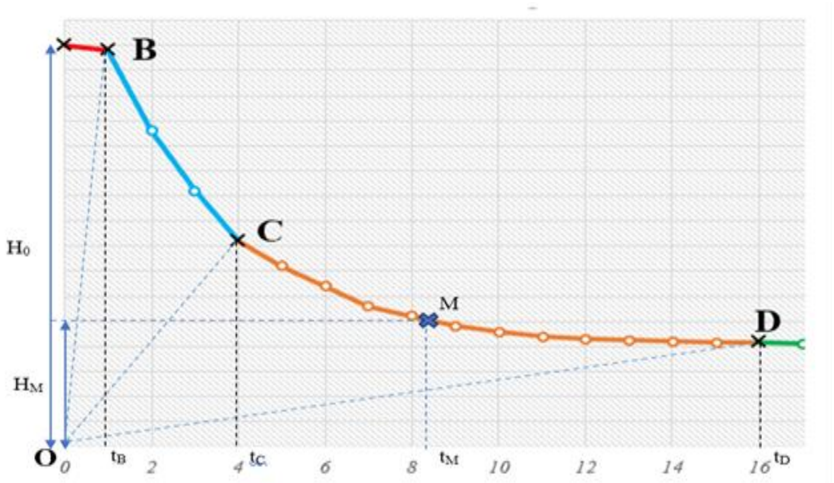


Figure 7 Main areas of muddy environment according to Kynch

3.6. Biological Treatment

In general, biological wastewater treatment is the process that allows the degradation of pollutants through the action of microorganisms. This process occurs spontaneously in natural environments such as sufficiently aerated surface water. A multitude of organisms are associated with this degradation in different transformation cycles. Among these organisms are usually bacteria, algae, fungi and protozoa. This extremely rich microflora can adapt to various types of pollutants that it consumes as food (substrates). It is thus possible to systematically use this microflora in a controlled process to carry out wastewater treatment [26].

The principle of biological treatment is to cause, in the presence or absence of oxygen, a more or less controlled proliferation of micro-organisms capable of degrading the organic matter brought in by the effluent.

It is in fact a real transfer from a non-accessible form of pollution (colloidal and dissolved matter) to a manipulable form (suspension of microorganisms).

The microorganisms responsible for purification agglomerate in the form of flocs and grow using the pollution as a necessary substrate for the production of vital energy and the synthesis of new living cells.

Partof the polluting elements that is not biologically degraded can be adsorbed and incorporated into the sludge flocs. [26]

In order to succeed in the biological treatment process, the presence of the main components of the biological treatment is ensured, which is based on the existence of a biomass that allows the degradation of organic matter by consuming oxygen and nutrients. (Figure 8)

Substrats (MO) + Micro-Organismes + O_2 + Nutriments (N, P)

↓

Micro-Organismes (Nouvelles cellules) + CO_2 + H_2O + Résidu (Organique et Inorganique) + Energie

Figure 8 Chemical and biological equation of the biological treatment process

Monitoring over a period of 55 days showed that the pH of the solution decreases with time, this is due to the phenomenon of nitrification by bacteria such as Nitrobacter where nitrites are oxidized into nitrates. (Figure 9). [27]

Similarly, the organic pollution presented by BOD5 in wastewater to decrease from 587 mgO2/l to 226 mgO2/l, with a yield equal to 61.5%. (Figure 10).

The removal of organic substrates in wastewater is proportional to the increase of dissolved oxygen in the water due to the continuous agitation which allows a natural injection of oxygen, however the growth of microorganisms reaches the stationary phase, the oxygen consumption has become almost stable, which means that the bacterial growth has attenuated its maximum on the fifteenth day. (Figure 11) [28].

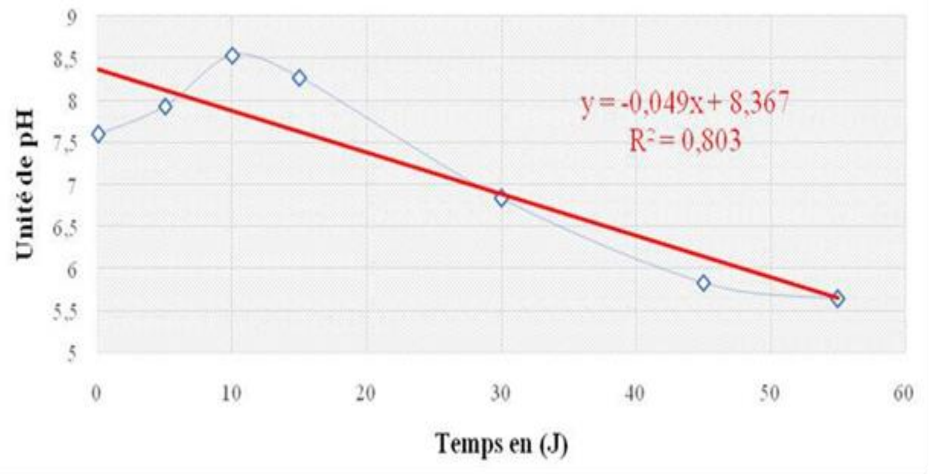


Figure 9 Evolution of pH as a function of number of days

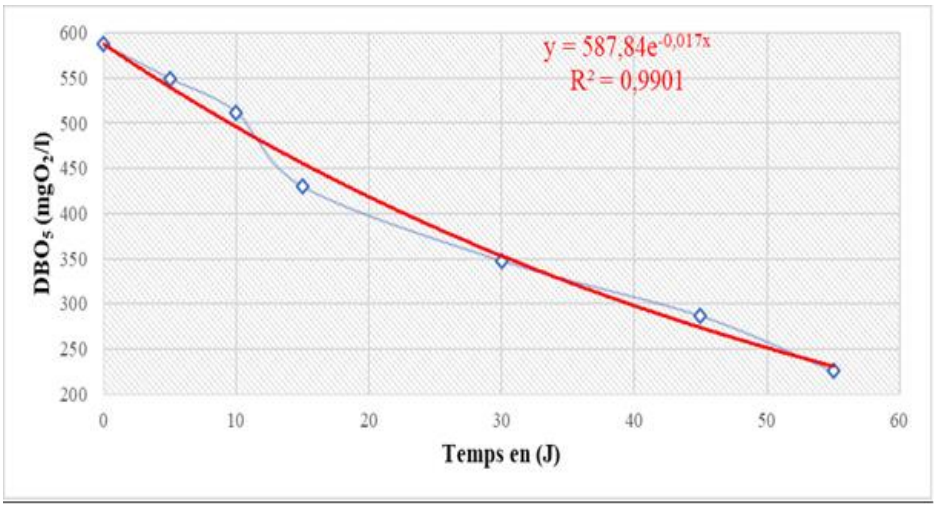


Figure 10 Variation of BOD5 as a function of time

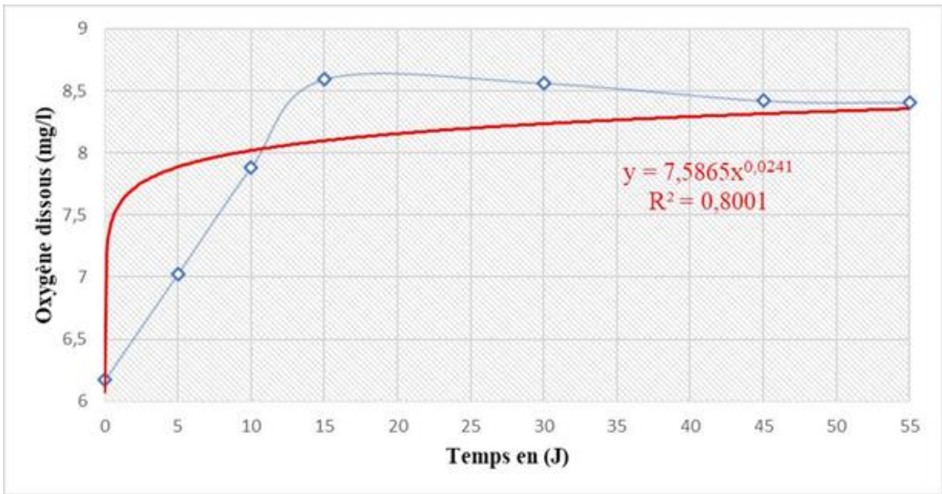


Figure 11 Variation of dissolved oxygen as a function of time

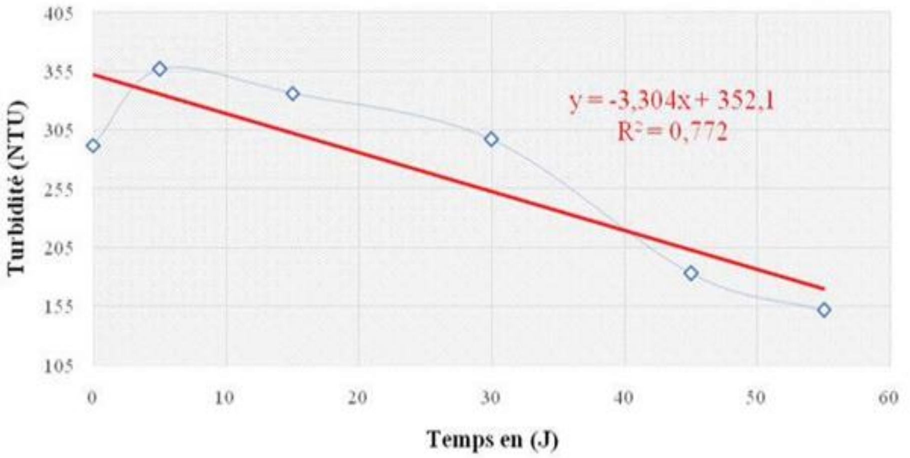


Figure 12 Turbidity variation as a function of time

Based on the results obtained from different wastewater treatment methods, either coagulation-flocculation or biological treatment, it is inferred that coagulation-flocculation treatment is more effective than biological treatment, however, the BOD_5 yield and turbidity using coagulation-flocculation exceeded 65% and 99% successively, whereas the BOD_5 yield and turbidity did not exceed 62% and 48% using the aeration biological treatment method. (Table 5)

The results obtained in our laboratory have shown that the coagulation-flocculation treatment process is more efficient compared to the biological treatment process. However, these results do not confirm that the coagulation-flocculation treatment process is always the most efficient, since a quantity of wastewater not exceeding 1 litre has been treated for a given period of time.

That said, coagulation-flocculation treatment can meet the need for a small-scale plant in industry.

Table 5 BOD_5 and Turbidity Removal for Both Treatment Processes

Type of treatment	**Coagulation-Flocculation**		**Organic**	
Physicochemical parameter	BOD5 mgO2/l	Turbidity NTU	BOD5 mgO2/l	Turbidity NTU
Before treatment	587	292	587	292
After treatment	194	1,77	226	152
Return in % (%)	66,95%	99,39%	61,50%	47,95%

4. CONCLUSIONS

At the end of this study, relating to the characterization of the quality of the waste water of the town of Tiflet, it is deduced that the town today finds itself in a critical situation, an enormous quantity of waste water loaded with pollutants, 37.107 CFU/100 ml of CF, 54.105 CFU/100 ml of SF, 587 mgO2/l of BOD_5, 832 mgO2/l of COD, 292 NTU of turbidity, 282 mg/l of TSS.

These alarming results affirm that these urban discharges should not be discharged directly into the natural environment or reused in agriculture without prior treatment. On the other hand, wastewater treatment by coagulation-flocculation using FeCl3 followed by decantation following Kynch's law, is more efficient than biological treatment with continuous agitation in the open air, i.e. 66.95% BOD5 abatement against only 47.95%.

The treatment processes experimented in the laboratory were limited by a determined amount of wastewater, showing that coagulation-flocculation would be useful mainly for industrial installations.

Nevertheless, biological treatment is still useful considering the time factor required but also the exemption of the use of chemicals which increases the cost of treatment from an economic point of view.

In the end, the implementation of a wastewater treatment plant in the town of Tiflet is a fundamental requirement and the choice of the town's wastewater treatment system must be based on a relevant study of the cost of treatment, design, construction and operation.

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