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Characterization of Domestic Waste water and Performance Indicators of the Waste water Treatment Plant of the City of SETTAT

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***Abstract*— The city of SETTAT undergoes, like other cities of Morocco, an increasing rate of urbanization and a natural increase of the population. These socio - economic changes generate the increase of significant quantities of sewage water.**
Taking into account the requirements of treatment reliability imposed by the 1991 directive, the set of requirements of 17 October 2002 Decree of water quality standards intended for irrigation [1],the study in this paper have as a main objective the modeling and optimization of purifying performance of the treatment plant wastewater stabilization ponds in the city of SETTAT through monitoring indicators of pollution such as (TSS,COD) and some physicochemical parameters (pH, conductivity, temperature).
It appears from this study that the performance of the station was very efficient and is able to achieve a reduction of COD and TSSof 80% and 83% respectively.

***Keywords*— experimental design, performance, modeling, optimization,indicators**

I. Introduction

In Morocco, no less than 600 million m^3 of wastewater are produced annually of which only 8% are clean [2].
The park of wastewater treatment plants are dominated by extensive systems (about 90 %), especially the lagoon with their different variants (over 80 %). [3]
The natural lagoon has taken an important place among the methods of treating domestic-wastewater.

Many diagnoses made on the area of sewerage in urban areas show a delay in the treatment of wastewater.
It is in this case:
- A low sewage treatment rate, the treatmentcomponent is the weak link in the chain of sanitation in Morocco:
- An inefficient management of sanitation services. [4]

- Awareness of the importance of preserving the environment - primarily water - led legislatures from Morocco to enact laws more restrictive.

Thus, the knowledge of the physico-chemical quality of wastewater is essential to predict the potential impacts on the receiving environment.
The choice of field of wastewater reuse depends mainly on the quality of the effluent, types of crops, irrigation and soil conditions of the soil. [5]
Indeed, for the reuse for agricultural irrigation, the quality is determined primarily by salinity and especially the sodium ion content. [6]

II. Methodology

This preliminary study aims to optimize the biological process. For this, we tried to take into account that water that has undergone this treatment should be done in conditions requiring a COD below 400 mg / L of O2 and a suitable pH in the pH range (6,8 to 7,8). Actually high pH plays an important role in the aerobic biological treatment process because the biomass needs a pH close to neutrality to complete its purification activity. It should be noted that this treatment is possible in a range of pH (5 to 9) with an optimum range of 6 to 8. [7]

A. Study Site

The water-treatment station of the municipality of SETTAT has as an objective, the wastewater's treatment in the urban area and the re-use of the effluent for irrigation of agricultural area located downstream of the station.
The treatment station concerned in our study is located 8km from the town of SETTAT. It has been operating since the month of May 2006, sized 175 000. It consists of 3 sets of anaerobic ponds, facultative and maturation in parallel to a site area of approximately 80 ha.
Such series are very beneficial, they allow different pools to perform their various functions in the processing and produce a high quality effluent. [8]

B. Methodology of the experiments

Our main goal is to extract as much information as possible with a limited number of experiments.

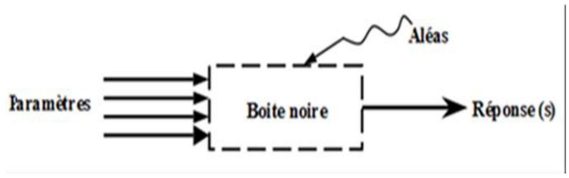


Fig.2.1.Model"blackbox"

The "black box" models are built primarily on the basis of measurements made on the inputs and outputs of the process model. Modeling is then used to represent the relationships between inputs and outputs , equations (algebraic , differential , or recurrent) parameterized , and estimating the parameters from the available measures, so as to obtain the best possible accuracy with the smallest possible number of adjustable parameters .
Using response surface methodology (RSM) and central composite design (CCD) [9], one of these parameters on the treatment efficiency, will be achieved.

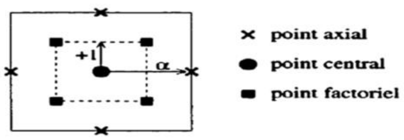


Fig.2.2.Points Central Composite Design (CCD).

<u>The concept of response surface:</u>
The concept of response surface models a dependent variable Y, said response variable, depending on a number of independent variables (factors).
Y is the vector of observed response, representing the percentage of biodegradation using the independent variables x_1 (conductivity), x_2 (temperature) and x_3(pH) in coded values.
The main goal of the RSM is to determine the optimum operating conditions for a given system that meets the operating specific conditions [10].
The prediction model is given by the following equation:

$$y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_{11}X_1^2 + a_{22}X_2^2 + a_{33}X_3^2 + a_{12}X_1X_2 + a_{13}X_1X_3 + a_{23}X_2X_3 + a_{123}X_1X_2X_3$$

In order to optimize the biodegradation reaction parameters , each parameter in the design (RSM) was studied in five different levels (-α , -1, 0 , +1 , + α) .
The choice of five levels for each variable is required by this design to explore the region of the response surface near the optimum.
In total, 20 trials must be planned for an optimization experiment involving three factors.

C. Experimental Protocol

To maximize our 3 above factors and after a series of tests made for each experimental factor aside, we were able to identify the intervals of work for our three variables to finally choose our test matrix.
We symbolize by the sign (-α) low level and the sign (+α) the high level of each factor.

The experimental tests were carried out according to the following steps: The water temperature (T water ^{O}C), pH and conductivity are measured directly in the water column to a depth of 20 cm with electrodes.
The evaluation of the response of the test is established by determining the efficiency of treatment applied by measuring the response of the water sample before and after depending on the experimental AFNOR.
The percentage reduction of pollution is calculated from the following equation:

$$\%\,abattement = \frac{C_E - C_S}{C_E} \times 100$$

C_E: inlet concentration of COD, TSS.
C_S: outlet concentration of COD, TSS

Measures/Analysis/Tests	Methodsand References
T (°C, au 1/10)	Thermometer
pH (unite pH, au1/100)	pH metre(01PHT01)
(D.C.O en mg/l), TSS	Norms AFNOR
Optimisationof thebiodegradation	methoddesign ofexperimentents
Analysis of the effectsand interactions offactors	Statgraphics

Table 2.1Materials and method

VI	**Ranges and experimental levels**				
	- α	-1	0	+1	+α
Cond µS/cm	1920	2050	2250	2450	2580
T °C	17	18,8	21,5	24,2	26
pH	7,35	7,45	7,60	7,75	7,85

Table 2.2 Ranges and experimental levels of the variables independent from the test.

III. RESULTS AND ANALYSIS:

A. *Qualitative aspect of effluents of theWWTP*

Parameters	Max	Min	Moy	ET
Cond (µS/cm)	2650	1920	2250	360
T (°C)	26	17	21,5	6,5
pH	7,9	7,1	7,5	0,8
COD (mgO_2/l)	748,8	441,6	612,73	109,9
TSS (mg/l)	862	460	659,16	176,5

Table 3.1Shows changes in the physical parameters (temperature, pH, electric conductivity) and indicators of pollution COD, TSS

B. *Matrix Result*

	Cond	T	pH	Y(COD)%	Y(TSS)%
1	1,0	-1,0	-1,0	80,4	62
2	-1,0	1,0	1,0	83,8	68,2
3	1,0	1,0	-1,0	89,1	89,9
4	1,68	0,0	0,0	68,2	70,1
5	0,0	0,0	0,0	78,6	83,2
6	1,0	1,0	1,0	81	88
7	0,0	0,0	0,0	80,1	83,5
8	0,0	0,0	0,0	80,6	82,7
9	-1,0	-1,0	1,0	86	87
10	0,0	0,0	0,0	79,7	82,9
11	0,0	-1,68	0,0	87	79
12	-1,68	0,0	0,0	78	75,9
13	1,0	-1,0	1,0	64	78,5
14	0,0	0,0	0,0	80,7	83,2
15	0,0	1,68	0,0	92	90,1
16	0,0	0,0	-1,68	88	87,3
17	0,0	0,0	0,0	81,2	83,7
18	0,0	0,0	1,68	77,6	84
19	-1,0	-1,0	-1,0	89,9	85,9
20	-1,0	1,0	-1,0	78	88,1

Table 3.2Matrix Result

IV. STATISTICAL ANALYSIS:

The software (Statgraphics Centurion XV, 2009) was used for statistical analyzes necessary for the models of performance COD and TSS.
To interpret and show the effect of the factors which were studied on different responses in experimental trials, we submitted our results to statistical analysis by the regression study.

A. ***Modeling multiple regressions:***

The coefficients of the parameters of the statistical model are formed from the principle of multiple regression modeling.

Regression coeffs. for y(COD)	
Coefficient	Estimate
constant	80,1621
A:Cond	-2,90562
B:T	1,46512
C:pH	-2,93557
AA	-2,57171
AB	4,975
AC	-3,3
BB	3,22658
BC	2,25
CC	0,857765

Regression coeffs. for y(TSS)	
Coefficient	Estimate
constant	83,1996
A:Cond	-1,50506
B:T	2,88997
C:pH	-0,713921
AA	-3,60357
AB	6,75
AC	4,175
BB	0,479989
BC	-4,925
CC	0,868899

Table 4.1 the coefficients coded regression model.

The positive or negative sign of regression coefficients indicates the direction of the contribution of the parameter in the response

B. *Operating model*

The answers are y (COD) and y (TSS) corresponding to the reduction of COD (%) and TSS performance models are represented by the following second order.

$Y(COD) = 80,16 - 2,90X_1 + 1,46X_2 - 2,93X_3 - 2,5X_1^2 + 4,97X_1X_2 - 3,3X_1X_3 + 3,22X_2^2 + 2,25X_2X_3 + 0,85X_3^2$

$Y(TSS) = 83{,}19 - 1{,}50X_1 + 2{,}88X_2 - 0{,}71X_3 - 3{,}60X_1^2 + 6{,}75X_1X_2 + 4{,}17X_1X_3 + 0{,}47X_2^2 - 4{,}92X_2X_3 + 0{,}86X_3^2$

These models take into account the linear effects, interactions and quadratic.

C. Validation of the model:

It is necessary to draw the graph of the model {estimated answers = f (experimental results)} adequacy to validate the models in question.

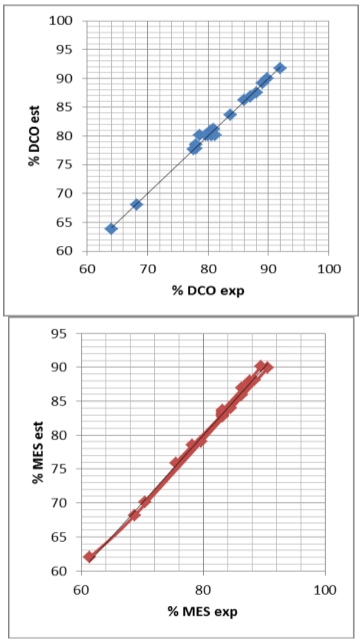


Fig.4.1. Graph of the model {estimated answers = f (experimental results)}

The point cloud is aligned with the line y = f (x), the descriptive quality of the model is a priori good.

D. The analysis of variance

Analysis of the variance shows the performance of a correlation coefficient (R^2) equal to 0.9888 adjusted data for COD and 0.9923 for data TSS. It gives an assessment of the quality of the model.

Thewords retained arethose that respectvalues"P-value" less than 0.05as suggested byDouglasandMontgomery[11]

The variable isall the more significantas the value ofFis high andthe value ofp is small($p < 0.05$).

•Analysis ofthe model results. ThePareto chartin Figure4.2 showsthedescending orderofimportance of all parametersand theirinteractions.The length of eachbarisproportional to the value.

Statistics calculated for the associated effect.The vertical line is used to judge which statistically significant effects are.

It is also interesting to note that:

- The greater the value F of factor is, the greater the effect of the factor is.
- One factor is considered significant if the absolute value of its effect is greater than the experimental uncertainty.

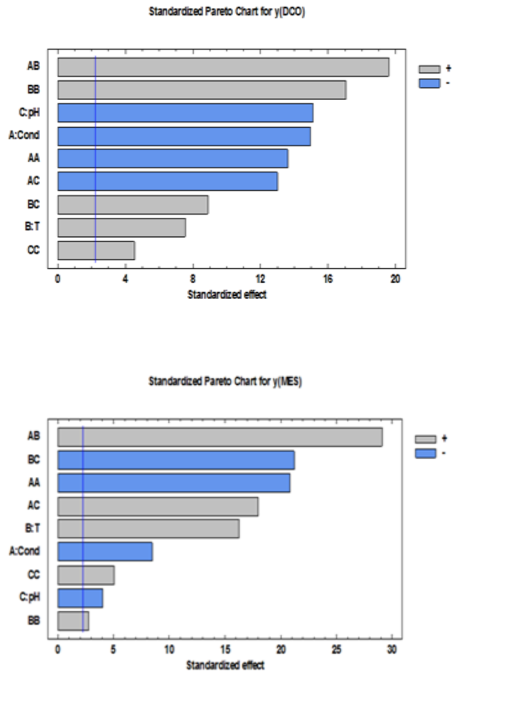


Fig.4.2.Diagramme de Pareto

Pareto Charts: The Pareto diagram can isolate the factors in order of decreasing contribution.Thus the pH, CE and T appear in the middle (in the field of study chosen) as the factor controlling essential to play on the performance of the reduction.

V. OPTIMIZATION

The purpose ofthis studyis to optimizethe bestpurifyingperformance for the station, that is to say,to highlightthe limits of thebiological processandfindthe optimumarea thatwill allow us toobtain maximumtreatment efficiencywhile minimizingthe salinity of thetreated waste waterin order todiagnosethe capacityof thewaste water forirrigation purposes. Conductivityis the key parameterthat emergedfrom this study.

The electrical conductivity of water is a direct indicator of salinity. It is a vital factor to follow when one is interested in reuse of wastewater in agriculture. [12]

After analyzing data from the previous paragraph and modeling of two answers depending on different factors, we found that the most significant effects on COD are those of pH and conductivity. On the contrary, on TSS, the effect of the conductivity is greater.

A. Analytical Optimization

To determine the maximum performance, the current value of the temperature is the coded value of the temperature T=0 representing T= 21.5 °C. The return equation (3.3) for T = 0 has the following form:

$Y(COD) = 80{,}16 + 4X_1 + 0{,}22X_3 - 2{,}57X_1^2 + 0{,}85X_3^2 - 3{,}3X_1X_3$

Y (TSS) =83, 2+7, 95 X_1 -7, 61 X_3-3, 6 X_1^2-4,175X_1X_3+0,87X_3^2

Analytical optimization of the functional response of return requires a cancellation of the first partial derivatives of the corresponding polynomial model, which gives a system of two equations:

ForY (COD)

∂Y (COD) /∂X_3= 0, 22 + 1, 7.X3-3, 3.X1=0

∂Y (COD) /∂X_1= 4-5, 14.X1 - 3, 3.X3 = 0

Solving the system gives the following values coded pH and Cond (Cond = -0.74 and pH = 0.29). The optimal values considered conductivity and hydrogen are potential 2100 µS / cm and 7.64, for which the model calculated from the return is 80.4 %.

For Y (TSS)

∂Y(TSS) /∂X_3 = -7, 61-4,175.X_1+1, 74.X_3=0

∂Y(TSS)/∂X_1=7,95-7,2.X_1-4,17.X_3=0

Solving the system gives the following values coded pH and Cond (Cond = 0.0 and pH = 0.38). The optimal values considered conductivity and hydrogen are potential 2250µ S / cm and 7.65, for which the model calculated from the return is 82.6%.

B. Response Surface Methodology (RSM)

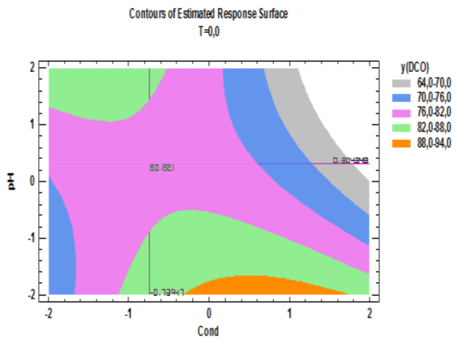
To determine the values of the factors that optimize a response Y, we tried a graphical representation of iso-response curves. The concept of iso response is a tool of optimization, management and decisions modifying or enlarging the field of study in order to comply with standards. These plots, widely used in the methodology of experiments constitute a real tool of decision making to the experimenter. [13]

These graphics are tracing the response function depending on two parameters. The other parameter is generally maintained at a fixed value close to the area where the probability of the presence of an optimum is highest.

C. Analysis of iso-response curves

The analysis of iso -response curves shows the influence of factors on the response and also determines an optimal region where the conductivity is minimal and performance is maximized.

The study conducted with Statgraphics (Fig. 7) gives the optimum value of return, for the same values of conductivity and pH as an average of 80.8 % for the reduction of COD and an average return of 83% for the TSS which is close to the values found analytically.



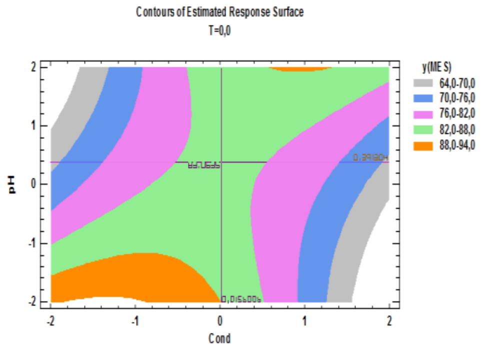


Figure 5.1: the iso –response curves for the reduction of the COD and TSS

depending on the conductivity and the pH at a fixed temperature (T = 21.5 ° C) ;

The best efficiency is obtained in the lowest (Cond = 2100µS/cm) conductivity and a suitable potential hydrogen (pH = 7.65)

VI. CONCLUSION:

In this work, we have preferred to use the methodology of experimental design. The results have allowed us to describe and model in a correct manner the influence of three experimental parameters on the effectiveness of the treatment. The optimal parameter values giving maximum efficiency could be determined.

It isimportant to remember thatthereuse of treated wastewaterfrom the city ofSETTATfor irrigationin the context oflimiting environmentalimpactsandrisk preventionstrategyrequiresrigorous controlsupstream ofthe WWTP.

The valorization of treated wastewaterfrom the citytherefore has apotential forlocalized irrigationdevelopment, however, adanger maycall into questionthe functioning of thestationfollowing amajor pollution and a high salinityfrom industrialdischarges which can lead, in term, to a degradationof irrigated soilsand the accumulation ofmetal elementsin soils.

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