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RESEARCH ARTICLE

OPTIMIZATION OF THE DRINKING WATER TREATMENT PROCESS OF A SUGAR PLANT STATION IN CÔTE D'IVOIRE

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Abstract

This article presents an optimization of the drinking water treatment process at the SUCRIVOIRE treatment station. The objective is to optimize the coagulation and flocculation process (fundamental process of the treatment of said plant)by determining the optimal dosages of the products injected and then proposes a program for calculating the optimal dose of coagulant in order to automatically determine the optimal dose of the latter according to the raw water quality. This contribution has the advantage of saving the user from any calculations; the latter simply enters the characteristics of the raw effluent using the physical interface of the program in order to obtain the optimum corresponding coagulant concentration. For the determination of the optimal coagulant doses, we performed Jar-Test flocculation tests in the laboratory over a period of three months. The results made it possible to set up a polynomial regression model of the optimal dose of alumina sulfate as a function of the raw water parameters. A program for calculating the optimal dose of coagulant was carried out on Visual Basic. The optimal doses of coagulant obtained vary from 25, 35, 40 and 45 mg/l depending on the characteristics of the raw effluent. The model obtained is: $DoseofSA = -2360{,}735 + 635{,}597pH + 2{,}444Cond + 0{,}078Turb - 0{,}046Coul + 0{,}111MES - 43{,}471pH^2 - 18{,}778 \times 10^{-3}Cond^2 + 3{,}030 \times 10^{-4}Turb^2 + 0{,}515 \times 10^{-4}Coul^2 - 10{,}206 \times 10^{-4}MES^2$. Finally, verification tests were carried out using this model on the process. The results obtained meet the WHO drinkability standards for all parameters for a settling time of two hours.

Introduction:-

Water withdrawn from the natural environment is generally not usable directly for human consumption because elements related to human activity can be entrained there (Lounnas, 2009). The quality of surface water (often

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polluted and therefore very variable) can only be treated on a case-by-case basis by treatments appropriate to its nature and degree of pollution (Kouamé and Assidjo, 2020). Indeed, the quality of treated water (drinking water) depends on the process implemented to treat surface water (Boukerroucha, 2011). It is with this in mind that we have been asked to optimize the drinking water treatment process at the Borotou-koro station so as to obtain good quality drinking water. The drinking water treatment process at the docking station essentially consists of the processes of coagulation-flocculation, filtration and disinfection. However, the basic process of treatment is coagulation-flocculation. In order to increase the treatment capacity of the existing works of the station and to guarantee good quality drinking water, we were asked to optimize the treatment process of the said station. The main objective is to determine the conditions and the appropriate treatments for the optimal removal of organic and mineral constituents from these waters.

Methods:-

Preparation of solutions:

A stock solution of 10 g/l is prepared periodically by dissolving alumina sulfate [Al_2 $(SO_4)_3$, 18H2O] in distilled water. This solution allows the addition of small quantities for the desired doses of coagulant.
A 1g/l stock solution is prepared periodically by dissolving NALCO 71661 in distilled water.

"Jar-Test" coagulation-flocculation test:

The Jar-test tests were carried out on a flocculator with 6 stirrers with a speed of rotation between 0 and 300 rev/ min. This device makes it possible to simultaneously agitate the liquid contained in a series of beakers each filled with 1000 ml of water. During our study, raw water and coagulant are subjected to rapid stirring at 150 rpm for 3 min. The speed is then reduced to 40 rpm (speed of formation of the flakes and their rate of enlargement) for a period of 12 min . After decanting for 10 min (a phase during which the destabilized floc is driven to the bottom of the beakers), the supernatant water is filtered into 250 ml beakers, to then be analyzed, in order to determine its physicochemical parameters.

Results and discussion:-

Characterization of the station's make-up water:

In order to highlight the problems encountered by the treatment station, we have characterized the make-up water of the station over different seasons. Table 1shows the results of the analyzes carried out.

Table 1:- Results of water analyzes by the station over different periods.

Dates	Parameters	Station results			WHO standards drinkability
		Raw water	*Filtered water*	*Potable water*	
05/03/17 *(dry season during the campaign)*	*pH*	*7,63*	*7,66*	*7,69*	***6,5 - 8,5***
	Conductivity (µS/cm)	*87,99*	*86,65*	*93,93*	***50-500***
	Turbidity (FTU)	*2*	*0*	*1*	***≤ 5***
	Color (mg/l pt)	*29*	*5*	*0*	***≤ 15***
	MES (mg/l TSS)	*2*	*0*		***Trace***
	TH (°f)	*3,2*	*3,1*		***≤ 5***
	Silica	*18,0*			
	Chlorine (mg/l)			*0,52*	***0,1-0,6***
10/06/17 *(rainy season during campaign)*	*pH*	*7,14*	*6,81*	*6,82*	***6,5 - 8,5***
	Conductivity (µS/cm)	*62,46*	*67,97*	*68,26*	***50-500***
	Turbidity (FTU)	*32*	*28*	*27*	***≤ 5***
	Color (mg/l pt)	*296*	*254*	*257*	***≤ 15***
	MES (mg/l TSS)	*20*	*15*		***Trace***
	TH (°f)	*2,2*	*2*		***≤ 5***
	Silica	*20*			
	Chlorine (mg/l)			*0,32*	***0,1-0,6***
	pH	*7,08*	*6,32*	*6,71*	***6,5 - 8,5***
	Conductivity (µS/cm)	*50,89*	*61,03*	*61,56*	***50-500***

01/07/17 *(rainy season during the inter-campaign)*	*Turbidity (FTU)*	*43*	*3*	*2*	***≤ 5***
	Color (mg/l pt)	*495*	*64*	*41*	***≤ 15***
	MES (mg/l TSS)	*66*	*8*		***Trace***
	TH (°f)	*2,5*	*1,9*		***≤ 5***
	Silica				
	Chlorine (mg/l)			*0,45*	***0,1-0,6***

In view of the results of this table, we observe a poor quality of the water treated by the station during the rainy seasons. This much worse treatment during the campaign could be explained by a bad dosage of coagulant and also by the fact that during the campaign, the factory has a high demand for water. Indeed, given that the station does not have a settling tank, the water does not have the necessary time to settle in the raw water receiving tank which serves as a settling tank, hence the poor quality of the water. However, in the inter-season, given the end of the company's activity, the quality of treatment is better even in the rainy season. During the dry season, the quality of the treated water meets the WHO drinking standards for most of the parameters. This is because the quality of the raw water itself is better. So a very small treatment gives the water the desired drinking qualities.

Evolution of water parameters as a function of the coagulant dose:

The Jar-Test was performed on raw station water, which we flocculated with alumina sulfate. After decanting, we took a certain quantity.

of water after filtration, which we analyzed. The results obtained are presented in figure.

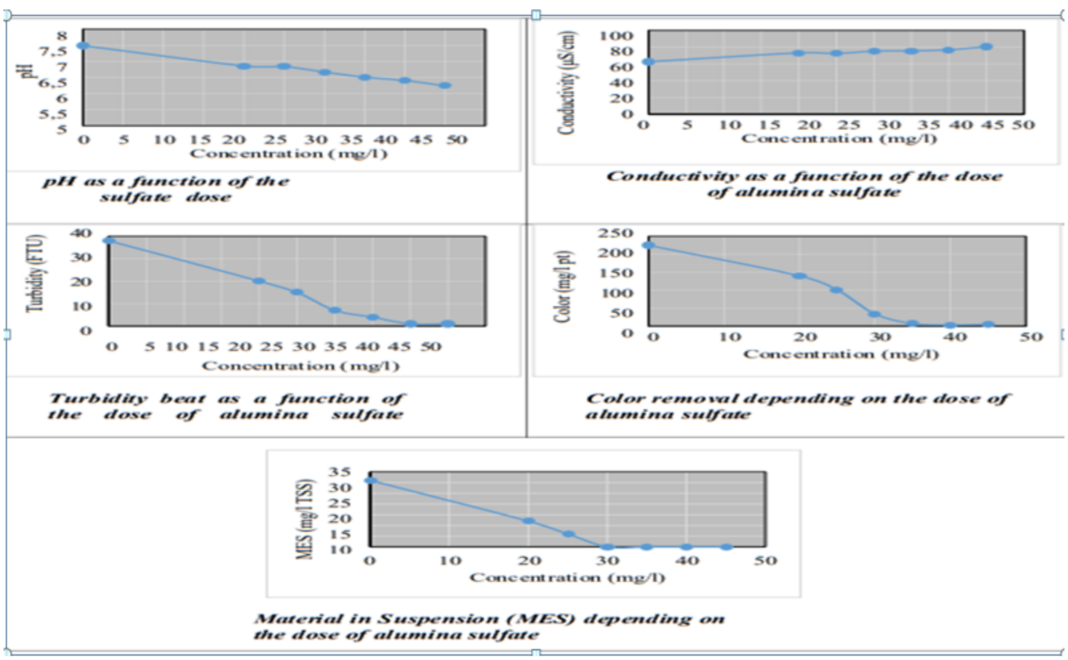

Figure 2:- Evolution of drinking water parameters according to the dose of alumina sulphate.

From the results of Jar-Test carried out, we notice that the pH decreases with increasing dose of alumina sulfate. On the other hand, the conductivity increases and the pH decreases due to the fact that when using alumina sulfate, each Al_3^+ needs to change to the $Al(OH)_3$, $3OH^-$ state from the bicarbonates and from the water itself even H^+ protons are released. From the curves, it can be seen that turbidity, color and SS decrease with increasing alumina sulfate until the optimal dose of 40 mg/l is reached. After this dose, an inverse coagulation effect occurs for the color and turbidity parameters (decoagulation).

Influence of raw water on the optimal dose of coagulant:

Jar-Test tests were carried out on raw water samples during the period from May to June 2017 to determine the influence of raw water on the optimal dose of coagulant. The results obtained are presented in table 2.

Table 2:- The influence of the quality of the raw water on the optimal dose of coagulant.

Sample	**AS dose (mg/l)**	**Water quality parameters**				
		pH	*Conductivity (µS/cm)*	*Turbidity (FTU)*	*Color (mg/lpt)*	*Suspended matter (MES) (mg/l TSS)*
1 (10/05/17)	00(Raw water)	7,40	67,73	14,00	160,00	9,00
	10,00	6,99	74,01	9,00	136,00	8,00
	20,00	6,81	76,89	11,00	139,00	6,00
	25,00	6,77	79,27	5,00	87,00	2,00
	30,00	6,60	81,20	1,00	20,00	0,00
	35,00	6,47	82,12	0,00	0,00	0,00
	40,00	6,35	84,02	5,00	0,00	0,00
2 (12/06/17)	00(Raw water)	7,51	63,17	113,00	624,00	111,00
	30,00	6,58	77,44	47,00	256,00	46,00
	35,00	6,45	78,41	10,00	41,00	8,00
	40,00	6,33	80,62	6,00	10,00	3,00
	45,00	6,18	81,88	5,00	8,00	2,00
	50,00	6,05	84,73	4,00	5,00	0,00
	55,00	5,90	88,14	11,00	36,00	6,00
3 (23/06/17)	00(Raw water)	7,35	39,27	168,00	964,00	186,00
	30,00	6,02	57,02	4,00	114,00	14,00
	35,00	5,90	58,42	0,00	24,00	2,00
	40,00	5,60	61,98	0,00	11,00	1,00
	45,00	5,25	67,41	0,00	18,00	0,00
	50,00	4,96	73,27	0,00	13,00	0,00
	55,00	4,84	75,87	0,00	15,00	0,00
4 (30/06/17)	00(Raw water)	6,78	57,63	45,00	486,00	71,00
	20,00	6,30	69,50	5,00	127,00	14,00
	25,00	6,04	69,45	0,00	8,00	0,00
	30,00	5,87	71,28	0,00	3,00	0,00
	35,00	5,53	74,55	0,00	7,00	0,00
	40,00	5,34	85,54	0,00	10,00	0,00
	45,00	4,93	87,82	0,00	14,00	0,00

The table shows the results obtained for each sample and the variation in the optimal dose of alumina sulfate depending on the quality of the raw water. We note for all samples that:

1. The optimal doses of alumina sulfate vary depending on the quality of the raw water. By comparing different samples, we notice that the optimum dose of coagulant varies according to the quality parameters (especially the turbidity) and also according to the nature of the colloids.
2. The raw water from the Borotou-Koro station is more or less loaded with organic matter. The coagulation-flocculation process with the use of alumina sulfate coagulant achieves a good efficiency of turbidity and color removal. However, it has a negative effect on the pH of the treated water.

Influence of the flocculant on coagulation-flocculation:-

A flocculant is a polymer (i.e. a long molecule formed by the repetition of a basic unit) which traps the agglomerated colloidal materials and thus forms large flakes which settle by sedimentation and can be more easily stopped by filters. The flocculants used in surface clariflocculation are acrylamide-acrylic copolymers with an ionic character. During our study, we used a mineral flocculant supplied by the company NALCO with the name NALCO 71661 in order to form larger flocs to allow rapid settling. To study the effect of the flocculant on improving the quality of surface water by coagulation-flocculation, we performed flocculation tests. During these tests, we maintained in the beakers the optimal dose of coagulant (35mg/l) determined beforehand, to which increasing doses of flocculant are added. Table 3 shows the results obtained for the search for the optimal dose of alumina sulfate according to the Jar-Test.

Table 3:- Jar-Test test for determining the optimal dose of alumina sulfate.

Parameters	Raw water	Injected dose of alumina sulfate (mg/l)					
		20	*30*	*35*	*40*	*45*	*50*
pH	7,56	6,63	6,59	6,50	6,39	6,26	6,14
Conductivity (µS/cm)	66,49	76,31	78,69	80,13	84,34	83,74	84,36
Turbidity (FTU)	26	18	13	3	4	6	7
Color (mg/l pt)	291	236	161	44	47	48	50
Suspended matter (MES) (mg/l TSS)	26	14	7	0	3	3	4
YieldColor removal (%)	0,00	18,90	44,67	**84,88**	83,85	83,51	82,82
YieldTurbidity removal (%)	0,00	30,77	50,00	**88,46**	84,62	76,92	73,08

From the results of coagulation-flocculation on surface water with increasing doses of alumina sulphate, we find that the removal efficiency increases up to the optimal dose of 35 mg/l. After this dose, decoagulation occurs. It is noted that a better efficiency of turbidity removal (88.46%) is obtained, but it remains insufficient for the removal of color (84.88%) according to the standard required for the color (15 mg/l). To improve this yield, we used the NALCO 71661 flocculant. The results obtained with the flocculant are shown in table 4.

Table 4:- Results obtained after adding the flocculant.

Parameters	water brute	Injected dose of Flocculant (mg/l)						
		00	*0,125*	*0,25*	*0,50*	*0,75*	*1,00*	*1,25*
pH	7,56	6,50	6,35	6,45	6,54	6,56	6,61	6,60
Conductivity (µS/cm)	66,49	80,13	80,30	81,35	91,60	93,84	93,30	113,2
Turbidity (FTU)	26	3	2,00	2,00	2,00	1,00	1,00	2,00
Color (mg/l pt)	291	44	36,00	32,00	31,00	24,00	12,00	16,00
Suspended matter (MES) (mg/l TSS)	26	0	3,00	4,00	6,00	1,00	0,00	1,00
YieldColor removal (%)	0,00	84,88	87,63	89,00	89,35	91,75	**95,88**	94,50
YieldTurbidity removal (%)	0,00	88,46	92,31	92,31	92,31	96,15	**96,15**	92,31

From the results obtained with the flocculant, we find that the color removal efficiency increases with increasing the dose of flocculant up to the dose of 1 mg/l, and then we have a resumption of the color. The flocs formed with the addition of the flocculant are large and settle very quickly (piston settling), unlike the use of alumina sulfate alone (diffuse settling). The optimum concentration of flocculant is 1 mg/L, thus improving the turbidity (96.15%) and color (95.88%) removal yields.

Mathematical modeling of the optimal dose of alumina sulfate:

Model data results:

The results of the analyzes of the test jar on the raw water of the station obtained over the three (3) months are presented in table 5.

Table 5:-Three-month jar test data at the docking station.

Test date	Raw water parameters					Dose of AS(g/m^3)
	pH	*Cond (µS/cm)*	*Turb(FTU)*	*Color (mg/l pt)*	*MES (mg/l TSS)*	
08/05/2017	7,54	67,43	9,00	128,00	46,00	**40,00**
09/05/2017	7,49	67,86	14,00	177,00	16,00	**35,00**
10/05/2017	7,40	67,73	14,00	160,00	9,00	**35,00**
11/05/2017	7,54	69,93	18,00	182,00	13,00	**35,00**
12/05/2017	7,38	67,27	14,00	212,00	17,00	**35,00**
15/05/2017	7,44	63,52	21,00	226,00	22,00	**40,00**
16/05/2017	7,45	66,11	18,00	212,00	16,00	**40,00**
17/05/2017	7,40	66,87	16,00	216,00	19,00	**40,00**
18/05/2017	7,45	68,62	20,00	221,00	22,00	**35,00**
19/05/2017	7,56	66,49	26,00	291,00	26,00	**35,00**
22/05/2017	7,40	57,63	73,00	408,00	72,00	**40,00**
23/05/2017	7,37	56,94	76,00	423,00	80,00	**40,00**
24/05/2017	7,30	54,62	65,00	465,00	64,00	**40,00**
26/05/2017	7,36	48,04	75,00	528,00	73,00	**35,00**
29/05/2017	7,28	51,76	68,00	468,00	66,00	**40,00**
30/05/2017	7,26	51,67	74,00	474,00	70,00	**40,00**
31/05/2017	7,31	54,36	90,00	555,00	83,00	**40,00**
01/06/2017	7,37	54,00	76,00	492,00	67,00	**40,00**
02/06/2017	7,39	54,00	71,00	447,00	59,00	**40,00**
06/06/2017	7,46	59,74	40,00	261,00	29,00	**40,00**
07/06/2017	7,55	59,61	43,00	270,00	34,00	**40,00**
08/06/2017	7,47	58,80	42,00	274,00	31,00	**35,00**
12/06/2017	7,54	59,09	60,00	342,00	55,00	**35,00**
13/06/2017	7,49	62,65	38,00	225,00	31,00	**35,00**
14/06/2017	7,53	61,78	30,00	274,00	45,00	**35,00**
15/06/2017	7,51	63,17	113,00	624,00	111,00	**45,00**
16/06/2017	7,52	66,84	53,00	254,00	38,00	**40,00**
19/06/2017	7,39	66,45	42,00	362,00	56,00	**40,00**
20/06/2017	7,50	65,68	31,00	264,00	36,00	**40,00**
21/06/2017	7,44	66,08	37,00	338,00	54,00	**40,00**
23/06/2017	7,35	39,27	168,00	964,00	186,00	**40,00**
27/06/2017	7,08	55,42	26,00	300,00	38,00	**35,00**
28/06/2017	7,27	46,44	68,00	531,00	83,00	**35,00**
29/06/2017	7,30	47,49	65,00	552,00	77,00	**35,00**
30/06/2017	6,78	57,63	45,00	486,00	71,00	**25,00**
03/07/2017	7,25	56,79	38,00	390,00	59,00	**35,00**
04/07/2017	7,32	53,30	32,00	368,00	64,00	**35,00**
05/07/2017	7,31	74,32	37,00	452,00	65,00	**35,00**
06/07/2017	7,36	48,15	62,00	576,00	95,00	**35,00**
07/07/2017	7,29	49,30	39,00	495,00	76,00	**35,00**
10/07/2017	7,44	53,06	30,00	330,00	50,00	**35,00**
11/07/2017	7,42	56,15	31,00	400,00	62,00	**35,00**
12/07/2017	7,52	55,14	14,00	312,00	45,00	**30,00**
14/07/2017	7,47	56,50	16,00	328,00	45,00	**35,00**
17/07/2017	7,42	52,24	73,00	654,00	124,00	**35,00**
18/07/2017	7,36	50,89	48,00	498,00	96,00	**35,00**
19/07/2017	7,30	53,54	43,00	428,00	68,00	**35,00**
20/07/2017	7,42	54,54	41,00	348,00	60,00	**35,00**
21/07/2017	7,41	54,41	27,00	348,00	54,00	**35,00**
24/07/2017	7,42	52,68	24,00	344,00	51,00	**30,00**

25/07/2017	7,52	53,54	21,00	316,00	49,00	**35,00**
26/07/2017	7,41	53,93	29,00	308,00	48,00	**35,00**
27/07/2017	7,40	51,60	33,00	370,00	52,00	**35,00**
28/07/2017	7,50	52,82	26,00	322,00	44,00	**35,00**

From these results, we modeled the optimal dose of alumina sulfate according to the raw water parameters. Several regression models (multiple linear regression and degree 2 polynomial regression) were performed using Xlstat software in order to choose the best one. The results of the different models are shown in table 6.

Table 6:- Results of the different regression models on Xlstat.

Regression	***Model***	***Coefficient of determination***
Linear multiple	$Y = pr_0 + \sum_{i=1}^{k} pr_i X_i$	$R^2 = 51,2\%$
Nonlinear (polynomial of degree 2)	$Y = pr_0 + \sum_{i=1}^{k} pr_i X_i + \sum_{i=1}^{k} pr_{k+i} X_i^2$	$\mathbf{R^2 = 70,8\%}$

Y: model response (optimal dose of SA);Pri: model coefficients or parameters;
Xi: model variables (respectively pH, conductivity, turbidity, color and SS);
From these results, we note that the nonlinear regression gives us the best coefficient of determination (70.8%), therefore the best model.

Results and interpretation of nonlinear regression:
The first table of results table 7provides simple statistics on the selected data. It also corresponds to the scope of the model. The second table table 8 gives the model's adjustment coefficients, including the R^2 (coefficient of determination) which gives an idea of the percentage of variability of the dependent variable, explained by the explanatory variables. The closer this coefficient is to 1, the better the model. The sum of the squares of the residuals (SCE) is the criterion used by Xlstat to fit the model.

Table 7:- Descriptive statistics.

Variable	Observations	Minimum	Maximum	Average	Standard deviation
Dose of AS	54	25,000	45,000	36,574	3,340
pH	54	6,780	7,560	7,396	0,128
Cond	54	39,270	74,320	57,850	7,283
Turb	54	9,000	168,000	44,500	28,735
Color	54	128,000	964,000	373,944	149,055
MES	54	9,000	186,000	55,963	30,663

Table 8:- Adjustment coefficients.

Observations	54,000
DDL	43,000
R^2	**0,708**
SCE	172,763
MCE	4,018
RMCE	2,004

DDL: Degree of freedom of the model; R^2: Coefficient of determination of the model; SCE: Sum of the squares of the errors (or residuals) of the model; MCE: Mean of the squares of the errors (or residuals) of the model; RMCE: Root of the mean of the squares of the model errors (or residuals).
In our case, 70.8% of the variability is explained by the five variables, which is a good result.
Table 9provides details of the model coefficients after adjustment.

Table 9:- Model coefficients.

Parameters	Coefficients	Standard error

constant	-2360,7353229	472,3083566
pH	635,5976267	127,1670902
Cond	2,4443765	1,0168549
Turb	0,0782910	0,0533247
Coul	-0,0461640	0,0248788
MES	0,1113887	0,0673656
pH^2	-43,4717785	8,7932290
$Cond^2$	-0,0187780	0,0084018
$Turb^2$	0,0003030	0,0004564
$Coul^2$	0,0000515	0,0000369
MES^2	-0,0010206	0,0005969

We see from the results of Table 9 that the pH coefficient is higher than the other coefficients. This high value means that the pH variable has a significant effect on the optimal dose of alumina sulfate. The model equation is: $Dose\ of\ SA = -2360{,}735 + 635{,}597pH + 2{,}444Cond + 0{,}078Turb - 0{,}046Coul + 0{,}111MES - 43{,}471pH^2 - 18{,}778 \times 10^{-3}Cond^2 + 3{,}030 \times 10^{-4}Turb^2 + 0{,}515 \times 10^{-4}Coul^2 - 10{,}206 \times 10^{-4}MES^2$.

Residue analysis:

Residue analysis was performed with Xlstat. The experimental results are compared to the model predictions. The residue is the difference between these two values. Figure 3 shows the graphical representation of the residuals as a function of the optimal dose of SA predicted by the model.

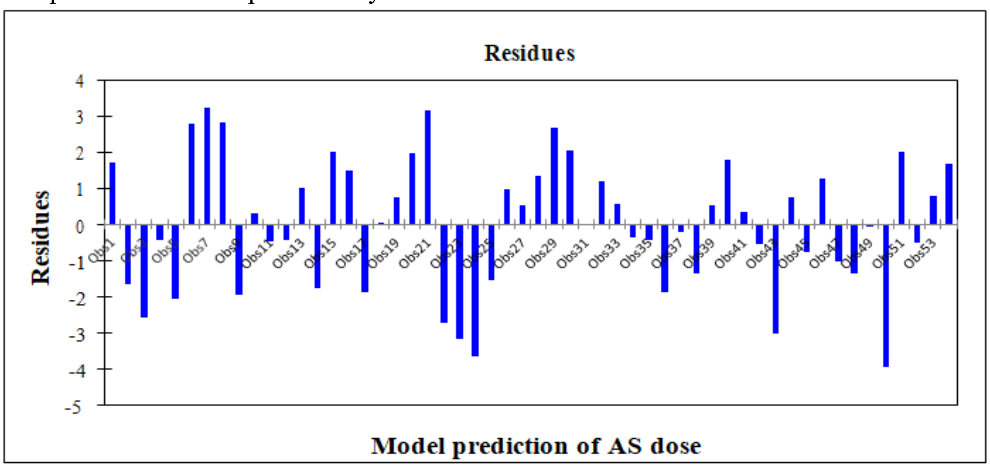

Figure 3:- Residues as a function of the optimal dose of AS predicted by the model.

It is observed that the residues are distributed randomly according to the optimal dose of AS, hence the lack of correlation between these two values.

Residue Normality Test: Anderson-Darling Test:

Analysis of the Anderson-Darling test for normality performed from Xlstat provided the results summarized in table 10.

Table 10:- Anderson-Darling test (Residues).

Variable	Observations	Minimum	Maximum	average	Standard deviation
Residues	54	-3,954	3,240	0,000	1,805
A^2	0,255				
p-value	0,717				
Alpha	0,05				

Interpretation of the test: Null hypothesis (H0): the variable from which the sample comes follows a normal distribution. Alternative hypothesis (Ha): the variable from which the sample comes does not follow a normal distribution. Since the calculated p-value is greater than the threshold significance level alpha = 0.05, the null hypothesis H0 cannot be rejected.

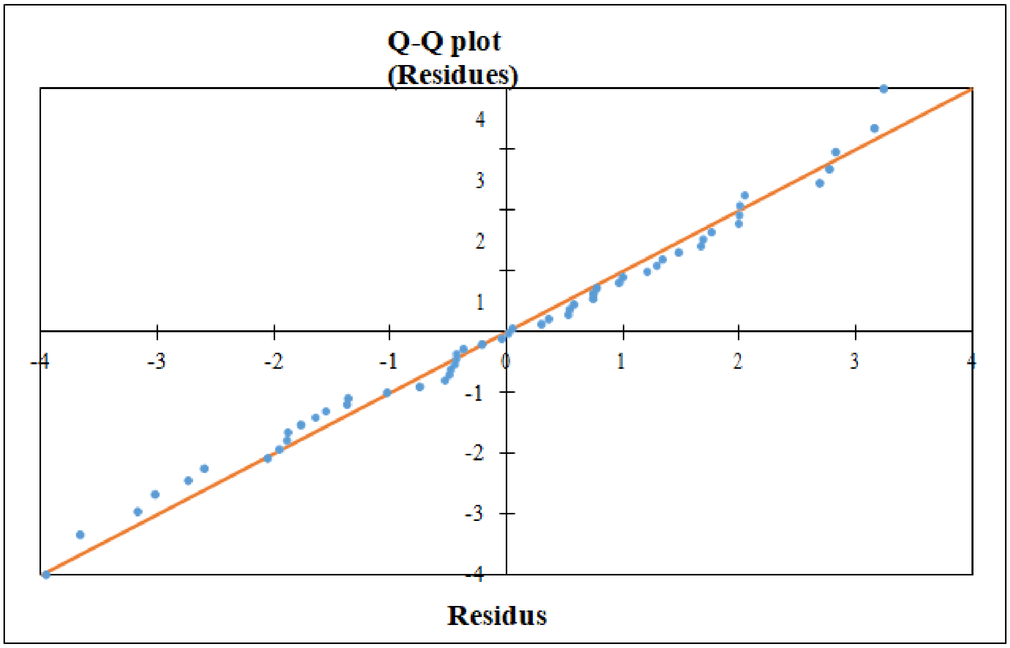

Figure 4:-Residue Normality Test of the Optimal Dose of AS.

The Q-Q plot makes it possible to compare the distribution function of the sample (on the x-axis) with that which a normal distribution of the same mean and same variance (on the y-axis) would have. In the case of a sample resulting from a normal distribution, one should observe an almost perfect alignment with the first bisector of the plane. Otherwise deviations must be observed. In our case, all the points representing the residuals are almost aligned. Therefore, the residuals are distributed according to a normal distribution, confirming Anderson Darling's test of normality.

Design of a program for calculating the optimal dose of alumina sulfate:

The design of the program for calculating the optimal dose of alumina sulfate essentially consists of two parts, which are:

1. Entering the values of the raw water parameters and
2. The calculation of the optimal dose which is carried out using the model obtained previously.

Indeed, we have created in the program a part where we can enter the analytical parameters of the raw water (pH, conductivity, turbidity, color, and suspended matter). Then a part for calculating the optimal dose of alumina sulfate. This calculation is carried out using the Calculate button of the program. Finally, we have the Restart and Exit buttons, which are respectively used to reset the program to perform another calculation or to quit (close) the program.

The result of the calculation is automatically displayed below the program if no error is made. Otherwise, an error message is automatically displayed notifying the executor that it has made an error in entering the raw water parameters. The interface of the calculation program is shown in figure 5.

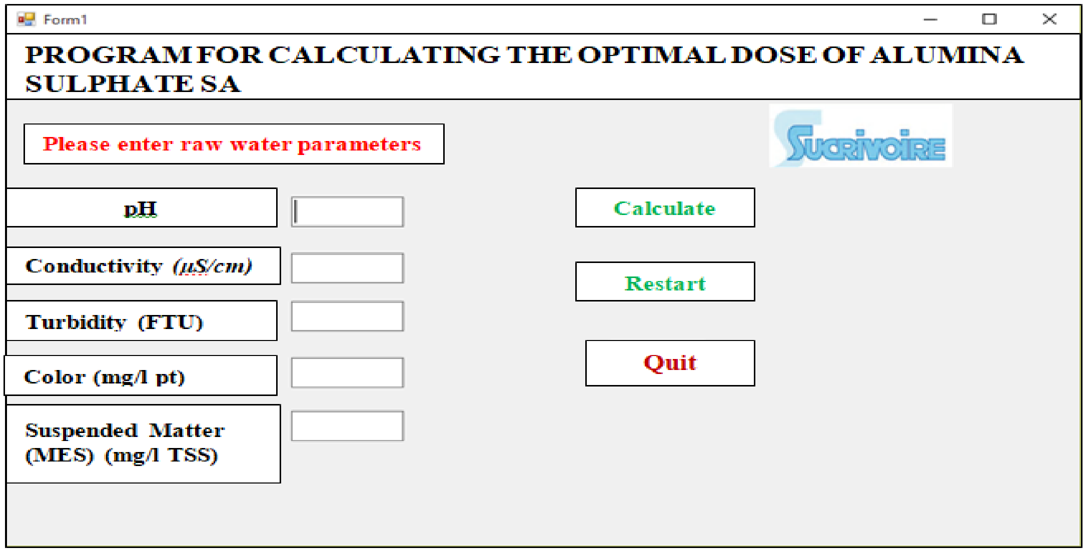

Figure 5:- Interface of the program for calculating the optimal sulphate dose.

Verification of the model on the process (station):

From the model and the program for calculating the optimal dose of coagulant, we have for each quality of raw water, the optimal dose of coagulant that would be needed to have good quality drinking water. Indeed, when we have a raw water quality, we analyze it in order to determine its parameters (pH, turbidity, color, conductivity and suspended matter). After determining the parameters, the calculation program gives us the optimal coagulant dose for the treatment. Thus, with this optimum value, a calculation of the dosing flow rate of the pump is carried out according to the discharge flow rate of the raw water arriving at the station and the preparation concentration of the alumina sulfate, according to the formula: $Q_P = (Qe \times T)/C$.Q_P = flow rate of the metering pump (l/h); Qe = raw water discharge rate (m^3/h); T = Optimal coagulant treatment rate (g/m^3); C = preparation concentration of alumina sulfate (g/l). Knowing the maximum flow rate of the metering pump (100% open), we determine the opening of the pump necessary to obtain the Q_P flow rate.The results obtained on the process are presented in table 11.

Table 11:- Model verification test results on the process.

Date	**Location**	**Dose of AS**	**Water quality parameters**					**settling time**
			pH	**Cond**	**Turb**	**Color**	**MES**	
10/08/2017		Raw water	7,44	58,23	18	244	34	
	Labo (Jar-Test)	**35 g/m^3**	6,30	78,38	0	6	2	10 min
	Station		6,54	67,90	0	7	3	24 h
18/08/2017		Raw water	7,35	60,53	14	193	23	
	Labo (Jar-Test)	**35 g/m^3**	6,31	79,84	0	5	3	10 min
	Station		6,68	66,26	0	8	4	24 h
23/08/2017		Raw water	7,35	50,32	20	310	42	

	Labo (Jar-Test)	**35 g/m³**	6,25	71,26	0	8	1	10 min
	Station		6,65	64,37	7	32	8	2 h
25/08/2017		Raw water	7,40	54,61	92	681	130	
	Labo (Jar-Test)	**40 g/m³**	6,20	74,98	0	6	5	10 min
	Station		6,65	66,67	10	45	12	2 h

In view of the results of this table, we see good elimination of turbidity, color and suspended matter from raw water at the laboratory level. This therefore corresponds to an optimal dosage of coagulant (alumina sulfate). However, at the station level we observe a good elimination of these same parameters when we have a settling time of 24 hours. But for two hours (2 h) of settling, the results obtained for these parameters do not meet the standards of potability required. This poor removal efficiency could be explained by the fact that the flocs formed during coagulation are not of sufficient size, given the poor agitation of the water during the injection. To overcome this floc size problem, we used a flocculant, which made it possible to form larger flocs. Therefore to allow a faster settling of these. The results obtained with the addition of the flocculant are shown in table 12.

Table 12:- Results of the verification test by adding flocculant to the process.

Date	**Location**	**Dose of AS**	**Dose Flocculant**	**Water quality parameters**					**settling time**
				pH	**Cond**	**Turb**	**Color**	**MES**	
19/09/2017		Raw water		7,45	56,24	60	584	86	
	Labo (Jar-Test)	**40 g/m³**	**1 g/m³**	6,42	78,64	2	8	0	02 min
	Station			6,78	72,51	4	14	2	2 h
21/09/2017		Raw water		7,37	54,42	25	312	32	
	Labo (Jar-Test)	**35 g/m³**	**0,5 g/m³**	6,47	80,25	1	5	0	02 min
	Station			6,82	66,45	3	12	2	2 h

The use of the flocculant allowed us to correct the settling time problem. Indeed, the results obtained at the level of the laboratory as well as those of the station for a settling time of two hours respect for most of the parameters the standards of drinkability.

Discussion:-

Our work revealed that the nonlinear regression gives the best coefficient of determination (R^2 = 70.8%), it follows that the model is very efficient and appreciable. This result is close to that of (Machkor, 2013) who established a second degree polynomial model, developed for the prediction of the dose of coagulant used during the clarification phase in the BAB LOUTA water treatment station with a coefficient of determination (R^2) of the order of 0.8, he concludes that the model found perfectly explains the phenomenon studied. This model (R^2 = 70.8%) better explains the phenomenon studied and makes it possible to predict the optimal coagulant doses to be used according to the parameters of the raw water to be treated, therefore to optimize the treatment processes of said station. Contrary to the work carried out by (Kouamé and Assidjo, 2020),the multiple linear regression carried out in our study reveals insufficiencies to be used as a mathematical model of description of the dose of coagulant according to the parameters of the raw water to be treated with a R^2 = 51.2%. In addition, our study showed that the residues are distributed randomly according to the optimal dose of AS hence the lack of correlation between these two values which is in accordance with the study by (Heddam et al 2012).The elimination efficiency increases up to the optimum dose of 35 mg/l. After this dose, decoagulation occurs. This result is similar to that of (Lounnas, 2009) concluding that the elimination yield increases up to the optimal dose (70 mg/l). After this dose, the opposite effect of alumina sulfate occurs (decoagulation) it is noted that a better efficiency of turbidity removal (88.46%) is obtained. The determination of the coefficients of the model showed that the coefficient of the pH has a higher value than the other coefficients. This high value means that the pH variable has a significant effect on the optimal dose of alumina sulfate. This is in line with the results obtained by (Medjram et al, 2008) affirming that indeed, the addition of an alkaline substance leads to the formation of aluminum hydroxide thanks to the increase in pH resulting in mechanism coagulation.

Conclusion:-

The objective of this work was to improve the quality of natural water intended for human consumption at the SUCRIVOIRE Borotou-Koro drinking station by optimizing the clarification. In this work we have studied more particularly the elimination of turbidity and color (organic matter) which represent a main problem of the station. Therefore, we first determined the optimal doses of coagulant (alumina sulphate) needed to eliminate these parameters as much as possible while respecting the standards of drinkability. Then taking into account the limits of the station, we used a flocculation adjuvant to allow rapid settling of the flocs formed. Finally, given that the optimal dose of coagulant varies with the characteristics of the raw water, we have therefore found a mathematical relationship linking this dose to the different characteristics of the raw water: $Dose\ of\ SA = -2360{,}735 + 635{,}597pH + 2{,}444Cond + 0{,}078Turb - 0{,}046Coul + 0{,}111MES - 43{,}471pH^2 - 18{,}778 \times 10^{-3}Cond^2 + 3{,}030 \times 10^{-4}Turb^2 + 0{,}515 \times 10^{-4}Coul^2 - 10{,}206 \times 10^{-4}MES^2$.

Subsequently, an automatic calculation program for this optimal dose was carried out.

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