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Modeling of water quality for water treatment plant effectiveness

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Abstract

The modelling and computer simulation of quality of water from a municipal water treatment plant was carried out to determine the effectiveness of the plant. This was done by analyzing the raw water and treated water through collation of data when the plant was operated as designed; development and simulation of models using multiple regression analysis was done usingr Microsoft Excel 2007. In developing a model equation, pH was made the dependent variable while the other parameters of water quality were made independent variables such as turbidity, temperature, dissolved oxygen, total hardness, total alkalinity, organic matter and chloride ion. The range of the work was based on the raw water and treated water from the plant for a period of two years, i.e. from January - December 2001, for the production of model equation, and January - December 2000, for the model equation test of the predicted value, respectively. The results showed that the models represented the data with impressive correlation coefficients of 0.99027and 0.99091 respectively. It was also observed that in the two models organic matter and dissolved oxygen were the most significant parameters. These showed that all the models were well correlated and the treated water was assessed to be within the acceptable limits of the World Health Organization's (W.H.O) Standards for drinking water, thus the models developed can be used to determine water treatment plant effectiveness.

Keywords: Modelling; Effectiveness; Simulation; Multiple Regression; Correlation.

1. Introduction

Water is the most basic resource, which is essential to man, animals and plants without which life on earth would have been impossible and industrial activities may never have existed. It is of equal importance with the air we breathe in maintaining the vital processes necessary to life and growth.

Water treatment is a process whereby naturally occurring (raw) water, from a variety of sources is put through a series of steps designed to purify it for the sole purpose of making it potable for human consumption. The extent of treatment required usually depends on the nature (characteristics) of the raw water and treated water quality desired. There are various water quality standard requirements to meet human consumption and one of the most referred to is the World Health Organization (WHO) guidelines for drinking water.

Since the available water is seldom found in conditions that meet potable specifications, a treatment plant is necessary to improve the water quality. Water supply to a community goes through treatment stages and the community water demand is carefully estimated with allowances for population growth. The most suitable raw water source is identified and analyzed, and then a water treatment plant is designed, constructed and operated along with its distribution network to effect the required changes.

When online, a periodic review of plant performance is undertaken to ascertain if the plant is working in accordance with prediction. Record keeping and periodic reviews of plant performance are necessary decision tools when the plant requires expansion or when operational problems arise. Modelling and simulation are inseparable procedures. They include complex activities associated with the construction of a model representing real processes and experimentation with the model to obtain data on the behavior of the system being modelled. In recent time, the modelling and simulation approach has become increasingly unavoidable for solving different kinds of practical problems. The purpose of studying systems through the modelling and simulation approach is to achieve different goals without actually constructing or operating real processes. This application is used to predict or estimate the value of certain parameters or predict the correlations among parameters.

The need to produce potable water within the regulatory standards has rendered the optimal operation of municipal Water Treatment Plant a challenging task. It is noted that virtually all water utilities are looking at improving the operation of the plant so as to keep control of costs and meet stringent water quality regulations. The quality of drinking water is thus influenced by day-to-day decisions of individual operators. It is assumed that an integrated approach through modelling and simulation, to the entire treatment plant can lead to a more efficient operation for plant effectiveness.

In the operation of water treatment plants, the processes are usually optimized individually on the basis of rules of thumb, operator knowledge and experience. However, changes in operational conditions of individual processes can affect subsequent processes and an optimal operation, which can include a number of water quality parameters, costs and environmental impact, are different for every operator.

The situation at Lower Usuma dam water treatment plant, Abuja is not different; thus it becomes expedient that these issues are addressed as would ensure the effectiveness of the operation of the plant.

2. Materials and Methods

2.1 The Water Treatment Processes of Lower Usuma dam water treatment plant, Abuja, Nigeria.

The incoming raw water from the Usuma Dam is treated according to the following sequence to obtain the required quality of treated water for distribution to the network:

i. Aeration
ii. pH Adjustment (Milk of Lime Dosing)
iii. Coagulation
iv. Flocculation
v. Pre-chlorination Disinfection
vi. Settling and Clarification (Pulsator Clarifiers)
vii. Aeration
viii. Filtration through sand (Aquazur v Filter)
ix. pH final neutralization (Lime Water Dosing)
x. Final Chlorination Disinfection.

2.2 Modelling for pH

Models based on multiple regressions of data were considered as follows.

$$Y = a_0 + a_1x_1 + a_2x_2 + \ldots \quad (1)$$

Where: Y is the response or dependent variable

x_i are the independent variables

a_0 is the free parameter

a_i are the regression parameters or regression coefficients.

Using data collected from laboratory analysis (January - December 2001) for the production of model equations, model equations were developed to approximate the influence of independent parameters in raw water and treated water on pH. Similarly, computer simulation was used in testing the models formed with additional sets of data (January - December 2000) for the model equation test of the predicted value.

The dependent variable considered was pH, chosen based on its significance in water treatment plant management. The independent variables were selected based on theory, which were also based on their relationship with the dependent variable. Since the pH of a solution is a reflection of the resultant effects of turbidity, temperature, dissolved oxygen, total hardness, total alkalinity, organic matter, chloride ion, manganese, total dissolved solids, phosphate, sulphate, nitrate, and various ions present, the effects were considered as being controlled by temperature. This is because, the water treatment plant under study has most of its treatment units exposed (open type), and various treatment processes, like aeration, coagulation, clarification, filtration, pre-neutralization and pre-disinfection take place in an open environment, with influence by environmental factors such as temperature. The use of Alum, lime and chlorine as the treatment chemicals for these treatment processes also affect the pH of water at every treatment stage .Also, the solubility of chemical and bacteriological activity is influenced by temperature. The amount of dissolved oxygen is limited by physical conditions, such as water temperature and atmospheric pressure.

These are reflections of alkalinity and acidity of the solution, which are a function of pH.

The independent variables were first selected based on theory, that is based on their relationship with the dependent variables. Then they were screened by the computer using the programme 'S plus' by stepwise regression. They were subjected to screening in such a way that the computer calculated the residual sum of squares or RSS and CP for the model. Then it was also calculated for each independent variable. The computer then eliminated any variable with the least RSS or CP or both which was less than that of the model. A new RSS and CP were calculated again for the model (Set value) and for the remaining variables. The process continued until no variable had an RSS or CP with value less than the Set value (Anyakora, 2008).

Considering all the available laboratory data in line with eq.(1), the model was developed as:

pH = f (Turbidity, Temperature, Dissolved Oxygen, Total Hardness, Total Alkalinity, Organic Matter, Chloride Ion, Total Dissolve Solids, Calcium, Iron, Manganese, Phosphate, Sulphate, Nitrate). . (2)

In the Federal Capital Territory Water Board, the dam, from which the raw water is sourced, is located within the higher altitude area of the territory. This virgin location is of minimal human activity, and free from industrial impurities, thus, the models obtained using eq. (1) and the procedures stated above are

pH = f (Turbidity, Temperature, Dissolved Oxygen, Total Hardness, Total Alkalinity, Organic Matter, Chloride Ion) . (3).

Where; Tu = Turbidity; T = Temperature; D.O = Dissolved Oxygen; TH = Total Hardness; TAC = Total Alkalinity; OM = Organic Matter; Cl^- = Chloride ion;
THus eq. (3) becomes;

$$pH = f(TU, T, DO, TH, TAC, OM, Cl^-) \quad \ldots\ldots 4.$$

For a linear model, eq. (4) can be generated as follows;

$$pH = f(aTU + bT + cDO + dTH + eTAC + fOM + gCl^-) \quad \ldots\ldots 5.$$

With the pH as the dependent variable in eq. (4), and a, b, c, d, e ,f, g, as the coefficients (constants), and Tu, T, DO, TH, TAC, OM, Cl^-, as the independent variables.

Thus, the model eq. (4) can be analyzed using the multiple regression analysis which is an extension of simple linear regression involving more than one independent variable. In order to use multiple regression analysis, eq. (4) was recast as;

$$pH = \alpha + aTU + bT + cDO + dTH + eTAC + fOM + gCl^- \quad \ldots\ldots (6).$$

Where α = Intercept.
Eq. (6) is thus the general equation for all the models.

3. Results and Discussion

3.1 Experimental Data

In developing the model equation only weekly data (with complete data) for all the parameters (when all the treatment and technological processes were as designed) were used. Table 1 presents results of Physio-Chemical analysis of raw water (weekly, January – December 2001)

Table 1: Physio-Chemical analysis of raw water (weekly, January – December 2001)

pH	**TUR** (NTU)	**TEMP** (^oC)	**D.O.** (mg/l)	**T.H.** (mg/l)	**TAC** (mg/l)	**O.M.** (mg/l)	**Cl^-** (mg/l)
7	1	25	4.2	24	22	0.5	26.9
7	1	28	6.6	22	28	0.1	30
6.7	1	26	4	21	22	0.8	25.2
7.4	2	28.5	4.8	24	25	0.4	33.6
7.4	2	30	4.4	26	24	0.1	23.3
7.4	1	29.5	3.2	24	24	0.4	24.1
7	14.7	26.4	4.3	32.4	21.3	1	30
6.9	2.9	25.9	3.9	25	21.3	1	30.3
6.9	3.6	26.7	3.3	24	20.6	0.4	28.2
6.8	2.2	27.7	3.3	26	21.6	0	29.8
3.8	2.6	17.2	0.1	22.6	30.7	0.03	17.9
5.6	2.9	25.9	1.1	24.9	28.4	0.07	18
5.6	2.6	25.5	1.4	27.4	33	0.09	28.4
6.5	3	30.1	1.6	25.7	29.6	0.07	17.2
6.7	6.2	29.1	1.3	14	21	1.1	7.3
6.73	6.2	28.75	0.8	25.1	33.1	1.4	27.9
6.64	3.3	29.04	3.3	23.6	18	0	27.3
6.63	2.94	28.93	2.94	22.57	13.43	1.8	26.4
6.83	2.53	28.36	2.53	21.71	18.57	1.1	25.5
6.69	3.58	28.29	3.58	26.57	18	0.5	28
6.7	1.7	28.2	3.5	23	18	0.7	26.1

Table 2 presents data of Physio-Chemical analysis of treated water (weekly, January – December 2001)

Table 2: Physio-Chemical analysis of treated water (weekly, January – December 2001)

	pH	**TUR (NTU)**	**TEMP (^oC)**	**D.O. (mg/l)**	**T.H. (mg/l)**	**TAC (mg/l)**	**O.M. (mg/l)**	**Cl^- (mg/l)**
	6.9	0	23	5.2	24	18	0.1	25.6
	6.8	1	28	5.1	23	26	0.2	27
	6.7	1	28	4.8	22	22	0	28.1
	6.8	1	29.5	4.1	22	22	0.6	28.6
	6.8	1	30	3.7	26	22	0	29.8
	6.8	1	30	4	22	22	0.1	26.9
	7.1	0.7	26.81	4.19	26	18	0	38.55
	6.82	1.37	27.04	5.51	24.33	20.86	0	34.55
	7.04	1.53	26.96	5.4	22	20.43	0	31.78
	6.82	1.13	27.54	5	21.43	19.86	0	29.8
	6.79	0.57	17.03	0	22.29	24.86	0	25.56
	5.66	1.43	26.21	2.81	24.29	30.57	0.01	29.19
	5.66	1.43	25.61	3.83	26.57	29.29	0	36.71
	6.6	2	30	5.67	26.57	26.43	0	19.87
	6.5	2.6	29	3.1	24	30.8	0.1	35.5
	6.43	*2.43*	*28.75*	*2.48*	*30.43*	*28.57*	*0.2*	*30.53*
	6.38	0.41	28.14	5.86	25.2	15.2	0	30.96
	6.49	1.85	28.14	4.54	23.71	15.57	0	30.23
	6.4	0.37	27.36	4.46	22.57	14.86	0.1	33.87
	6.47	0.39	29	3.73	28.67	13.67	0	28.88
	6.5	0.39	29	3.7	28.7	13.7	0	28.9
W.H.O. LIMIT	6.5-8.5	5	-	-	500	-	-	250

3.2 Simulation Results

Using the weekly data with complete parameters (when all the treatment and technological processes were as designed), the Multiple Regression Analysis using Microsoft Excel 2007 was adopted for the simulation. ANOVA two factors with replica were used. Thus, the values of lower 95% and upper 95% were duplicated.

Table 3 presents the results of the multiple regression analysis for model 1(Raw water)

Table 3: The results of the multiple regression analysis for Model 1(Raw Water)

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.9992							
R Square	0.9983							
Adjusted R Square	0.9262							
Standard Error	0.3328							
Observations	21							

ANOVA								
	Df	*SS*	*MS*	*F*	*Significance F*			
Regression	7	930.0142376	132.8591768	1199.89	3.1E-17			
Residual	14	1.550162378	0.110725884					
Total	21	931.5644						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	0	0	0	0	0	0	0
TUR(NTU)	0.0052	0.035615603	0.146185186	0.88586	-0.0712	0.0816	-0.0711814	0.08159435
TEMP(^{o}C)	0.1894	0.022041913	8.594530662	5.9E-07	0.14216	0.2367	0.1421647	0.2367151
D.O(mg\l)	0.2498	0.076839568	3.251349374	0.0058	0.08503	0.4146	0.0850278	0.41463676
T.H(mg\l)	0.0077	0.037169262	0.20744009	0.83865	-0.072	0.0874	-0.0720097	0.08743053
TAC(mg\l)	0.0088	0.015741804	0.55608854	0.58693	-0.025	0.0425	-0.025009	0.04251665
O.M(mg\l)	0.276	0.204960445	1.346678924	0.19948	-0.1636	0.7156	-0.1635805	0.71561234
Cl^-(mg\l)	0.0047	0.024188554	0.196194036	0.84728	-0.0471	0.0566	-0.0471336	0.05662494

Table 4 presents the results of the multiple regression analysis for model 2 (Treated water).

Table 4: The results of the multiple regression analysis for Model 2 (Treated Water)

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.998							
R Square	0.9959							
Adjusted R Square	0.9228							
Standard Error	0.512							
Observations	21							
ANOVA								
	Df	*SS*	*MS*	*F*	*Significance F*			
Regression	7	901.33	128.76	491.14	1E-14			
Residual	14	3.6703	0.2622					
Total	21	905						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	0	0	0	0	0	0	0
TUR(NTU)	-0.322	0.2296	-1.404	0.1822	-0.815	0.17	-0.81466792	0.1701035
TEMP(^{o}C)	0.1557	0.0544	2.8626	0.0125	0.039	0.272	0.03904134	0.2723357
D.O(mg\l)	0.2895	0.1169	2.4765	0.0267	0.0388	0.54	0.03876892	0.54016213
T.H(mg\l)	-0.016	0.0477	-0.329	0.7467	-0.118	0.087	-0.1179081	0.08650658
TAC(mg\l)	0.0542	0.0266	2.0396	0.0607	-0.003	0.111	-0.00279289	0.11110145
O.M(mg\l)	0.184	0.931	0.1976	0.8462	-1.813	2.181	-1.81276535	2.18073389

Cl^-(mg\l)	0.0206	0.0248	0.8291	0.421	-0.033	0.074	-0.03263497	0.07376696

3.3 Model Equations

Using the model equation 6;

$$pH = \alpha + aTU + bT + cDO + dTH + eTAC + fOM + gCl^{-}$$

The Raw Water Model 1 was generated as follows;

$$pH = 0 + 0.0052065TU + 0.1894399T + 0.2498323\,DO + 0.0077104\,TH + 0.0087538\,TAC + 0.2760159\,OM + 0.0047456Cl^{-}$$

Similarly, the Treated Water Model 2 was generated as follows;

$$pH = 0 - 0.3222822TU + 0.15568852T + 0.28946552DO - 0.0157008TH + 0.05415428TAC + 0.18398427OM + 0.02056599Cl^{-}$$

3.4 Comparison of Experimental and Model pH Values.

Table 5 shows the comparison of experimental and model pH values for raw water.

Table 5: Comparison of Experimental and Model pH Values for Raw Water.

pH (Experiment)	**pH (Model)**
7	7.01
7	6.99
6.7	6.7
7.4	7.39
7.4	7.38
7.4	7.4
7	7.1
6.9	6.91
6.9	6.91
6.8	6.8
6.8	6.79
5.6	5.61
5.6	5.59
6.5	6.51
6.7	6.7
6.73	6.7
6.64	6.65
6.63	6.62
6.83	6.81
6.69	6.7
6.7	6.7

CORRELATION COEFFICIENT = 0.99027967

Table 6 presents the comparison of experimental and model pH values for treated water.

Table 6: Comparison of Experimental and Model pH Values for Treated Water

pH (Experiment)	pH (Model)
6.9	6.9
6.8	6.85
6.7	6.71
6.8	6.75
6.8	6.8
6.8	6.81
7.1	7
6.82	6.8
7.04	6.9
6.82	6.81
6.79	6.73
5.66	5.65
5.66	5.6
6.6	6.6
6.5	6.52
6.43	6.44
6.38	6.37
6.49	6.49
6.4	6.41
6.47	6.47
6.5	6.6

CORRELATION COEFFICIENT = 0.99091647

Table 7 presents the result of Weekly Microbial Analysis (Total Coliform) of Raw and Treated Water (January – December 2001)

Table 7: Result of Weekly Microbial Analysis (Total Coliform) of Raw and Treated Water (January – December 2001)

Month	Raw Water (MPN/100 ml)	Treated Water (MPN/100 ml)
January	25.0 16.0 25.0 25.0	0 0 0 0
February	25.0 25.0 25.0 25.0	0 0 0 0
March	25.0 13.0 16.0 5.1	0 0 0 0
April	9.2 6.0 2.5	0 0 0

	25.0	0
May	25.0 1.1 2.2 2.4	0 0 0 0
June	10.0 25.0 25.0 16.0	0 0 0 0
July	12.7 2.2 2.2 2.4	0 0 0 0
August	1.0 3.5 2.7 8.2	0 0 0 0
September	6.0 8.6 10.1 25.0	0 0 0 0
October	25.0 16.0 5.2 3.8	0 0 0 0
November	6.2 5.1 9.1 9.1	0 0 0 0
December	4.0 4.8 1.9 2.5	0 0 0 0

Fig. 1 presents the Response surface plot for model 1.

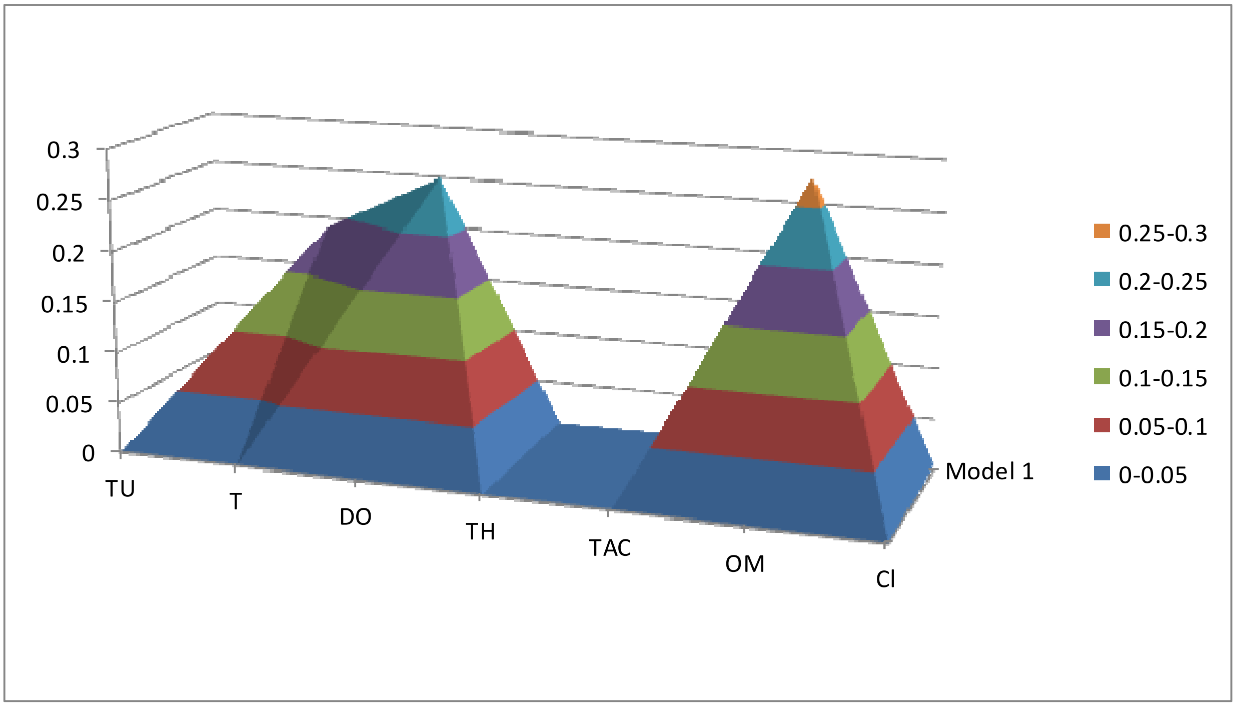

Fig. 1: Response surface plot for model 1.

Fig. 2 presents the Response surface plot for model 2.

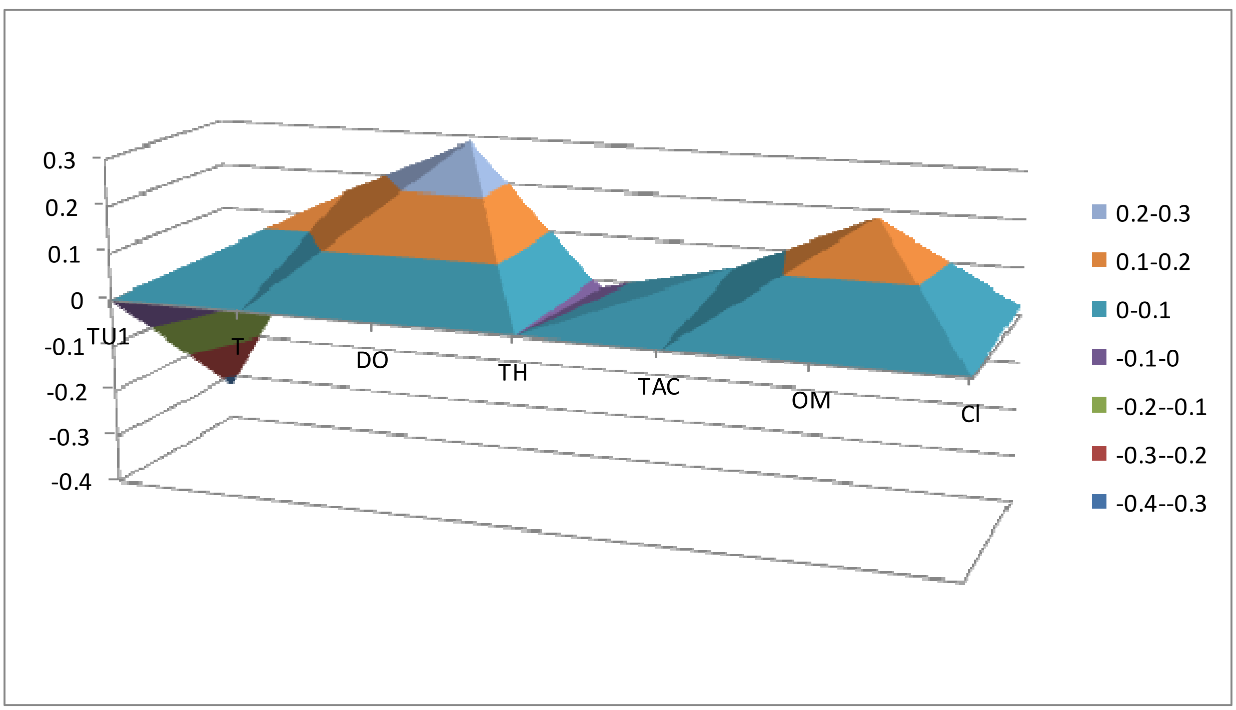

Fig. 2: Response surface plot for model 2

From table 1 the pH values fell within the range of 3.8 and 7.4. For cases of low pH, the use of lime for pre-neutralization process increases the pH acceptable range for effective coagulation. The introduction of other treatment chemicals ,like chlorine also affects the pH which is corrected by the use of lime for post neutralization process to correct the pH to acceptable standard limits, thus the reason for pH values of raw water in table 1 being similar to the values in table 2 and other notable variances in tables 1 and 2.

As expected, the result from Table 2 showed that most of the parameters are within the acceptable limits of the WHO Standards. Five pH values, 3.8, 5.66, 5.66, 6.38, 6.4, out of twenty one are outside WHO limit (6.5 – 8.5). This is as a result of operational lapses, e.g. insufficient use of treatment chemicals or due to human error while carrying out the laboratory analysis.

It is observed from Table 7, that a maximum value of 25/100ml for coliform density was achieved for the raw water. This is within the WHO specifications for river water used as raw water for domestic use for the period of study. Similarly, in figure 7, the bacteriological analysis of zero coliform (MPN/100 ml) recorded for treated water is within acceptable standard limits of absence in 100 mls.

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From the simulation result of model 1, it is shown that turbidity, temperature, dissolved oxygen, total hardness and chloride ions, increased with increasing pH. Alkalinity positive value effect on pH is in accordance with theory, because the more alkaline a substance is the higher is the pH (Abiabio, 1992). Additionally, the presence of total hardness in form of $CaCO_3$ (from raw water) in water enabled the noted positive correlation.

From the model equation, it is shown that there is no free parameter (intercept). This is an indication of the value of the dependent variable, pH when the independent variables are zero. In this case however, the variables do not have value of zero; thus, the free parameter is meaningless (Neter et al, 1983).

It is observed that the dissolved oxygen and organic matter have the highest coefficients of about 0.24 and 0.27 in model 1 respectively while their values in model 2 are 0.28 and 0.18 respectively. This implies that those parameters affect the model more than any other parameters in the model.

Also from Table 3, it can be observed that model 1 is well correlated. This is termed by the fact that the data exhibited a lower 95% confidence level for most of the variables, which are much smaller than their corresponding coefficients (values). The correlation coefficient, R^2, and R^2adj.are 0.9983 and 0.9262 respectively, also prove the goodness of the model.

From table 5, it is shown that the comparison of experimental and simulated pH have close values except in a few cases where large differences are noticed. This could be due to some experimental errors during the analysis. The correlation coefficients of 0.9902 and 0.9909 for models 1 and 2 respectively, show that they are well correlated.

The regression output has three components:

- Regression statistics table
- ANOVA table
- Regression coefficients table.

(1) Interpretation of Regression Statistics Table

From Table 3, the Multiple R value of 0.9992 and R^2 value of 0.9983 respectively showed perfect positive correlation. These results suggest there is a good fit to the data, hence the pH value, which is high in laboratory pH, is also likely to be high in model pH, while the one with low value in laboratory pH is also likely to be low in model pH. There may be differences in individual points but a definite trend of relationship can be observed, as shown in table 5. R^2 value of 0.9262 means that 92.62% of the variation in pH can be explained by the independent variables.

From table 4, the Multiple R value of 0.998 and R^2 value of 0.9959 respectively showed perfect positive correlation and follow a similar trend as in table 2.

(2) Interpretation of ANOVA Table

From table 3, F value gives the overall F-test value, F as 1199.89, since this value is big compared to the p value of $3.1E^{-17}$. The null hypothesis here is that the group means are all equal, and the alternative hypothesis is that they are not. A big F, with a small p-value, means that the null hypothesis is discredited and the means are significantly different, thus, the intercepts are not equal to zero and there is significance difference among the means. (Anthony, 2012)

From table 4, F value is 491.14 and the significance F is $1E^{-14}$, thus null hypothesis is discredited as above. From table 3, the column labeled significance F has the associated P-value of $3.1E^{-17}$. Since $3.1E^{-17} < 0.05$, we reject null hypothesis at significance level 0.05.

(3) Interpretation of Regression Coefficients Table

Column "Coefficient" gives the least squares estimates of the population coefficient. From table 3, the coefficients have negative values with dissolved oxygen having the highest value (high effect) and chloride ion having the least value (less effect) on pH with values 0.276 and 0.0047 respectively. In model 2, the dissolved oxygen and organic matter have the highest coefficients of 0.28 and 0.18 respectively. This implies that those parameters affect the model more than any other parameters in the model. Also, the turbidity concentration, a parameter to be reckoned with, is most significant with the negative effect on pH in model 2.

Also, the simulation result of model 2 showed a similar trend with model 1, but turbidity and total hardness exhibited negative effect on pH. This is as a result of post - chlorination and post - disinfection processes through the use of lime and chlorine (Anyakora, 2008). It is observed that the total hardness showed a negative correlation with alkalinity contrary with literature, this is considered to be the alkalinity mask effect (Bajpai et al, 1982).

Column "Standard error" gives the standard errors (i.e. the estimated standard deviation) of the least squares estimates of the population coefficient.

Column "t Stat" gives the computed t-statistic for null hypothesis as given in the previous column.

Column "P-value" gives the p-value for test of null hypothesis.
Columns "Lower 95%" and "Upper 95%" values define a 95% confidence interval for the population coefficient.

From Tables 3 and 4, it can be observed that model 1 and 2 are well correlated by the data due to the fact that the lower 95% confidence for most of the variables is much smaller than their corresponding coefficients (values).

Test hypothesis of zero slope coefficient ("test of statistical significance")

From tables 3 and 4, all the parameters have p values > 0.05, thus ,they are therefore statistically insignificant at significance level $\alpha = 0.05$ as $p > 0.05$, except temperature and dissolved oxygen

Overall test of significance of the regression parameters

From the ANOVA table in table 4, the F-test statistic is 1199.89 with p-value of $3.1E^{-17}$.
Since the p-value is less than 0.05, we reject the null hypothesis that the regression parameters are zero at significance level 0.05.

Figures 1 and 2 show the response surface plot for models 1 and 2 respectively. From the figures, dissolve oxygen and organic matter optimize the response, pH.

4. Conclusion

The following conclusions can be made in respect of modelling of water quality for plant effectiveness;

a. Based on the simulation results obtained, the models help to determine the influence of all available variables (i.e. turbidity, temperature, dissolved oxygen, chloride ion, organic matter, total hardness, and total alkalinity) on pH. They also help to predict their values when all the treatment and technological processes as designed are fully operational.
b. The results showed that the models well presented the data with impressive correlation coefficients of 0.99027and 0.99091 respectively. It was also observed that in the two models, organic matter and dissolved oxygen are values that optimise the response, while temperature and dissolved oxygen were the most significant parameters. These showed that all the models were well correlated and can be used to determine the effectiveness of water treatment plant.
c. Based on the results obtained, it is deduced that the Lower Usuma Dam Water Treatment Plant, Abuja is effective within the period of study. In terms of water quality, it is in conformity with the World Health Organization's (WHO's) Standards. Nevertheless, the little variations observed were as a result of raw water characteristics, treatment processes involved, insufficient data, human error and seasonal changes.

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