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RESEARCH ARTICLE

Modeling Of Hussain City Water Treatment Plant In holly Karbala governorate(HCWTP)

Fatin Abdulkadhium M. alnasrawi
Department of civil Engineering, Karbala University, Karbala, Iraq, 2014

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***Corresponding Author**

Fatin alnasrawi

Abstract

The aim of present study is programming a Performance and efficiency of Hussain City Water Treatment Plant (HCWTP) by using a data fit statistical program version 9, after application limited data from 2013in data fit program had extracted a statistical models, and these models will have been benefitting in any time to estimate the future efficiency for the same plant. The data fit consider one of many important programs used in this branch but it don't take external conditions effects on a plant. in general, a data fit is deem important program, easy application, and it is assist at save the time and cost through the application of this models . So that we need such as these statistical models and its must be found in any plant for application for emergency conditions.
In this study, concluding single and multiple statistical regression models, the regression works are divided to many parts and linked between different variable where in a single regression work is divided to three parts, The result of this work presented in table (1.2, 1.3, 1.4) while the result of multiple regression presented in table (1.5).

INTRODUCTION

1-Introduction:-

1.1 BACKGROUND:-

Clean drinking water is a basic human need. Therefore, The National Environmental Standard for Sources of Human Drinking Water aims to reduce risks to the quality of water bodies from which the source water for drinking-water supplies is taken. water in nature it always contains impurities; For this reason we needs water treatment plants to purity water from this pollutant (Mackenzie,et al.,2004;Mohammed,et al.,2012).
The principal objective of water treatment plant is to produce water satisfied a set of drinking water quality standards at a reasonable price to the consumers. A water treatment plant utilizes many treatment processes to produce water of desired quality. These processes generally fall into board divisions: unit operations and unit processes(Qasim,et al.,2000),.
Basic considerations for developing a treatment process train depend upon the characteristics and seasonal variation in the raw water quality, regulatory constrain, site conditions, plant economics, and many other factors(Mackenzie,et al.,2004;Qasim,et al., 2000) .

1.2 THE PURPOSE:-

The main objective of water treatment is to purify the polluted water and make it fit for the human consumption, through the removal undesirable constituents from water supply. To explain more, there are three basic purpose of Water Treatment Plant are as follows:

Production of biologically and chemically safe water is the **primary goal** in the design of water treatment plants; anything less is unacceptable. A properly designed plant is not only a requirement to guarantee safe drinking water, but also skillful and alert plant operation and attention to the sanitary requirements of the source of supply and the distribution system are equally important. **The second basic objective** of water treatment is the production of water that is appealing to the consumer. Ideally, appealing water is one that is clear and colorless, pleasant to the taste, odorless, and cool. It is none staining, neither corrosive nor scale forming, and reasonably soft.

The third basic objective of water treatment is that water treatment may be accomplished using facilities with reasonable capital and operating costs. Various alternatives in plant design should be evaluated for production of cost effective quality water (CPCB**,** 2002)..

Either the purpose of this research is modeling the of Hussain city water treatment plant in holly Karbala governorate(HCWTP) by using the data fit statistical program and concluding single and multiple statistical regression models. Single regression work was divide to three parts, first regression model linked between discharge of raw water and concentration of impurities of raw water; for this state 13 statistical models for input impurities to plant had extracted. but in second regression model linked between removal efficiency for impurities and operated discharge of plant; also had been extracted 13 statistical models for impurities removal efficiency of plant. Finally; third regression model connected between overall efficiency of plant and operated discharge of plant; one statistical regression model extracted. A Second part of regression work; a multiple regression in three forms were used. from these models are selected model that give the best fitting of data. In (HCWTP) selected one best fitting model Because of the Coefficient of Multiple Determination $R^2 = 0.999$

1.3 DATA COLLECTION:-

In order to knowledge the quality water of the HCWTP for 18 physicochemical and microbial parameters were evaluated during one year and which that 2013 . a 3 samples from influent to WTP and 3 samples from effluent from WTP were taken and analyzed in one month. Then, the average monthly of these three tests for parameters were used in statistical work. a Standard Deviation (δ) for average monthly of data were determine show in table(1.1). The measured parameters are: Temp. Tur. ,Ph, E.C., Alk , T.H , Ca , Mg , Cl ,SO4, TDS , TSS , Na , K , Al , total Coliform, E.coli and Plant Count . Finally, these parameter were tested in water laboratories of directorate water in holly Karbala governorate**.**

Table(1.1) The Standard Deviation for the average Monthly data used in this research

pollutant	Raw water				Treated water			
	range		average	δ(Standard Deviation)	range		average	δ(Standard Deviation)
	Max.	Min.			Max.	Min.		
TUR.	48	8.5	20.417	12.495	4.5	2.65	3.471	0.508
PH	8.4	7.7	7.958	0.1982	8.125	7.5	7.7254	0.181
E.C.	1341.25	1136	1209.304	52.198	1328.75	1113.5	1172.417	56.66
ALK.	145	110.5	127.84	11.604	138	104	122.021	11.47
T.H.	453.3	379	414.379	27.941	439.25	373.7	406.221	24.92
Ca	118	87.3	102.175	11.5013	114	82.7	97.6	10.505
Mg	47	30.75	38.77	3.9876	48	33	39.63	3.827
CL	137.73	106	119.446	10.742	141	109	122.183	11.41
SO_4	361	264.3	303.317	30.121	369	263.25	308.69	32.262
TDS	861	721	772.917	36.06	850.5	712.5	751.067	36.48
TSS	54.5	24.5	33.49	9.156	10.7	5.3	7.592	1.674
Na	106.5	72.51	88.731	10.331	107	72.5	88.78	10.51
k	4.5	2.95	3.6	0.388	4.4	2.8	3.442	0.3442
Al.	0	0	0	0	0.045	0.0075	0.027	0.0118

2. COMBINATIONS OF TREATMENT PROCESSES:-

Status of the Hussain city water treatment plant HCWTP is located in the southeastern region of the holly Karbala city. It covers 600,000 inhabitants right now, It was designed with a design capacity 8000 m^3/hr but the average operated inlet flow rate is about 8270 m^3/hr and it's includes at a different units as follow:-

2.1 Intake Structure:-

Intakes are structures constructed in or adjacent to lakes, reservoirs, or rivers for the purpose of withdrawing water (Davis,2010). their primary purpose of Intakes to selectively withdrew the best quality water while excluding coarse sediment, and other objectionable suspended matter, that achieved by supplied the intake with screen technology.(Qasim,et al,2000)

Intake of (HCWTP) is located on the Hussainia River, The total energy of each pump is 1450 m^3/ h, the pressure of the head of the water is20 m. in the summer season , the pump is working at maximum capacity because the growing consumption during that period.

2.2 The Purification Process:-

***2.2.1 The rapid mixing tanks*:-** a large portion of the suspended particles in water are sufficiently small that their removal in a sedimentation tank is impossible at reasonable surface overflow rate and detention times. Suspended particles at lower end of the size spectrum do not readily settle, colloidal particles as a result of their small size, a very large ratio of surface area to volume(Steel,Terence,1979) .These are colloidal particles can be sedimentation only after physical and chemical condition. Chemical conditioning of colloids is known as *Coagulation* and involves the addition of chemicals that modify the physical properties of colloids to enhance their removal.(Qasim,et al,2000).the rapid mixing can be accomplished with in a tank with the vertical shaft mixer or within pipe specialized mixing system (Mackenzie,Susan,2004).

In the (HCWTP) two rapid mixing basins which dimensions (10m*5m). The rapid mixing basin the first step in (HCWTP), a detention time less than 1 min, A coagulant, usually an aluminum (i.e., alum) is added to the tank at high mixing speed , and mixing by hydraulic power to the flow of water.

2.2.2 *Flocculation*:- is Physical condition its involve bring the particles into contact so that they will collide, stick together, and grow to a size that will readily settle or filter out. Enough mixing must be provided to bring the floc into contact and to keep it from settling in the flocculation basin. Too much mixing will shear the floc particles so that the floc is small and finely dispersed. Therefore, the velocity gradient must be controlled within a relatively narrow range(Davis,2010).flocculation and sedimentation may be combined in a single unit and the sludge blanket of tank very popular for water treatment purpose(Tebbutt,1998), a combined unit exit in the(HCWTP) the diameter of flocculation tank is (12m) and the floc agglomeration under velocity gradient.

2.2.3 *Sedimentation tanks*:- in a (HCWTP) is a final stage of purification, the water after flocculation tank incoming to the circle sedimentation tank that numbers and diameters of sedimentation tank is (8, 40m) respectively and utilizes gravity to remove the discrete particle from water, the installation from the top makes it work sweeping clays floating after that the water pumped to the filtration tank.

2.3 Filtration:-

Filtration processes are used principally for the removal of particulate material in water including clays and silts, micro-organisms and precipitates of organics and metal ions. The process of filtration involves passing water, containing some physical impurity, through a granular bed of media at a relatively slow velocity.

Filters can be classified according to the medium type as:

1. Single (mono.) medium filters. 2. Dual media filters. 3. Mixed-media filters.(Simon, Jefferson,2006) .

There are two types of filter which are used in water treatment plant: Slow sand filters and rapid sand filters. (Al-Tufaily,Entesar,2010)

in a (HCWTP) are used a rectangular slow sand filter tank which dimensions (8m*10m), with a suitable arrangement of pipework to collect the filtered water and when necessary provide the water/air for the backwash. Effective size of sand Filters out the Standard Specifications because Ministry of Municipalities is forcing treatment plants to equip the sand from quarries of their own, therefore the plant don’t have high efficiency to remove the pollutant from water in this stage.

2.4 Disinfection:-

Disinfection is normally the last step in purifying drinking water. Water is disinfected to destroy any pathogens which passed through the filters (Hong,2006) , Chlorine is the one of the most common disinfection chemical that being used(ElDib.,Elbayoumy,2003). for a(HCWTP) After the drawing water from the filters stage passes to the sterilization basin where added chlorine before the passage of water into a reservoir of pure water, after all that the water is pumped to Water networks.

3.*The Regression Analysis Technique:-*

regression analysis was done by using "Data Fit" program version 9.0, a non-linear regression models were used for each variable. The relationship between a single variable Y, called dependent variable, and one or more independent variables, X1, … Xn are explained or modeled by a single and multiple regression analysis respectively.

3.1 The Dependent Variable (Y) and The Independent Variables(X)

In the present work, has been used single and multiple regression for modeling(HCWTP) :

3.1.1 Single Regression:- The proposed Non. Linear single regression model which used in all single regression is $y = a\,x^{b}$ ……..(1)

Where:-

y = dependent variables. x = the independent variables, and a,b = model coefficients.

In the single regression for modeling a presence study were divided into three part as follow:-

-First Single Regression Model:- relationship of this model connected between pollutant concentration of raw water and discharge of raw water .After application the result from Data fit of this study presented in table(1.2)

table (1.2) the result of regression of influent concentration of pant

POL.	Model	Coefficient of Multiple DeterminationR^2	Standard Error of the Estimate	Correlation Matrix		
				Y	X	
TUR.	$y = 5.98606\ x^{0.48733}$	0.9689	11.95	0.4186	1	X
				1	0.4186	Y
PH	$y = 7.74641\ x^{0.010992}$	0.95898	0.202	0.1511	1	X
				1	0.1511	Y
E.C.	$y = 1299.05\ x^{-0.02928}$	0.93922	50.8	-0.3696	1	X
				1	-0.3696	Y
ALK.	$y = 163.107\ x^{-0.100043}$	0.9721	2.583	-0.6116	1	X
				1	-0.6116	Y
T.H.	$y = 459.6263\ x^{-0.0424}$	0.9155	11.98	-0.1692	1	X
				1	-0.1692	Y
Ca	$y = 96.137\ x^{0.02484}$	0.9139	11.72	0.2367	1	X
				1	0.2367	Y
Mg	$y = 55.4362\ x^{-0.14723}$	0.9186	2.58	0.7146	1	X
				1	0.7146	Y
CL	$y = 119.972\ x^{-0.0018}$	0.90013	11.265	-0.1781	1	X
				1	-0.1781	Y
SO_4	$y = 365.453\ x^{-0.07644}$	0.9714	28.756	-0.2385	1	X
				1	-0.2385	Y
TDS	$y = 839.389\ x^{-0.03375}$	0.95878	34.69	-0.404	1	X
				1	-0.404	Y
TSS	$y = 19.236\ x^{0.2236}$	0.9962	8.61	0.432	1	X
				1	0.432	Y
Na	$y = 102.0325\ x^{-0.05721}$	0.97609	10.415	-0.3641	1	X
				1	-0.3641	Y
K	$y = 5.0265\ x^{-0.1374}$	0.9035	0.286	-0.7018	1	X
				1	-0.7018	Y

*Y:- concentration for each pollutant in raw water(mg/l).
X:- discharge of raw water(m^3/sec);

-Second Single Regression Model:- relationship of this model connected between the removal efficiency for each pollutant and operated discharge for (HCWTP). The result of study presented in table(1.3)

Table (1.3) result of removal efficiency of pollutant.

POL.	Model	Coefficient of Multiple Determination R^2	Standard Error of the Estimate	Correlation Matrix		
				Y	X	
TUR.	$y = 10.611\ x^{2.3977}$	0.9038	5.325	0.8359	1	X
				1	0.8359	Y
PH	$y = 36.08297\ x^{-3.0831}$	0.9795	1.3561	-0.30082	1	X
				1	-0.30082	Y
E.C.	$y = 0.00396\ x^{7.942}$	0.9117	1.140041	0.6781	1	X
				1	0.6781	Y
ALK.	$y = 4.1285\ x^{0.1214}$	0.900354	1.313	0.0169	1	X
				1	0.0169	Y
T.H.	$y = 1.215\ x^{0.5562}$	0.9032198	0.85433	0.05544	1	X
				1	0.05544	Y
Ca	$y = 24.92\ x^{-2.084}$	0.94663	1.8193	0.21143	1	X
				1	0.21143	Y
Mg	$y = 2.3003E - 005\ x^{11.553}$	0.9367	1.248	0.238	1	X
				1	0.238	Y
CL	$y = 2.3003E - 005\ x^{11.553}$	0.9367	1.248	0.238	1	X
				1	0.238	Y
SO_4	$y = 0.00846\ x^{7.5105}$	09202	1.2734	0.1678	1	X
				1	0.1678	Y
TDS	$y = 0.01491\ x^{6.274}$	0.9241	1.456	0.4736	1	X
				1	0.4736	Y
TSS	$y = 14.825\ x^{1.962}$	0.9605	4.6642	0.80921	1	X
				1	0.80921	Y
Na	$y = 137.865\ x^{-6.6175}$	0.9479	0.97411	-0.2919	1	X
				1	-0.2919	Y
k	$y = 0.8737\ x^{1.9523}$	0.94596	1.7788	0.2169	1	X
				1	0.2169	Y

Y**:-**removal efficiency for each pollutant.

$$\text{Removal Efficiency\%} = \frac{\text{pollutant influent} - \text{pollutant effluent}}{\text{pollutant influent}} * 100 \ldots\ldots.(2)$$

X**:-** operated discharge of plant(m^3/sec);

-**Third Single Regression Model:-** relationship of this mode connected between the removal efficiency of plant for all pollutant and operated discharge for (HCWTP). The result of study presented in table(1.4)

Table (1.4) result of removal efficiency of plant

Model	Coefficient of Multiple Determination R^2	Standard Error of the Estimate	Correlation Matrix		
			Y	X	
$y = 15.8491\ x^{0.76505}$	0.96664	0.71157	0.8169	1	X
			1	0.8169	Y

* Y:- the removal efficiency of plant for all pollutant

$$\text{Removal Efficiencyof plant \%} = \frac{\sum \text{Removal Efficiencyfor all pollutant in one month}}{\text{n}} * 100 \ldots\ldots(3)$$

X:- operated discharge for plant(m^3/sec)

3.1.2 Multiple Regression:- The Non-linear multiple regression models in three forms were used for modeling of Hussain City Water Treatment plant to choose which form gives the best fitting of data, The Proposed Models of Multiple Regression were used as shown :-

$Y= a_1X_1 + a_2 X_2 + a_3 X_3 + a_4X_4 + a_5X_5 + a_6 X_6 + \ldots\ldots\ldots\ldots + a_n X_n + q$…….(4)

$Y= a_1X_1 + a_2 X_2 + a_3 X_3 + a_4X_4 + a_5X_5 + a_6 X_6 + \ldots\ldots\ldots\ldots\ldots + a_n X_n$……(5)

$Y= EXP (a_1X_1 + a_2 X_2 + a_3 X_3 + a_4X_4 + a_5X_5 + a_6 X_6 + \ldots.. + a_n X_n + q)$…….(6)

Where;
Y = dependent variables.
$X_1, X_2, \ldots, X_n$ = the independent variables.
$a_1, a_2, a_3, \ldots a_n$ = are model coefficients, and
q= model constant term.
The result of **regression of (HCWTP)** in table(1.5)

table(1.5) the result of multiple regression for plant removal efficiency

The best data fitting of multiple regression model	R^2	Standard Error
$Y = -1.052X_1 + 4.394X_2 - 1.259X_3 + 0.148X_4 + 0.1596X_5 + 0.338X_6 - 0.31X_7 - 0.754X_8 - 0.327X_9 + 1.886X_{10} + 5.066X_{11} - 0.708X_{12} + 39.488X_{13} - 179.49X_{14} + 9.84X_{15} + 0.871X_{16} + 7.79$	0.999	2.818E-13

where

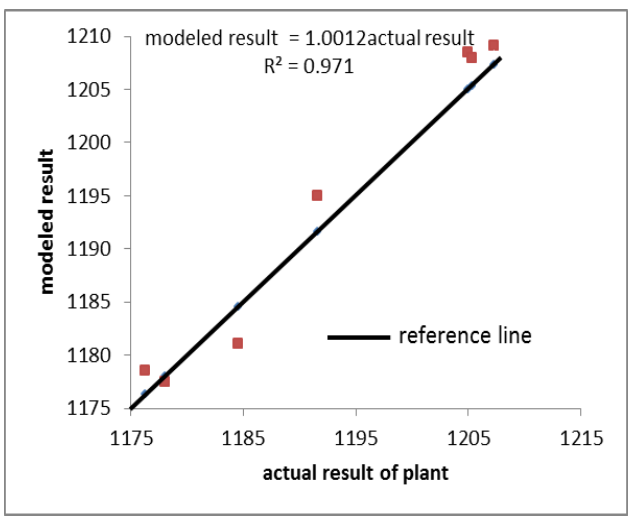
Y	Removal efficiency of plant	X_6	Calcium(mg/l)	X_{12}	sodium(mg/l)
X_1	Turbidity (NTU)	X_7	Magnesium(mg/l)	X_{13}	potassium(mg/l)
X_2	PH	X_8	Chlorine(mg/l)	X_{14}	aluminum(mg/l)
X_3	Electric Conductivity (µS/Cm)	X_9	Sulphate(mg/l)	X_{15}	Operated discharge of plant(m^3/sec)
X_4	Alkalinity (mg/l)	X_{10}	Total dissolved solid(mg/l)	X_{16}	Operated discharge of river(m^3/sec)
X_5	Total Hardness	X_{11}	Total Suspended Solid(mg/l)		

**All concentration of pollutants are treated concentrations influent from plant

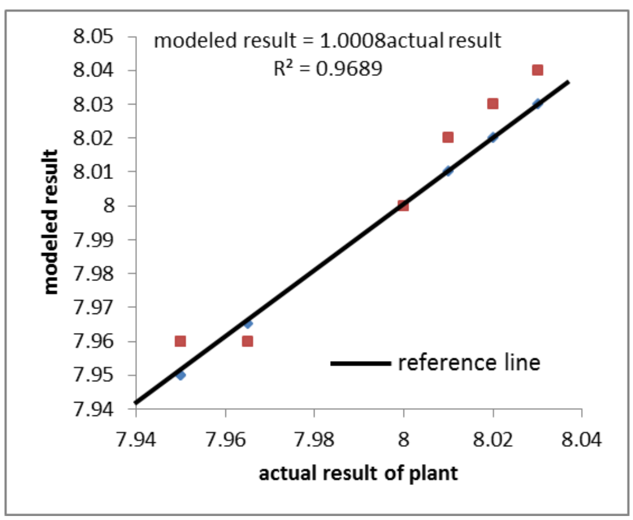
4. Verification of models Results of Data Fit program

To a sure that the result of data fit program are successfully, verification must be done. That achieved by a compression the data fit result for specific condition with actual water treatment plant that worked with same conditions. the data that used for verification were taken from year 2012 . some of statistical models cannot work verification such as (Mg, Cl, SO_4 in table 1.3) because of the removal efficiency for some months which taken from year 2012 equal to zero.

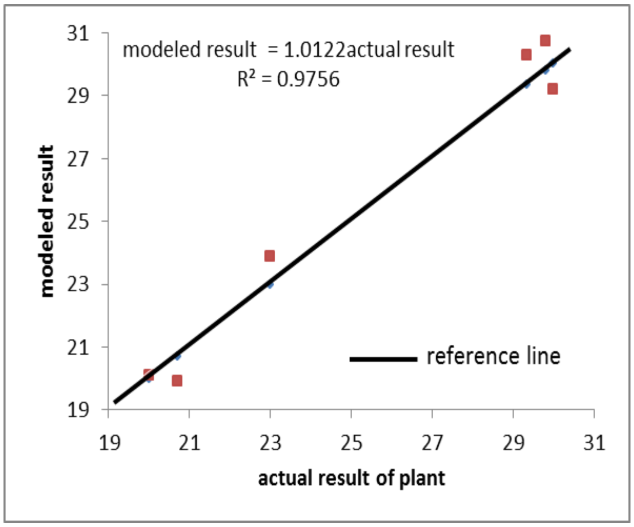
1- The verification of influent concentration models



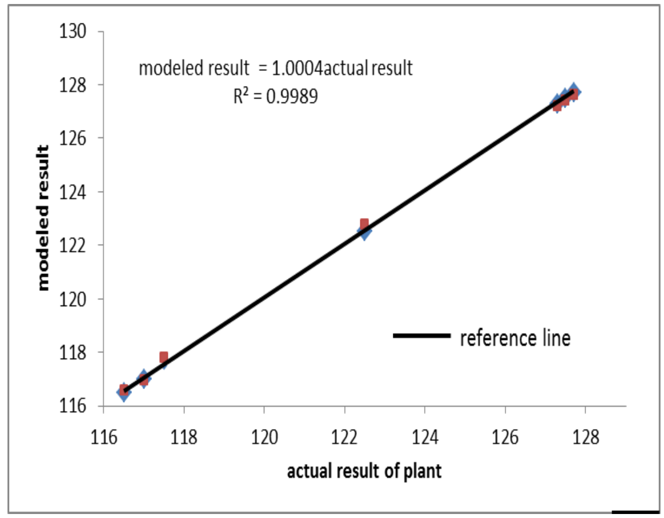
Fig(1.1): Verification of electric conductivity model of treatment plant



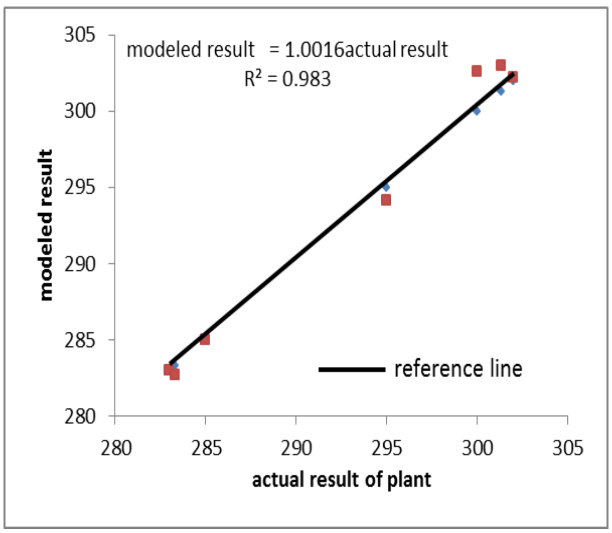
Fig(1.2): Verification of Ph model for treatment plant



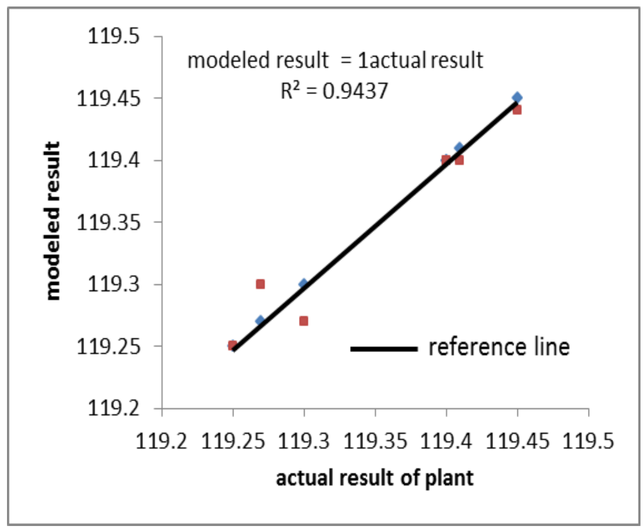
Fig(1.3): Verification of turbidity model for treatment plant



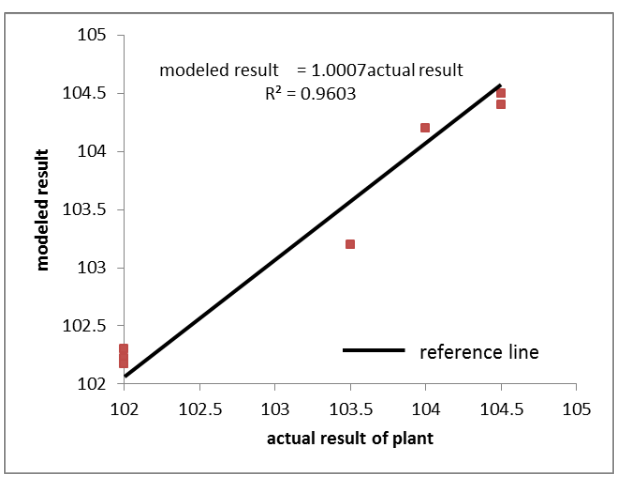
Fig(1.4): Verification of alkalinity model for treatment plant



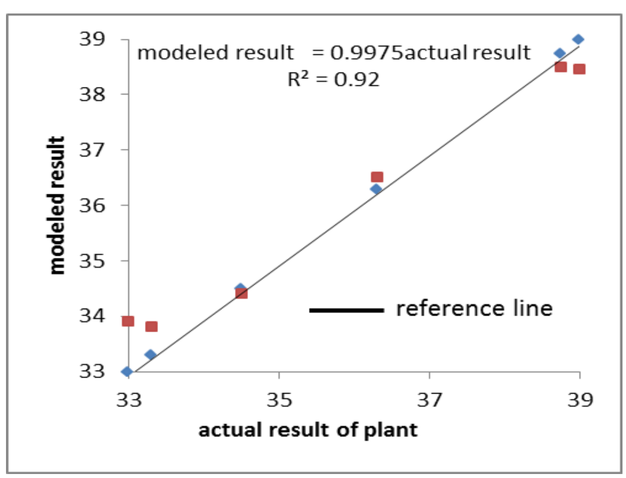
Fig(1.5): Verification of Sulphate model for treatment plant



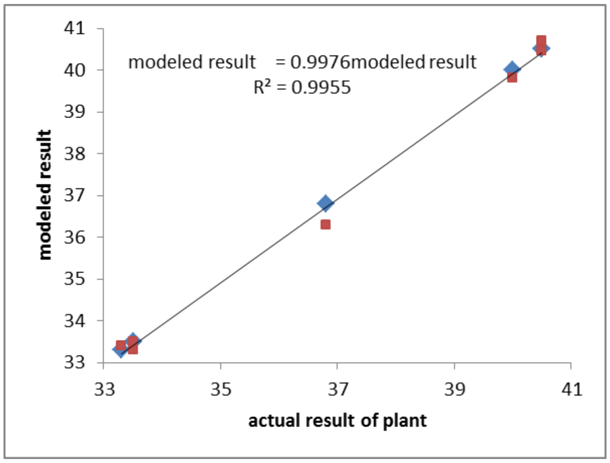
Fig(1.6): Verification of chlorine model for treatment plant



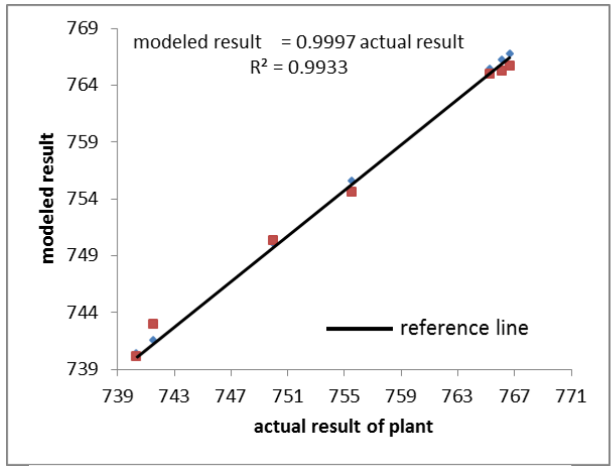
Fig(1.7): Verification of calcium model for treatment plant modeled



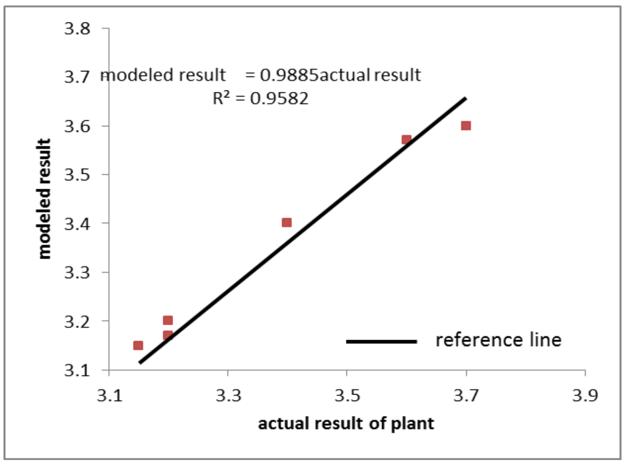
Fig(1.8): Verification of magnesium model for treatment plant modeled



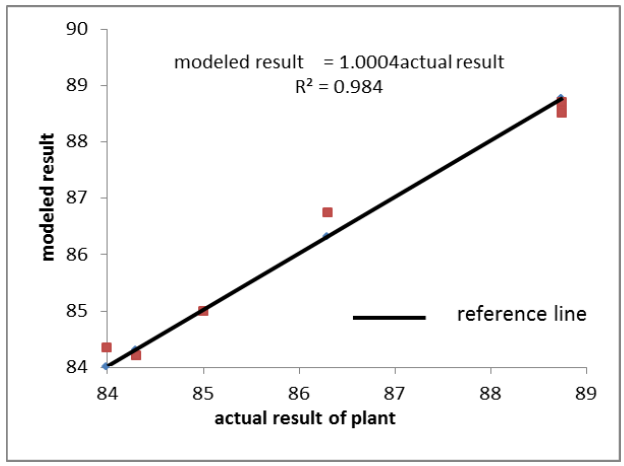
Fig(1.9): Verification of Total suspended solid model for treatment plant



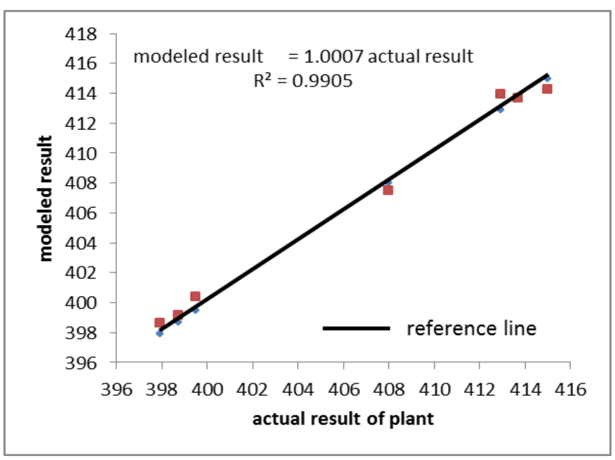
Fig(1.10): Verification of Total dissolved solid model for treatment plant



Fig(1.11): Verification of Potassium model for treatment plant

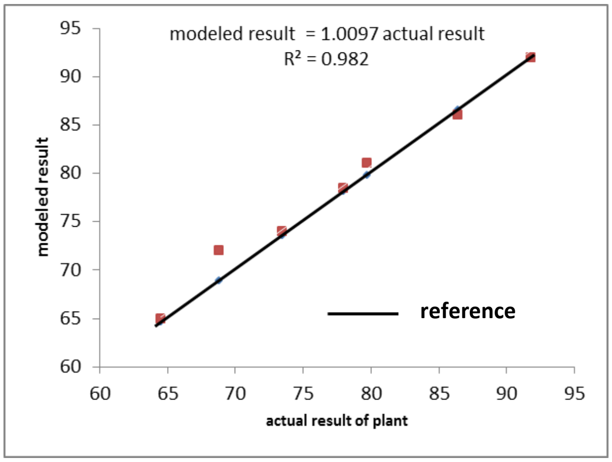


Fig(1.12): Verification of sodium model for treatment plant

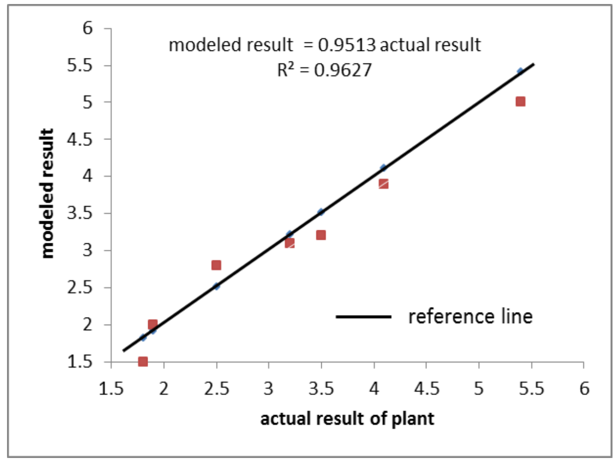


Fig(1.13): Verification of Total hardness model for treatment plant

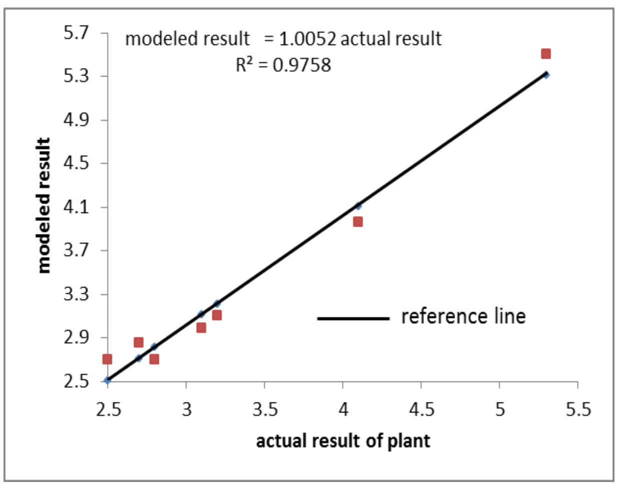
2- removal efficiency of pollutant models



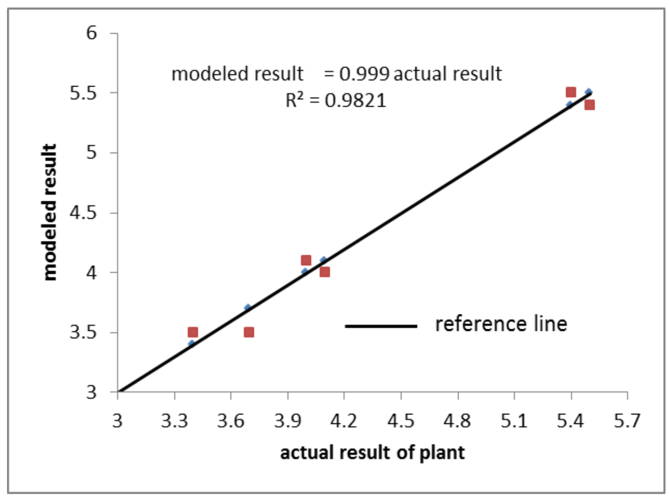
Fig(1.14): Verification of turbidity removal efficiency model of treatment plant



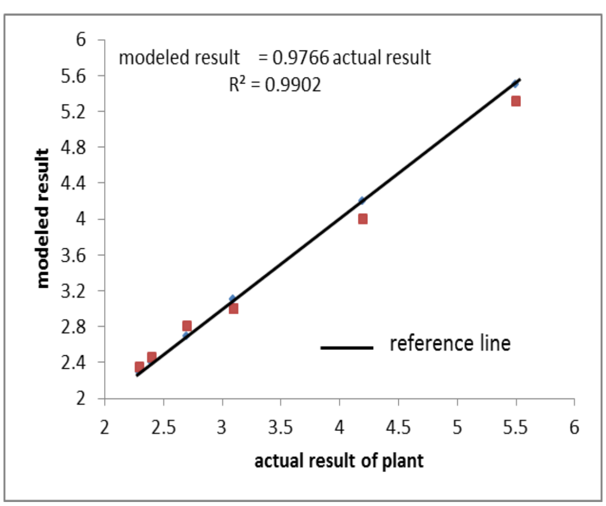
Fig(1.15): Verification of Ph removal efficiency model of treatment plant



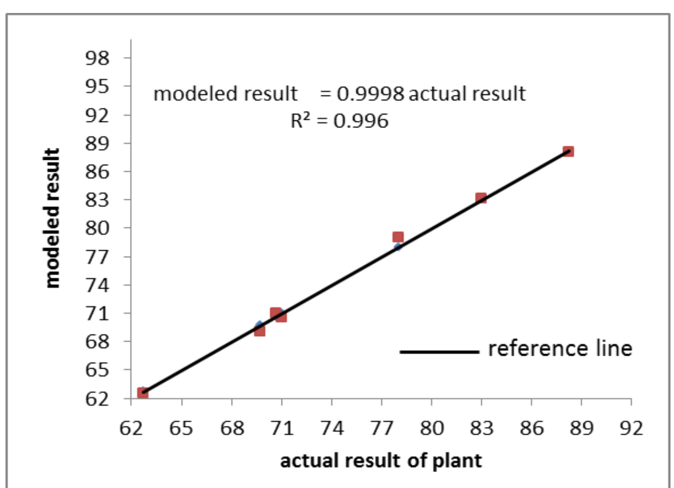
Fig(1.16): Verification of E.C. removal efficiency model of treatment plant



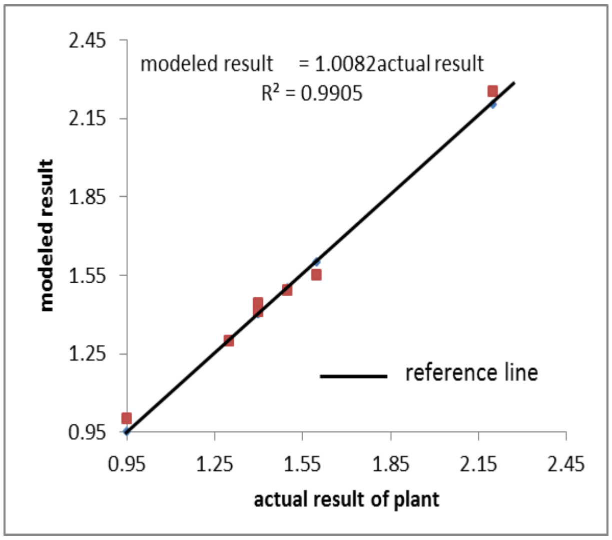
Fig(1.17): Verification of AlK. removal efficiency model of treatment plant



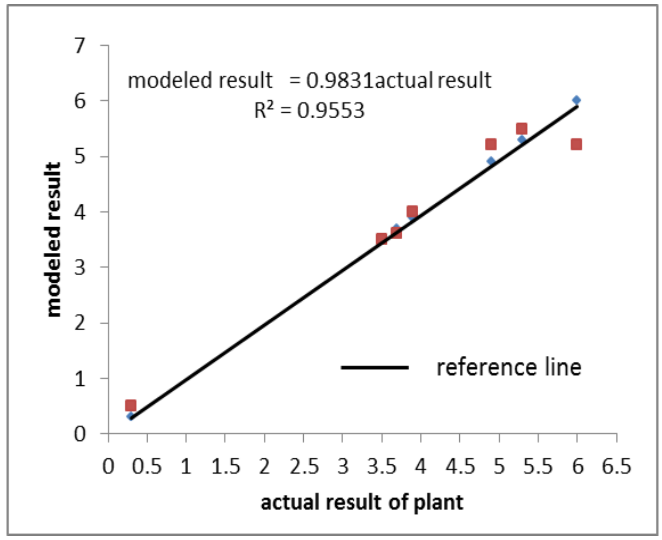
Fig(1.18): Verification of T.D.S removal efficiency model of treatment plant



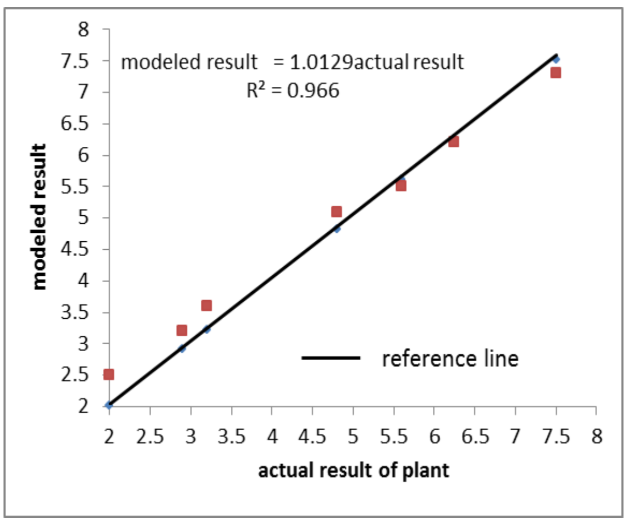
Fig(1.19): Verification of T.S.S removal efficiency model of treatment plant



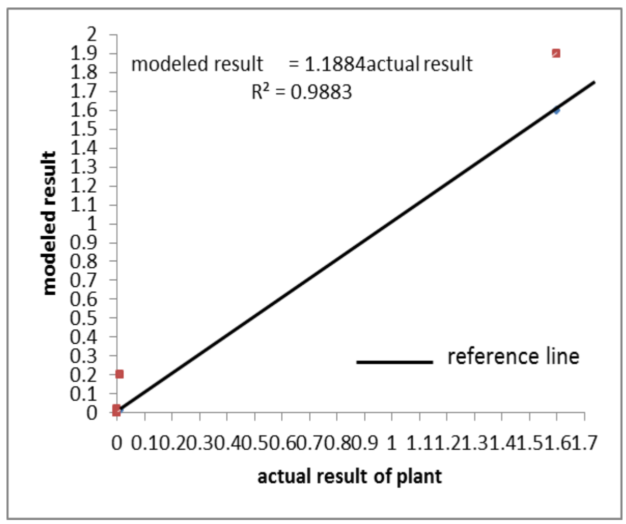
Fig(1.20): Verification of T.H removal efficiency model of treatment plant



Fig(1.21): Verification of Ca removal efficiency model of treatment plant

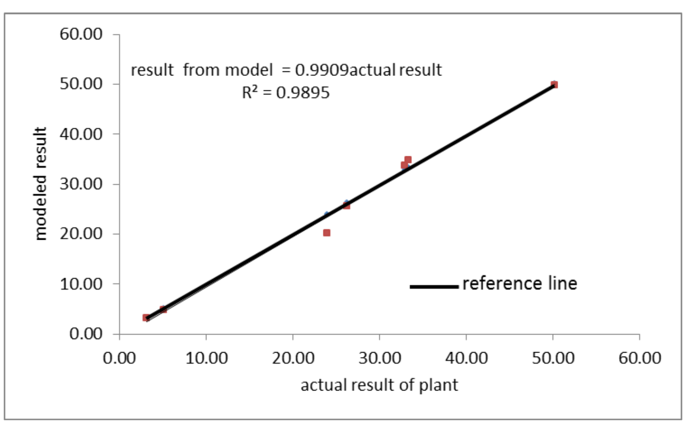


Fig(1.22): Verification of K removal efficiency model of treatment plant



Fig(1.23): Verification of Na removal efficiency model of treatment plant

3- verification of multiple regression model for plant removal efficiency



Fig(1.24): Verification of plant removal efficiency

5. Conclusions

- A data fit statistical program are used for modeling a (HCWTP).
- Statistical models must be save in any plant for application in emergency conditions also it is assist to save the time and cost.
- The average operated flow rate of (HCWTP) over from the design capacity therefore statistical regression models designed at these conditions (i.e. statistical regression models work at operated flow rate) otherwise the error ratio well be appearance in application .
- The (HCWTP) need to clean, also the plant very ancient therefor, the efficiency of removal for some elements equal to zero.
- Rapid sand filters sand should be according to standards limitation.

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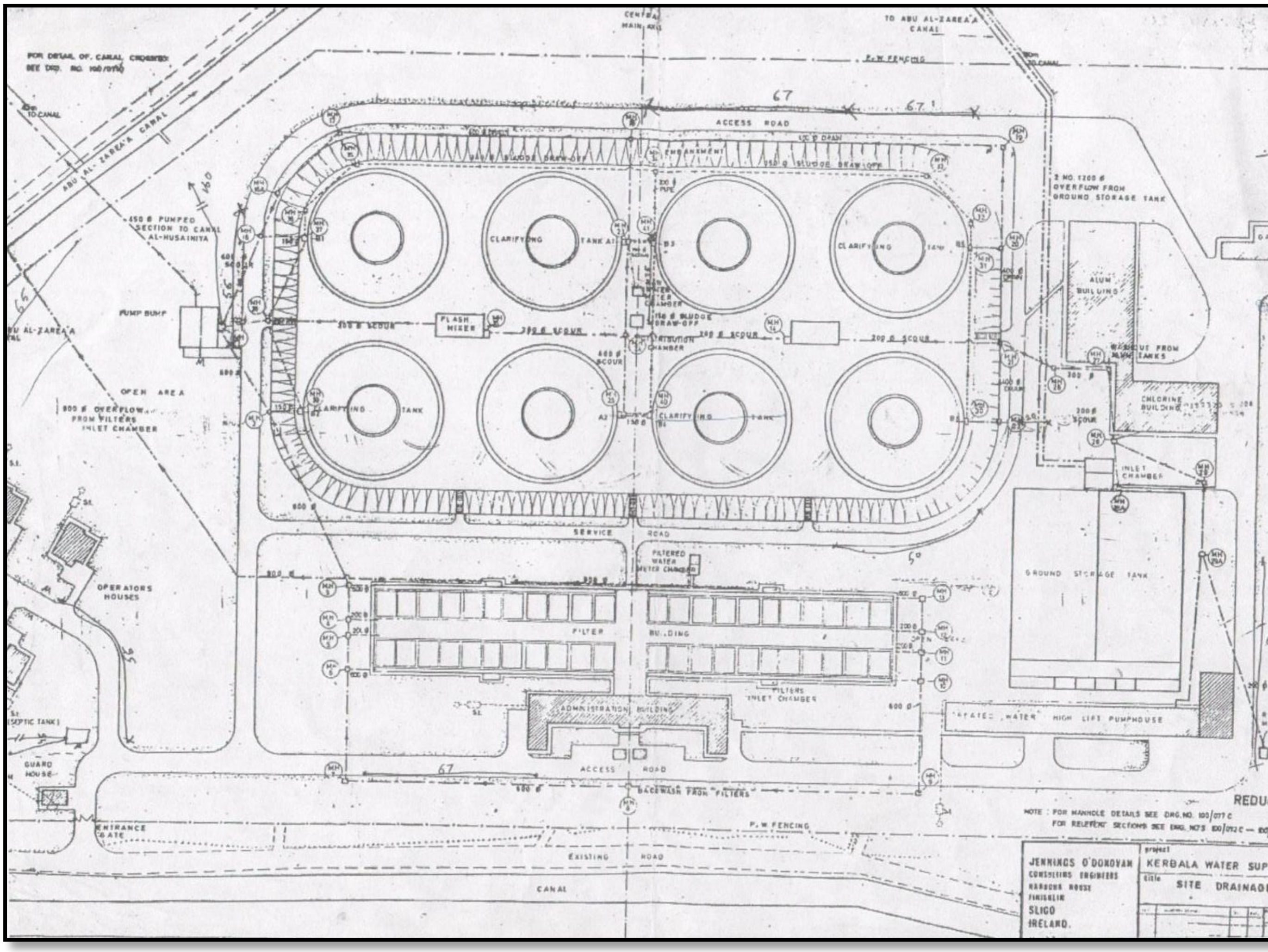

fig(1.25) general layout of HCWTP