Performance Assessment of AL-Hussein City Water Treatment Plant In Holly Karbala Governorate (HCWTP) By Statistical Program

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Abstract

This study aimed of a assessment performance al- Hussein City water treatment(HCWTP) that located in the northeastern part of the holy Karbala city. the evaluation of performance and comparison the result with standard limits were achieved After a development of statistical models that have been modeled by non-linear regression for the raw water quality parameter data of al-husayniyah river influent to the plant and the water effluent data from the plant for the same parameter but after treatment by using ,(Datafit) program version 9.1 software Such as these models approved that its very efficient and fast, and its can using at any time in the future especially at emergency condition to estimate the efficiency of plant, but it does not take some of the external conditions into account affecting the quality of the water, in general its very good application when you used in estimating the efficiency of plant. The results of this study showed after comparison with the Iraqi standard that all the properties of water of al-husayniyah river matching to the standard limits except Electrical conductivity recorded 1159.79 μmhos/cm, 1183.4μmhos/cm for hot and cold season respectively, its value higher than limitation. while the efficiency of al (HCWTP) is57.103%, 62.11% for hot and cold season respectively from the multi-regression efficiency model while the efficiency from single-regression is 44.25%,48.18% also for two season. so, the discharge of the plant has a evident effect in the estimation of the removal efficiency of each parameters as well as the overall efficiency of plant, But it is not the only element affecting in the estimation of the overall efficiency , for this reason the efficiency from multi-regression considered more accurate than from single- regression.

Key words: Modeling Water Treatment Plant , Datafit,, efficiency of water treatment plant, regression

الخلاصة

تم اجراء هذه الدراسة من خلال تقييم أداء محطة مدينه الحسين لتنقيه المياه الواقعة في الجزء الشمالي الشرقي في محافظه كربلاء المقدسة وتم التقييم والمقارنة مع المواصفات القياسية بعد تطبيق الموديلات الإحصائية التي تم نمذجتها من عملية الانحدار اللاخطي لبيانات معاملات المياه الخام لنهر الحسينية الداخلة للمحطة والخارجة منها بعد المعالجة باستخدام البرنامج الإحصائي data fit نسخة 9.1 ، هذا واثبت أن مثل هذه الموديلات يمكن استخدامها في أي وقت بالمستقبل وأنها كفوءة وسريعة في حاله الطوارئ لكنها لا تأخذ بنظر الاعتبار بعض الظروف الخارجية المؤثرة على نوعية الماء لكن على العموم تعتبر جيد جدا في حالة الاستعانة بها في تقدير كفاءة محطة المحطة. وأظهرت النتائج بعد المقارنة مع المواصفة العراقية إن جميع مواصفات الماء الخام لنهر الحسينية مطابقة للمواصفات القياسية ماعدا التوصيل الكهربائي سجل قيم 1159.79(μS/cm) و 1183.4(μS/cm) للموسم الحار والبارد على التوالي وهي قيم أعلى من المحددات. أما فيما يخص كفاءة محطة مدينة الحسين لتنقية الماء سجلت قيم57.103% و 62.11% للموسم الحار والبارد على التوالي من نموذج الانحدار اللاخطي المتعدد للكفاءة حيث إنها تعطي نتائج أكثر دقة من نموذج الانحدار اللاخطي المنفرد حيث سجلت الكفاءة 48.18% و44.25، ومن هذا تبين أن تصريف المحطة له تأثير واضح في تقدير كفاءة الإزالة لكل عنصر وأيضا الكفاءة الكلية لها ، إلا انه ليس العنصر الوحيد المؤثر في تقدير الكفاءة الكلية ولهذا السبب يعزى دقة نتائج تقدير الكفاءة من نموذج الانحدار اللاخطي المتعدد.

كلمات مفتاحيه:– نمذجة محطة تنقية الماء، كفاءة محطة المعالجة، الانحدار، البرنامج الإحصائي داتا فت

1-Introduction:-

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 and Susan 2004, Mohammed and shakir.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 and Susan, 2004, Qasim *et.al.*,2000) .

The modeling data technique was adopted by many researcher, some of these studies are:-

Al-Tufaily, 2010 , Multiple non-linear regression models were used in regression data on design water treatment plant,7models were modeled by data fit. the volume of treatment units, required area and power required assumed to be the dependent variables (y) and Independent variables assumed a Population factor, Design period, Growth rate, Consumption, Time of storage, Coagulation time, Flocculation time, Surface loading rate, and Filtration rate.

Khan, 2012, evaluated the surface water quality in al Kufa river station by using Multiple non-linear regression models in data fit program, where the study showed that found a relationship between Biological Oxygen Demand(dependent variables) and pH , Phosphate, Nitrate, Turbidity unit, Chloride , Precipitated dust particles (Independent variables.

2-The Purpose of Study:-

The study aim to

1- Characterization water quality parameter by statistical models
2- Identify the relationship between parameter and water discharge
3- Assessing the efficiency of water treatment plant and explain the effect weight of each water quality parameters on efficiency of it.

3-The Purpose Of Water Treatment:-

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 basic purpose of Water Treatment Plant are as follows:

The first Objective:- The most important requirement in the design of water treatment plants; is that produce a final product must be safe to drink and fitting to microbiologically and chemically specification standard as well as aesthetically acceptable**(Schutte,2006).** 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**(CPCB , 2002)**.

The second objective: One of the most challenging elements in design water treatment is that provide effective quality water to the consumer with rational costs**(Rebert and Kubel, 2008)**. A sensitivity treatment cost analysis may be carried out using facilities with reasonable capital ,operating and maintenance costs **(Beca,2010)**. Various alternatives in plant design should be evaluated for production of cost effective quality water**(CPCB , 2002)** .While The Factors affecting the water purification at water treatment plant today include:

1-Retrogradation in the quality of many raw water sources.
2-Removal of potentially harmful synthetic organic substances in water sources
3-Removal of resistant micro-organisms from water
4-Improved training of process controllers for new processes and process optimization
5-Demands for process integration and flexibility(Schutte,2006).

4-Combinations of Treatment Processes For A Case Study:-

Status of the Hussein city water treatment plant HCWTP is located in the southeastern region of the holly Karbala city at al-husayniyah river and was constructed in Eighth decade of the last century. 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 in hot season and 5400m^3/hr in cold season this plant includes a different units as follow:-

4.1 Intake Structure and pumping station:-

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 that achieved by supplied the intake with screen technology**(Qasim *et.al.*,2000)**. The intake structure can be very simple, e.g. a submerged intake pipe, or an elaborate tower-like structure that can house intake gates, screens, control valves, pumps and chemical feeders. The intakes may be submerged, floating or fixed tower. Submerged and floating intakes are used for small water supply projects**(Schutte,2006)**.

Raw water pumping stations are generally located at the intake structure. The purpose is to lift the water from the source to an adequate height from where the water can flow by gravity to the plant**(Schutte,2006)**.

Intake of (HCWTP) constructed adjacent al-husayniyah River And it's away from the plant by about 250m. Its consist of 8 Centrifugal pumps ,The 6 pumps total energy of each pump is 1400 m^3/ h, and 2 pumps total energy of each pump is 400 m^3/ h. The head pressure of the water is 20 m. In the hot season , nearly the pump is working at maximum capacity because the growing consumption during this period.

4.2The Purification Process:-

4.2.1 The rapid mixing tanks:-

a large portion of the suspended particles in water IS sufficiently small(this particle called colloidal particles)that their removal in a sedimentation tank is impossible at reasonable surface overflow rate and detention times**(Steel *et.al.*,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)**.

Agitation time and velocity gradient two main factor effected on rapid mixing **(Mackenzie and susan, 2004**)

The (HCWTP) two rapid mixing basins which its dimensions (10m*5m). The rapid mixing basin the first step in (HCWTP), a detention time less than 1 min, A coagulant, usually an Aluminum sulphate($Al_2(SO_4)_3.16\ H_2O$.) (i.e., alum) is added at high mixing speed (revolution speed=100 r p m) to the Hydraulic Flash Mixer tank that used in plant.

4.2.2 Flocculation:-

follows coagulation ,its 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**(Davis,2010).** Flocculation involves the stirring of water to which a coagulant has been added at a slow rate, causing the individual particles to "collide". Flocculation can take place in different types of equipment. A simple mechanical stirrer can be used for flocculation or a specially designed channel with baffles to create the desired flow conditions can also be used to flocculate the particles in water. The basis of the design of a flocculation channel is that the flow velocity of the water has to be reduced to enable large, strong aggregates to form. If the flow velocity is too high the aggregates may break up again, causing settling of the broken flocs to be incomplete**(Schutte ,2006)**. 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 channel is (12m), Water depths in the basin range from 4 m and the basin consist of vertical blade that Spin slowly to save a 70 1/sec velocity gradient and detention time 30min. The velocity of flow in flocculation tank not less than 0.40 m/sec, The flow velocity from the flocculation basin to the settling basin should be low enough to prevent shear and breakup of the floc but high enough to keep the floc in suspension.

4.2.3 Sedimentation tanks:-

In the design of an ideal sedimentation tank, one of the controlling parameters is the settling velocity (vs) of the particle to be removed. the settling properties of particles are categorized into four classes: (1) discrete particle settling, (2) flocculant settling, (3) hindered settling, and (4) compression settling By convention these categories have been labeled Type I, Type II, Type III, and Type IV settling**(Mackenzie,2010)**

In a (HCWTP) a Type II sedimentation tank is characterized by particles that flocculate during sedimentation is used, the water after flocculation tank incoming to the circle sedimentation upflow clarifier that numbers and diameters of sedimentation tank is (8, 40m) respectively and utilizes gravity to remove the discrete particle from water because There is no adequate mathematical relationship that can be used to describe Type II settling. And The Stokes equation cannot be used because the flocculating particles are continually changing in size and shape. In addition, as water is entrapped in the floc, the specific gravity also changes.

4.3Filtration:-

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 **(Simon,2006)**. Filtration also aids in the removal of color, tastes, odors, iron, and manganese**(Simon,2006)**

The process of filtration involves passing water, containing some impurity, through a granular bed of media, a small particles are removed by the sand grains and are retained in the bed of sand, while clean water flows out from the bottom of the sand bed(**Schutte, 2006)** .

Filters can be classified according to the medium type as:

1. Single (mono.) medium filters.

2. Dual media filters.
3. Mixed-media filters**(Simon,2006)**.

There are two types of filtration processes classified according to the speed which are used in a treatment plants: Slow sand filtration and rapid gravity sand filtration**(Al-Tufaily and Entesar,2010)**. The choice of a typical filter medium is dictated by the durability required, the desired degree of purification, and the length of filter run and ease of backwash sought**(Steel,1979)**.

In a (HCWTP) are using a rectangular slow sand filter tank which the number and dimensions (40,8m*10m) and 4 tanks stand by, and consist a suitable arrangement of pipe work to collect the filtered water and when necessary provide the water/air for the backwash. Effective size of sand Filters in tanks out the Standard Specifications because Ministry of Municipalities is forcing treatment plants to equip the sand from quarries of their own, therefore the plant doesn't have high efficiency to remove the pollutant from water in this stage.

4.4 Disinfection:-

Schutte , 2006 defined a disinfection is destroys disease-causing organisms in water. Disinfection is achieved mainly by chlorine, but ultraviolet radiation and other oxidising chemicals such as ozone and chlorine dioxide are also used disinfection is normally the last step in purifying drinking water **(Hong,2006)**. Chlorine is the one of the most common disinfection chemical that being used**(Eldib and 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 and the concentration of residual free chlorine=0.5 mg/l after 30minute of pumping water to water network pipe to ensure microbiologically safe water.

The layout ofal-hussein city water treatment plant explain in figure (25)

5-Data Collection That Used In The Anlysis:-

In order to knowledge the quality water of the HCWTP for 14 physicochemical and microbial parameters were evaluated during one year and which that 2015. at average from (3 to 5) samples from influent to WTP and from effluent from WTP for on parameter were taken and analyzed in one month and the pollution levels are being determined that The measured parameters used in regression are: Tur. ,Ph, E.C., Alk , T.H , Ca , Mg , Cl ,SO4, TDS , TSS , Na , K , Al . a Standard Deviation (δ) for a data used in analysis were determine show in table(1.1) . Finally, these parameter were tested in water laboratories of directorate water in holly Karbala governorate**.**

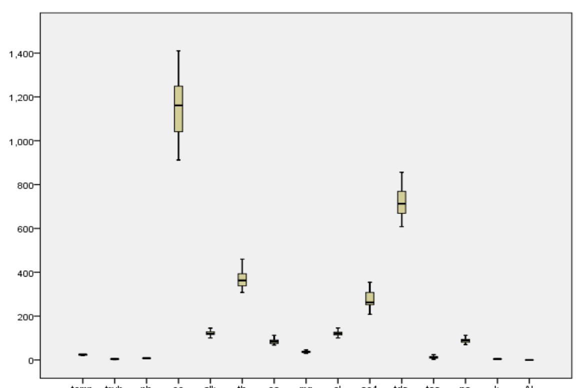
Table(1) The Standard Deviation for the used data

Pollutant	Raw water					Treated water				
	Range		Range	Average	δ(Standard Deviation)	Range		Range	Average	δ(Standard Deviation)
	Max.	Min.				Max.	Min.			
TUR.	58	5	53	18.22	9.79	5	0.7	4.3	3.73	1.21
PH	8.4	7.4	1	7.998	0.187	8.3	7.2	1.1	7.81	0.22
E.C.	1433	931	502	1186.7	109.63	1425	912	513	1160.19	104.53
ALK.	166	104	62	127	12.39	160	100	60	122.27	11.77
T.H.	483	318	165	390.85	40.01	470	308	162	383.87	39.36
Ca	130	70	60	93.68	13.85	126	68	58	89.65	13.15
Mg	52	27	25	37.54	4.78	53	29	24	38.22	4.63
CL	160	96	64	119.375	12.61	166	100	66	122.21	12.79
SO_4	370	204	166	284.44	37.98	375	208	167	289.17	38.18
TDS	918	616	302	751.433	65.89	912	608	304	734.46	63.21
TSS	85	16	69	33.86	10.69	24	3	21	10.47	4.63
Na	118	70	48	90.12	11.74	116	70	46	89.46	11.16
K	5.2	2.5	2.7	4.00	0.56	5	2.4	2.6	3.84	0.58
Al.	0	0	0	0	0	0.1	0	0.1	0.024	0.022

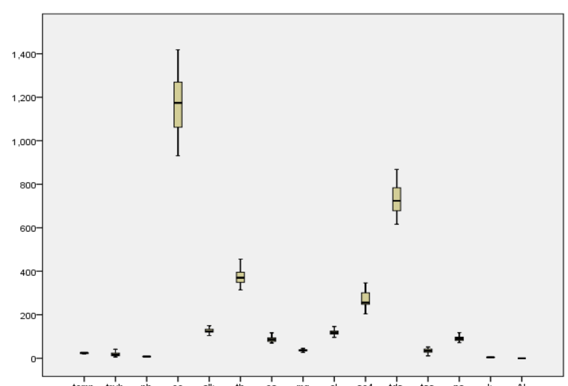
*Al increase because added of alum.

6-The Regression Analysis Technique:-

Before analyzing the data, and the results to be more confident; the extreme values of the data water quality parameters for raw and treated water were excluded by using SPSS program. The reason for the use of SPSS for contains it the property for excluded such this values. Fig (1) and (2) show the data after excluding all the extreme values



Fig(1) exclude value for raw water



Fig(2) exclude value for treated water

6.1-Models Formation:-

A Data Fit is a science and engineering tool that simplifies the tasks of data regression analysis therefore a regression analysis was done by using "Data Fit" program version 9.1 software.

In this study the statistical models are described the relations of parameters of water quality and discharge. a statistical method [correlation analyses] was utilized for analyzing data collected, identify relationships between parameters .while the overall significance of the model was determined by Variance analyses (Prob(F)).

A non-linear regression models were used for describing each variables. 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.

6.2The Dependent Variable (y) and The Independent Variables(x):-

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

6.2.1 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.

The selected model defined a convex/concave curve equation and description as it's a power function this equation usually represented any data of flow(flow of water, transport of temperature, moving of asteroids, comets) therefore considered a best equation to representation a flow data of plant.

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

-First Single Regression Model:-

this model represented a relationship of a concentration of raw water quality parameter(river water quality parameter) influent to pant and discharge of raw river water .After application the result from Data fit of this study presented in table(2)

Table (2) the result of regression of river water quality parameter influent to pant

POL.	Model	Coefficient of Multiple Determination R^2	Standard Error of the Estimate	Correlation Matrix			Prob(F)
				Y	X		
TUR.	$y = 4.59691\,x^{0.5075786}$	0.8834	7.723	0.61997	1	X	0.6342`
				1	0.61997	Y	
PH	$y = 8.0084\,x^{-0.0005}$	0.60025	0.188	-0.0102939	1	X	0.8797
				1	-0.0102939	Y	
E.C.	$y = 1373.686\,x^{-0.0565}$	0	98.5	-0.406702	1	X	0.6551
				1	-0.406702	Y	
ALK.	$y = 150.958\,x^{-0.06727}$	0.7531	10.76	-0.446833	1	X	0.5656
				1	-0.446833	Y	
T.H.	$y = 395.34\,x^{-0.00442}$	0.7009	11.98	-0.0241021	1	X	0.7518
				1	-0.0241021	Y	
Ca	$y = 92.663\,x^{0.00423}$	0.631	13.91	0.02040444	1	X	0.83452
				1	0.02040444	Y	
Mg	$y = 42.044\,x^{-0.04403}$	0.682	4.65	-0.2733996	1	X	0.931
				1	-0.2733996	Y	
CL	$y = 141.8216\,x^{-0.0671}$	0.747	11.22	-0.432592	1	X	0.5898
				1	-0.432592	Y	
SO_4	$y = 302.548\,x^{-0.02392}$	0.6167	37.84	-0.0904128	1	X	0.1856
				1	-0.0904128	Y	
TDS	$y = 877.3260x^{-0.06027}$	0.7512	57.30	-0.457626	1	X	0.9112
				1	-0.457626	Y	
TSS	$y = 19.3402\,x^{0.21100}$	0.7176	9.50	-0.0904128	1	X	0.6677
				1	-0.0904128	Y	
Na	$y = 118.766\,x^{-0.10796}$	0.7641	9.41	-0.51322	1	X	0.8116
				1	-0.51322	Y	
K	$y = 4.3447\,x^{-0.03175}$	0.5263	0.55	-0.0539644	1	X	0.9183
				1	-0.0539644	Y	

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

-Second Single Regression Model:-

this model represented a relationship of the removal efficiency of plant for each pollutant and operated discharge for a (HCWTP). The result of study presented in table(3)

Table (3) result of removal efficiency of plant for pollutants.

POL.	Model	Coefficient of Multiple Determination R^2	Standard Error of the Estimate	Correlation Matrix			Prob(F)
				Y	X		
TUR	$y = 50.28064x^{0.64558}$	0.7653	10.5962	0.5959008	1	X	0.8145
				1	0.5959008	Y	
PH	$y = 2.6499x^{-0.17595}$	0.6024	1.49119	-0.0655911	1	X	0.6375
				1	-0.0655911	Y	
E.C.	$y = 1.58172x^{0.52169}$	0.707035	2.3888	0.7809711	1	X	0.4407
				1	0.7809711	Y	
ALK	$y = 3.32434x^{0.178445}$	0.63411	1.95	0.0464297	1	X	0.55592
				1	0.0464297	Y	
T.H.	$y = 2.279899x^{-0.406865}$	0.61344	1.08	-0.1310047	1	X	0.8981
				1	-0.1310047	Y	
Ca	$y = 4.89397x^{-0.234283}$	0.5408	2.74	-0. 0851563	1	X	0.518
				1	-0. 0851563	Y	
TDS	$y = 2.1358x^{0.05949}$	0.5108	2.30	-0.0575713	1	X	0.9164
				1	-0.0575713	Y	
TSS	$y = 51.2859x^{0.4613}$	0.85064	10.83	0.427738	1	X	0.6323
				1	0.427738	Y	
K	$y = 7.09852x^{-0.87931}$	0.527084	3.87	-0.174182	1	X	0.9503
				1	-0.174182	Y	

Y:-removal efficiency for each pollutant.

$$\text{Removal Efficiencyat}, \% = \left(1 - \frac{\text{pollutant effluent}}{\text{pollutant influent}}\right) * 100 \ldots\ldots(2)$$

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

Some of the water quality parameters are considered as additives chemicals, and it is added to complete the processing stages so, a relationship of model for these parameters only connected between effluent concentration and operated discharge for a (HCWTP). The result of study presented in below table

Table (4) result of effluent concentration of pollutants

POL.	Model	Coefficient of Multiple Determination R^2	Standard Error of the Estimate	Correlation Matrix			Prob(F)
				Y	X		
Mg	$y = 42.776981x^{-0.185790}$	0.6488	4.497	-0.2610082	1	X	0.907
				1	-0.2610082	Y	
CL	$y = 142.0423x^{-0.24842}$	0.5765	11.79	-0.41635	1	X	0.300
				1	-0.41635	Y	
SO_4	$y = 291.8441x^{-0.0151128}$	0.8530	38.36	-0.0253158	1	X	0.8487
				1	-0.0253158	Y	
Na	$y = 105.44511x^{-0.271674}$	0.6431	10.43	-0.393818	1	X	0.310
				1	-0.393818	Y	
Al	$y = 0.01166x^{1.66312}$	0.5042	0.022	0.2008302	1	X	0.86
				1	0.2008302	Y	

-Third Single Regression Model:-

relationship of this model connected between the removal efficiency of plant for all pollutant and operated discharge for a (HCWTP). The result of study presented in table(5)

Table (5) result of removal efficiency of plant

Model	Coefficient of Multiple Determination R^2	Standard Error of the Estimate	Correlation Matrix			Prob(F)
			Y	X		
$y = 45.97866x^{0.160352}$	0.24982	2.12	0.493762	1	X	0.9678
			1	0.493762	Y	

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

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

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

6.2.2 Multiple Regression:-

The Non-linear multiple regression models in three forms were used for modeling of Hussein 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)

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

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

The best data fitting of multiple regression model	R^2	Standard Error	Prob(F)
$Y = 0.606X_1 - 1.784X_2 + 5.973*10^{-3} X3 - 1.910*10^{-2} X_4 + 6.360*10^{-3} X_5 + 1.728*10^{-2} X_6 - 6.566*10^{-3} X_7 - 7.1597*10^{-3} X8 - 1.233*10^{-2} X_9 - 6.594*10^{-3} X_{10} - 0.127 X_{11} + 2.6703*10^{-2} X_{12} - 1.1059 X_{13} - 0.1424 X_{14} + 3.1515 X_{15} + 2.5414*10^{-2} X_{16} + 65.337$	0.6604	1.547	0.5719

table(6) the result of multiple regression for plant removal efficiency

Correlation Matrix																	
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	Y
X1	1																
X2	0.055114214	1															
X3	-0.10079803	-0.02630662	1														
X4	-0.08467628	-0.1807576	0.471400595	1													
X5	0.022070411	-0.13964267	0.43887021	0.111908419	1												
X6	0.016195424	-0.11259959	0.377221205	-0.03892098	0.80722763	1											
X7	0.066725452	-0.15479085	0.261935075	0.188892112	0.383300342	-0.05474497	1										
X8	-0.15567198	0.18235716	0.546913046	0.456302188	0.128878392	0.030361755	0.208081898	1									
X9	-0.03167825	-0.2275369	0.38389533	0.08288128	0.839986517	0.764220497	0.227503229	-0.01216907	1								
X10	-0.13664321	-0.1058988	0.878813893	0.459093177	0.453083214	0.431462958	0.259700508	0.525294039	0.432848254	1							
X11	0.509154177	0.231991667	-0.34378386	-0.22458186	-0.5027741	-0.53286775	-0.03525345	-0.15399623	-0.51188204	-0.38371187	1						
X12	-0.15265071	-0.00530868	0.481315015	0.595406989	-0.01760111	-0.04918862	0.080706344	0.726172079	0.148045091	0.515032711	-0.18170654	1					
X13	0.186842145	0.000556312	0.038853312	0.139464638	-0.27829032	-0.36861122	0.05686289	0.160674054	-0.20694158	-0.03311598	0.371158763	0.277715995	1				
X14	-0.02025383	-0.1553632	-0.1640435	-0.1744416	-0.00594181	0.009851929	0.039518436	-0.18445485	0.002151161	-0.10496595	0.022917779	-0.17809838	-0.15408291	1			
X15	0.064401478	-0.0926683	-0.32162135	-0.40713816	0.00297609	0.124631828	-0.26100821	-0.41635188	-0.02531584	-0.32506871	-0.09034254	-0.39381804	-0.05418875	0.20083024	1		
X16	0.18496605	0.046875204	-0.40922592	-0.43563589	-0.00406402	0.042121671	-0.28315346	-0.43950787	-0.09639134	-0.43080835	0.127650856	-0.4899789	-0.03191258	0.078427494	0.74986405	1	
Y	-0.44087075	-0.22078777	0.041461544	-0.13667207	0.24079348	0.343140582	-0.14969579	-0.1156422	0.201599678	0.040323379	-0.57168744	-0.14734319	-0.42429118	0.125512316	0.490595735	0.297775429	1

table(6) a correlation matrix of the plant removal efficiency

Where

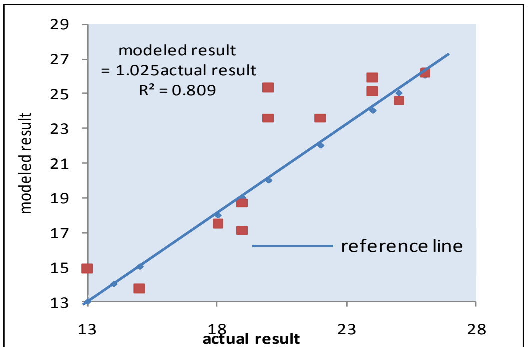
Y	Removal efficiency of plant	X_6	Calcium(mg/l)	X_{12}	sodium(mg/l)
X_1	Turbidity (NTU)	X_7	Magnesium(mg/l)	X_{13}	potassium(mg/l)
X_2	PH	X_8	Chlorine(mg/l)	X_{14}	aluminum(mg/l)
X_3	Electric Conductivity (µS/Cm)	X_9	Sulphate(mg/l)	X_{15}	Operated discharge of plant(m^3/sec)
X_4	Alkalinity (mg/l)	X_{10}	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 effluent from plant**

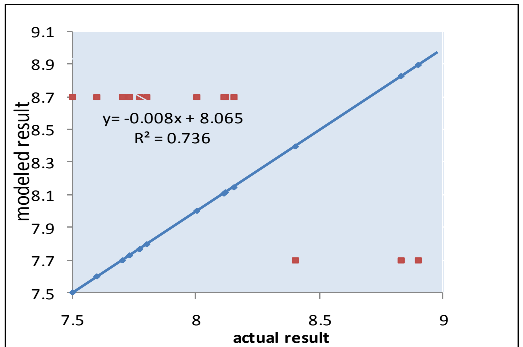
7-Verification of models Results of Data Fit program

To be sure that the results were obtained from statistical models of a datafit program are successfully, verification must be done. That achieved by sorting a sample from the data using in analysis to use for verification(This sample has approximately same statistical description of the data used in the regression analysis) then, a compression between the result of this sample with actual data of water treatment plant (both other worked at the same specific condition i.e. same discharge)

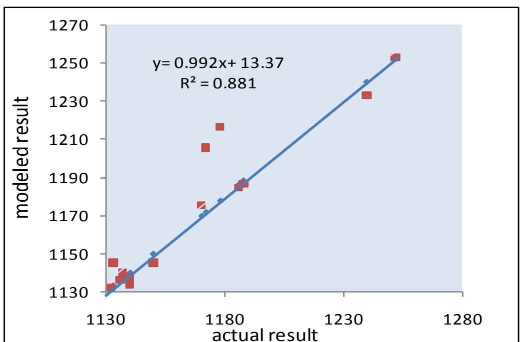
7.1 The verification of raw water quality parameters models



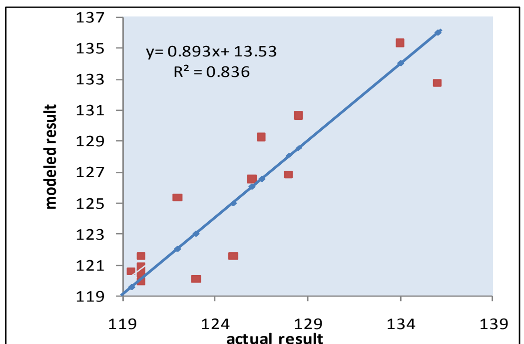
Fig(3): Verification of Tur. model for raw water



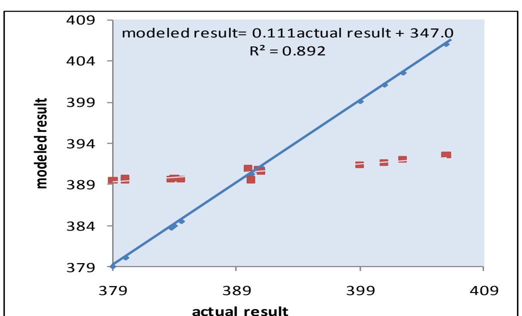
Fig(4): *Verification of ph model for raw water*



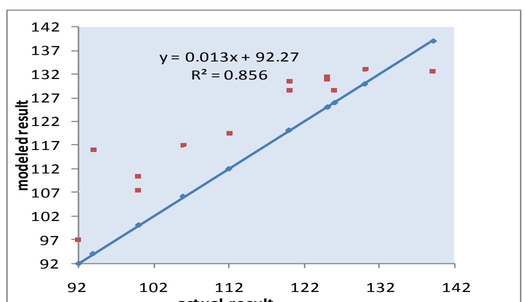
Fig(5): *Verification of Ec model for raw water*



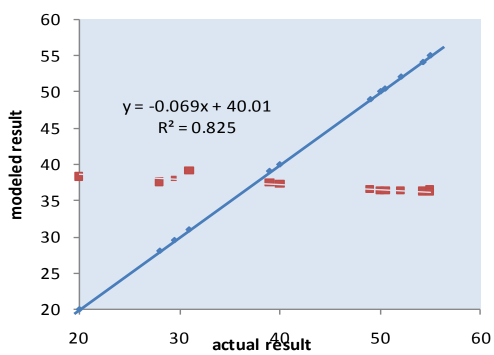
Fig(6): *Verification of Alk model for raw water*



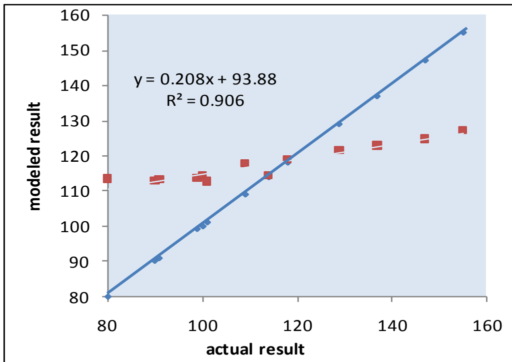
Fig(7): *Verification of T.H. model for raw water*



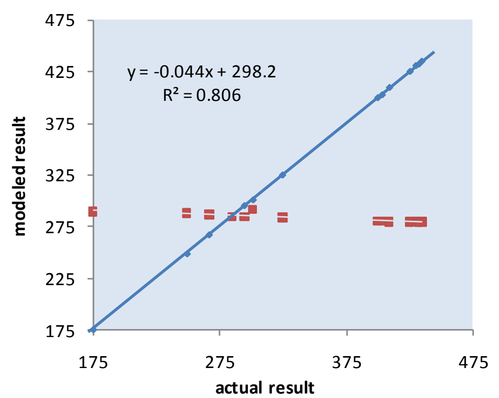
Fig(8): *Verification of Ca. model for raw water*



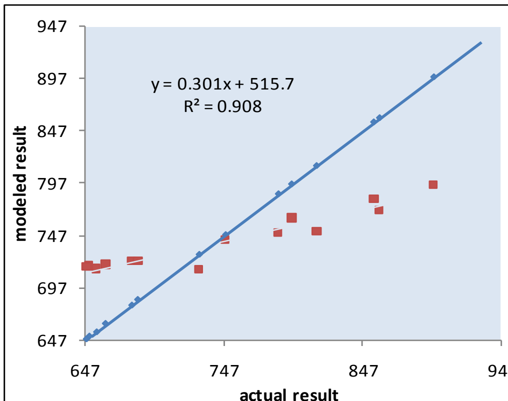
Fig(9):*Verification of Ca. model for raw water*



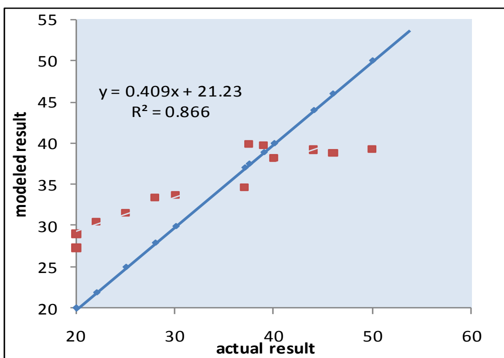
Fig(10):*Verification of CL. model for raw water*



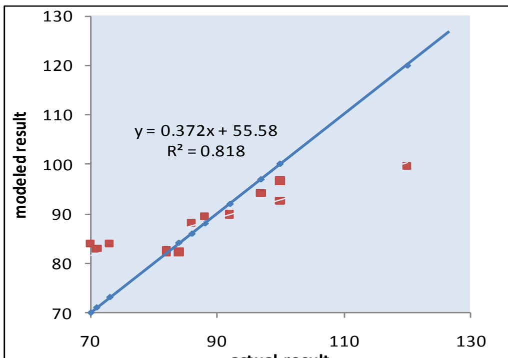
Fig(11):*Verification of So4. model for raw water*



Fig(12):*Verification of TDS. model for raw water*

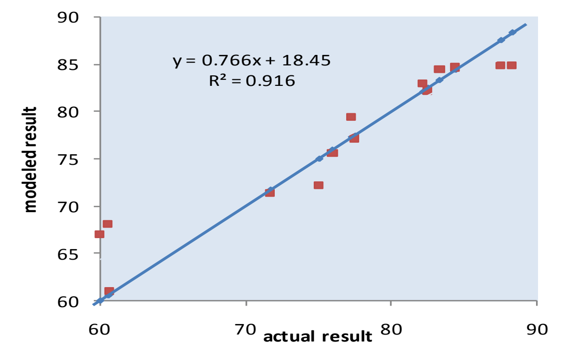


Fig(13):*Verification of TSS. model for raw water*

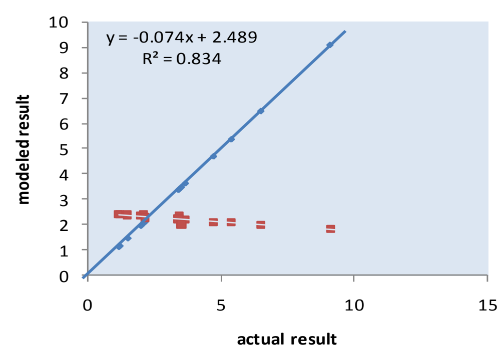


Fig(14):*Verification of Na. model for raw water*

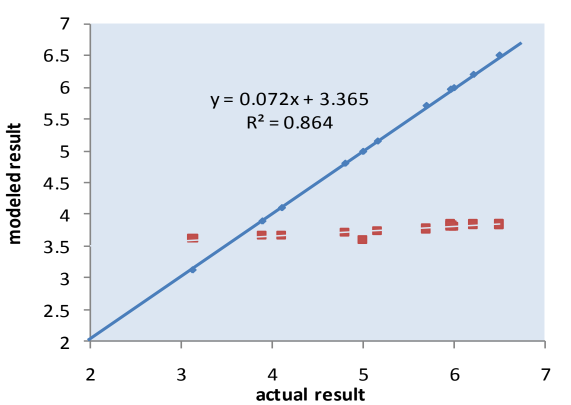
7.2 verification of removal efficiency of plant models for each parameter.



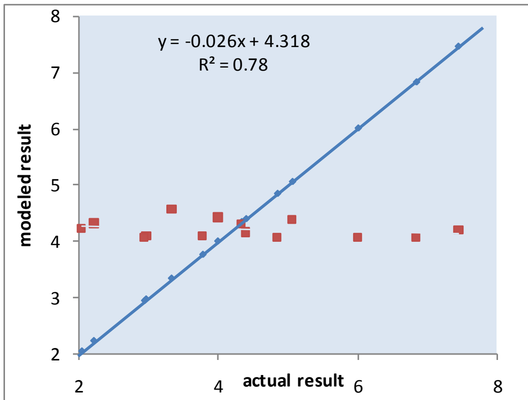
Fig(15): *Verification of **Tur.** removal efficiency model of treatment plant*



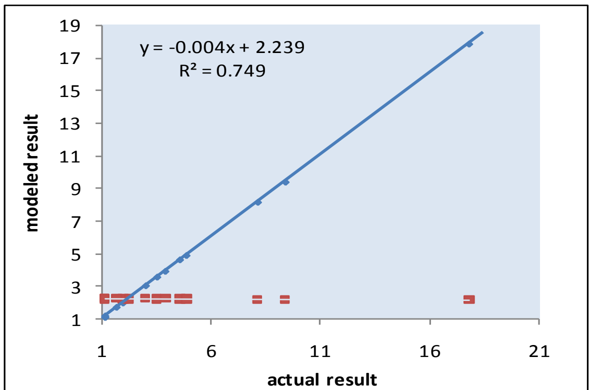
Fig(16): *Verification of **EC** removal efficiency model of treatment plant*



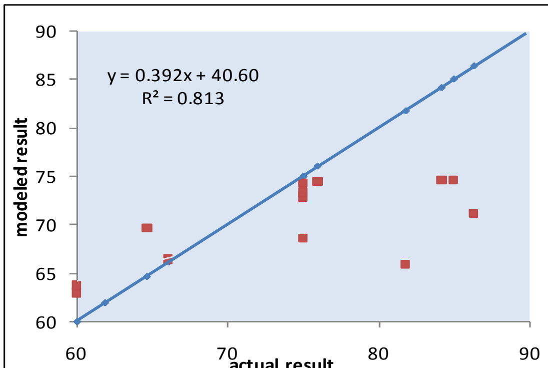
Fig(17): *Verification of **ALK** removal efficiency model of treatment plant*



Fig(18): *Verification of **ALK** removal efficiency model of treatment plant*

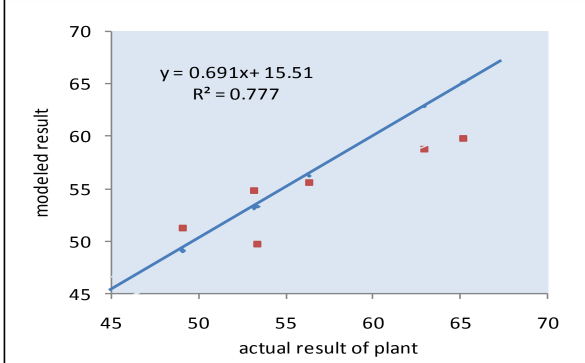


Fig(19): *Verification of **TDS** removal efficiency model of treatment plant*

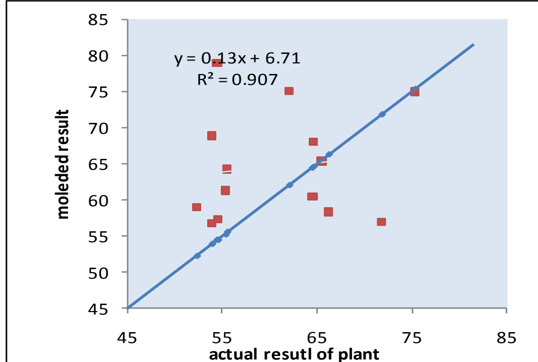


Fig(20): *Verification of **TSS** removal efficiency model of treatment plant*

7.3verification of mono and multiple regression model for plant removal efficiency



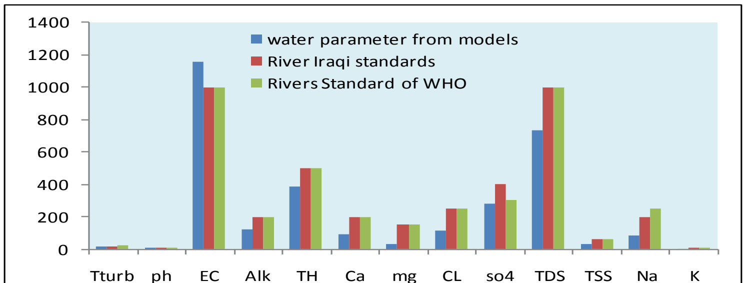
Fig(21): *Verification of overall removal efficiency model of plant* ***(single -Reg.)***



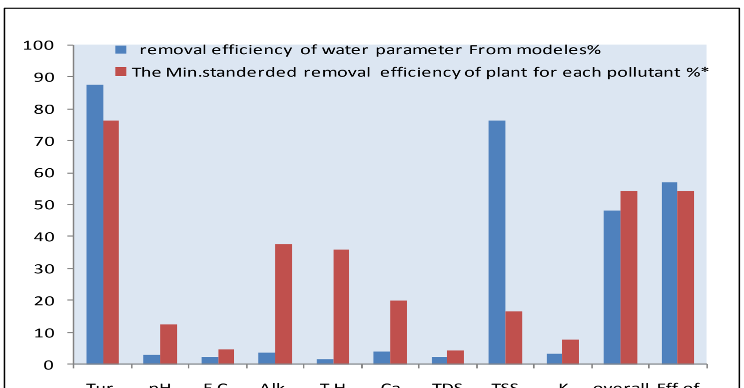
Fig(22): *Verification of overall removal efficiency model of plant* ***(multi-Reg.)***

8-Application Of Models

After verification, and to illustrate the Possibility of application these models; It was selected values for each the (river and plant) discharge only in a hot and cold season to extract the water quality parameter value , then, comparing the results obtained with the water Standard Specifications, More details illustrated as showing in figures below.



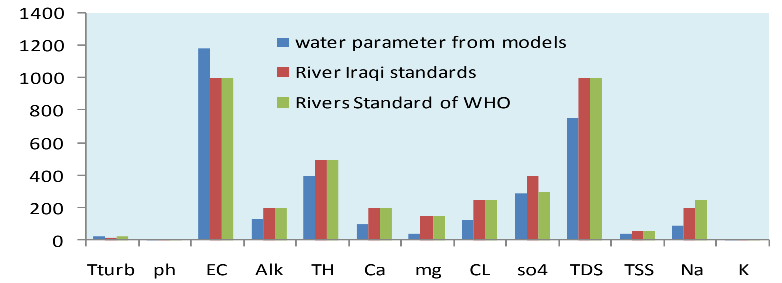
Fig(23):-river water quality parameter input to plant (HCWTP)from models in hot season(Qriver in 29 julay=20m3/sec)



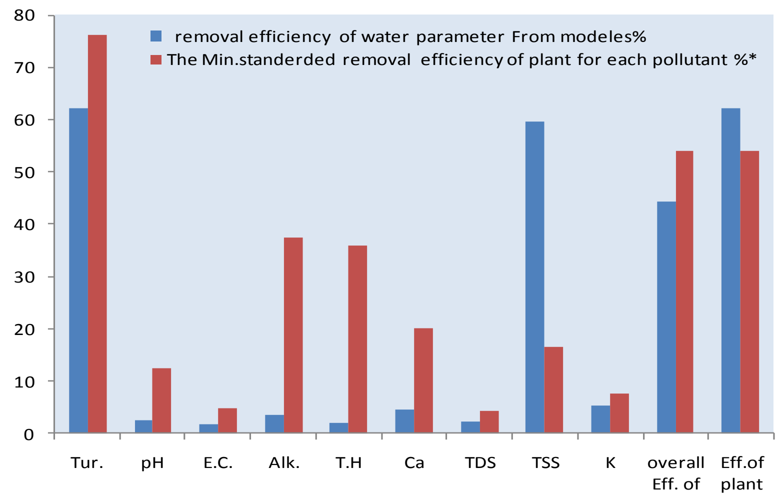
Fig(24):-the removal efficiency of a (HCWTP)for each pollutant in hotseason(Qrplant in 29 julay=2.36m3/s)

*the removal efficiency from models for each variable compare with the min. removal efficiency

$\text{removal efficiency}\ \% = (1 - \frac{\text{water Standard Specificationst for each variable}}{\text{pollutant influent}}) * 100$, if the first value more than second it's ok. Or it's not ok.



Fig(25):-river water quality parameter input to plant (HCWTP)from models in cold season(Qriver in 27 December =14m3/sec)



Fig(26):-the removal efficiency of a (HCWTP)for each pollutant in cold season(Qplant in 27december=1.389m3/s)

9-Discussion of the Results

From Table(2):-The electrical conductivity, alkalinity, Magnesium, chlorine, total Dissolved Solid and sodium have negative relation with river discharge, this interpret that the relationship between each variable and discharge inverse relationship (i.e. when the discharge increase the concentration decrease), while the PH, total hardness, sulfate, potassium have a poor negative relation, because of the above variables depends on the presence of carbonate and bicarbonates and the concentration of salts and not only on the discharge. The other parameters have a positive correlation, Or the turbidity has a higher positive correlation with the river discharge. The increase discharge of surface runoff cause of erosion of the river bed and bank along this stretch thus, the sediment is increase Which is the main causative of increased turbidity (assuming most of the sediment provided to the river is not deposited) **(Goransson ,*et.al.*, 2013) .**

From Table(3,4,5and6):- The data of discharge of plant has Formed a negative relation with the some removal efficiency of water quality variables and some other has positive relation, the efficiency of Ph ,total dissolve solid, calcium have a poor negative correlation while alkalinity has a poor positive relation with discharge of plant. while the overall efficiency has a good correlation with discharge of plant, but the overall efficiency from multi regression give value more accurate.

Usually the discharge in hot season higher than cold season, the efficiency of al (HCWTP) from single-regression model also increase (44.25% in hot ,48.18%in cold) season. This contradicts the efficiency has been obtained from multi-regression model (The optimum correlation equation in an exponential form with coefficient of determination R^2 equal to 0.6604) is (57.103%in hot, 62.11%in cold). Above value interpret, at higher amount of production, the effort will be increased on the plant, therefore the output quality will be less and this adversely affects at the efficiency. Statistically, the efficiency has negative higher correlation with turbidity and total suspended sold effluent concentration (i.e Increase their output concentration of Tur. & TSS reduces the efficiency of plant),This proves what explained above paragraph. Therefore Has been added all variables affecting on the efficiency. and,

After the application of models above shows that the quality of the river water is very good and almost all variables matching with the limits of standard specifications, either plant efficiency was good but it's not required efficiency where this goes back to the plant very ancient therefore the quality of the output become less of required . And this, can be summarized the results of the application of models it is highly efficient but they do not take the time factor into consideration where it there is jump clear both in the water quality properties as well as the discharge . So, time factor as well as the speed of the most important factors that must be entered in subsequent studies.

10-Conclusions And Recommendations

From the present study the following conclusions can be obtained:

1- A data fit statistical program is used for modeling a (HCWTP), And The application of these models is satisfactory compared to what has been obtained from result.
2- It's necessary to save such as statistical models in any plant for application in emergency conditions also it is assist to save the time and cost.
3- After was reached from the results, it was suggested to take the time factor into consideration in the next works and develop 2 models for each parameter one to hot season and the other to cold season.
4- The variable speed of river was suggested to inter as additional variable in regression data of river to get because the change in speed will affect the properties of water
5- The average operated flow rate of (HCWTP) in some emergency condition over than the design capacity and statistical regression models designed at natural conditions of flow therefore the error ratio well be appearance in application at this state.
6- The (HCWTP) need to clean, also the plant very and need to maintenance and develop units according to Modern processing techniques ancient therefore, the removal efficiency of plant for some element was few.

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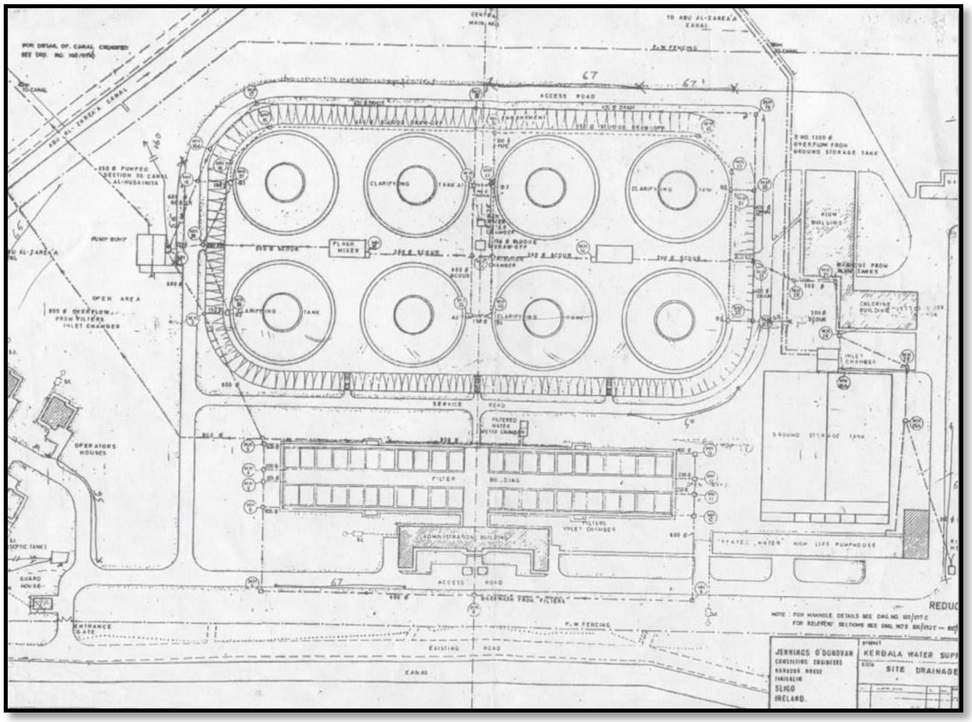

Fig 25: layout of al-Hussein city water treatment plant