Modeling of Conventional Water supply Treatment Plant

Ass. Prof. Dr. Mohammad A.M. Al-Tufaily & B.Sc. Entesar K.H.
Department of Environmental Engineering
Babylon University, Iraq, 2010

Abstract

This study presents a computer program designed in Visual Basic software 6.0. This program is flexible and easy to be used by practiced engineer for designing conventional water treatment plant Also, the program deals with the different environmental factors that affect the design of water treatment steps. The program can compute the hydraulic design of conventional water treatment plant, include transition system, influent and effluent structures and head losses calculations.

1.1 Introduction

The availability of a reliable and clean supply of water is one of the most important determinants of our health. Historically, improvements in human health have been related to improvements in our water supply system from source to tap, so drinking water treatment plants are important in modern society. (Parsons et al., 2006; Paulus et al., 2004)

1.2 Objective of Research

Design of computer programs in (Visual Basic V 6.0 software) to design, control, and operation conventional treatment plant , Prepare computer program to design transition system and calculate the hydraulic profile for conventional treatment plant .

1.3 Objectives of Water Treatment

Three basic purpose of Water Treatment Plant are as follows:

- ❖ To produce water that is safe for human consumption.
- ❖ To produce water that is appealing to the consumer.
- ❖ To produce water using facilities which can be constructed and operated at a reasonable cost.

Production of biologically and chemically safe water is the primary goal in the design of water treatment plants; anything less is unacceptable.

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**,** 2003)

1.4 Conventional Water Treatment Plant

The treatment processes of raw water before it can be used for public consumption must be based on removal level of impurities to comply with various guidelines. The extent of treatment depends upon the quality of the raw water and the desired quality of treated water. (Hong, 2006)

The choice of which treatment to use from the great variety of available processes depends on the characteristics of the water, the types of water quality problems likely to be present, and the costs of different treatments. The processes and technologies used to remove contaminants from water and to improve, protect water quality are similar all around the world. The most widely applied water treatment technology, a combination of some or all ;intake, pre-sedimentation, coagulation, flocculation, sedimentation, filtration, disinfection and sludge processing. These paths of treatment called "**Conventional water treatment plant**".

1.5 Treatment Steps at Conventional Water Treatment plant

1.5.1 Intake structure

Raw water intake structure are used to control of withdrawal raw water from a surface source, thier primary purpuse to selectively withdrew the best quality water while excluding fish, floating debris, coarse sediment, and other objectionable suspended matter,that acheived by supplied the intake with screen technology (e.g fine screen and coarse screen).(Qasim et al.2000)

The design of water supply intakes requires a series of design considerations in order to arrive at a desirable concept that can obtain and deliver the water economically with an acceptably low impact on the environment. (Alsaffar and Zheng, 2007)

1.5.2 Pre-sedimentation

Pre-sedimentation is a step that is often required before coagulation and flocculation in order to remove large particles from the raw water stream. These larger particles can reduce the efficiency of the coagulation and flocculation process. Settling of larger-sized particles occurs naturally when surface water is stored for a sufficient period of time. (FSCI, 2003)

1.5.3 Coagulation

Latterman 1999 defined Coagulation as a complex process, involving many reactions and mass transfer steps. As practiced in water treatment the process is essentially three separate and sequential steps: coagulant formation, particle destabilization, and inter-particle collisions. These processes had been achieved by adding chemical material.

1.5.3.1 Coagulants

These chemicals involved in coagulation are known as coagulants or coagulant aids. Coagulants are simple electrolytes that are water soluble, with a low molecular weight in organic acid, bases or salts. Choice of specific coagulants and coagulant aids depend on the nature of the solid–liquid system to be separated (Fernandez 2002).

One of the more common coagulants used is aluminum sulfate, another iron (II) is other common coagulants. The use of Fe (II) appears to be the most promising of the ClO_2 removal techniques and has been successfully used in laboratory and, to some extent, in pilot and full-scale studies Another coagulant is iron (III) which is lower costs and in some cases slightly better removal of natural organic contaminants.(Hong, 2006)

1.5.3.2 Coagulant Dos

Optimum pH and coagulant dose vary significantly with raw water characteristics. The best approach for determining the treatability of a water source and determining the optimum parameters (most effective coagulant, required dose rates, pH, flocculation times, most effective flocculants aids) is by use of a jar test.

Fernandez 2002 thought that the simple jar test cannot perfectly simulate conditions in full scale coagulation or a clarification process.

Menendez et al. 2007 showed that there was no rule or equation that perfectly correlates the appropriate alum dosing with the turbidity of the influent water, this is because it depends on the chemical properties of the water, such as the pH, as well as the composition of the matter causing the turbidity, but the following equation gives an approximate alum dose for a given turbidity. The operator should note however, that this is only an approximation and that the operator should change the dose based on plant's reaction, using corresponding effluent turbidity as a measure of performance. Note that for equation the units for turbidity (T) are NTU and for alum dose (C_D) the units are mg/L.

$$CD = 33 * \log(T) - 28$$

1.5.3.3 Flash Mixing

In the coagulation process, coagulant chemicals are added to the water as it passes through the static or flash mixer. A static or flash mixer is used to mix chemicals into the water quickly; it does this by the turbulence created by the mixer, so agitation of water by hydraulic or mechanical controls mixing cause velocity gradients. (CPCB, 2003)

Rapid mixing chamber consists of a mechanical mixer with an impeller or propeller to create turbulence in this chamber, the axis of rotation for mixer is vertical or horizontal on the direction of flow. There are two main conditions that have effect on the rapid mixing and flocculation process.

1. The intensity of agitation is called velocity gradient.
2. Agitation time is defined as the ratio of the volume chamber to the flow entering through this chamber.(Fernandez, 2002)

In the design of rapid mixer, the detention time is less than the detention time in the design of the slow mixer for flocculation. Another equipment used to disperse the chemical in coagulation process consist of a channel with fully turbulent flow of sufficient length to yield the desired detention time, followed by a hydraulic jump, has been used successfully.

1.5.4 Flocculation

FSC I 2003 defined flocculation as slow stirring process that causes the flocs to grow and to come in contact with particles of turbidity to form larger particles that will readily settle. The purpose is to produce a floc of the proper size, density, and toughness for effective removal by sedimentation and filtration. Floc formation depends on the rate at which collisions between flocs and particles occur, and how the flocs stick together after collision. Gentle mixing during this stage provides maximum particle contact for floc formation, whilst minimizing turbulence and shear which may damage the flocs. Effectiveness of flocculation depends on the delay (or contact) time and mixing conditions prior to any flocculants being added, the rate of treatment, water temperature and the mixing conditions within the flocculation chamber.

Flocculation basins are normally designed with multiple mixing compartments in a series, with a velocity gradient successively lower in each compartment. This type of design is called (tapered flocculation)

1.5.5 Sedimentation

Qasim ,2000 define sedimentation as a physical treatment process that utilizes gravity to separate suspended solids from water. This process is widely used as the first stage in surface water treatment to remove turbidity causing particles after coagulation and flocculation.

Conventional clarifiers (or sedimentation tanks) may be classified on the basis of flow direction (horizontal, radial, or up flow), the presence or absence of a sludge blanket, and shape (circular, rectangular, or hopper/wedge bottomed).

Parsons and Jefferson 2006 at their study showed that Particles at sedimentation unit may settle in one of four distinctively different ways depending on concentration and the relative tendency of the particles to agglomerate while they settle. At low solid concentrations, typically less than 500– 1000 mgl^{-1}, settlement occurs without interference from neighboring particles. As the concentration increases the influence of surrounding particles increases the settling rate. As the particle concentration increases further the process changes from clarification to hindered settling and thickening. As a discrete particle settles it will accelerate, under the force of gravity, until the drag force on the particle balances its weight force. At this point the particle descends at a constant velocity called the terminal settling velocity. The exact expression for the terminal settling velocity depends on the flow regime around the particle as it settles.

There are many factor affect the sedimentation basin these factors are:

- Particle Size.
- Rise Rate.
- Weir Loading Rate.
- Water Temperature
- Detention Time

1.5.6 Filtration

Filtration is the process of passing water through a porous medium with the expectation that the filtrate has a better quality than the influent, the medium is usually granular bed, such as sand, anthracite, garnet, or activated carbon (Najee, 2007).

Filters can be classified according to the medium type as:

1. Single (mono.) medium filters:

2. Dual media filters:
3. Mixed-media filters

There are two types of filter which are used in water treatment plant: Slow sand filters and rapid sand filters. (Tebbutt, 1998).

Qasim 2000 stated that the mechanisms by which granular filtration media remove solids from water are complex and are not fully understood. Common suggest a number of mechanisms that act simultaneously in the solids removal process, these mechanisms are:

- Straining.
- Sedimentation.
- Impaction, and
- Interception.

A filter bed must be cleaned when either (1) the head through the filter exceeds the design value, (2) turbidity break through causes the effluent quality to be less than a minimum acceptable level, or (3) a pre-selected maximum filter run time has passed since it was last cleaned-Filter units are cleaned by backwashing.

1.5.7 Disinfection

Disinfection is normally the last step in purifying drinking water. Water is disinfected to destroy any pathogens which passed through the filters Chlorine is the one of the most common disinfection chemical that being used. Most of the plants surveyed used chlorine as their disinfection agent. (Hong, 2006)

The primary purpose of disinfecting water supplies is to inactivate microbial pathogens to prevent the spread of waterborne diseases. (Parsons and Jefferson 2006)

1.6 Sludge Treatment Processes

1.6.1 Sludge thickening

After removal from a clarifier or sedimentation basin, sludge can be thickened in a gravity concentration tank. Thickening can be economically attractive in that it reduces the sludge volume and produces a more concentrated sludge for further treatment in the dewatering process, or for perhaps hauling to a land application site. Some dewatering systems will perform more efficiently with higher solids concentrations. Thickening tanks can also serve as equalization facilities to provide a uniform feed to the dewatering step. Although there are a few types of thickeners available on the market, the water industry almost exclusively uses gravitational thickening. (Raymond and Latterman, 1999)

Sludge thickening mainly involves physical processes such as gravity settling, flotation, centrifugation, and gravity belts.

1.6.2 Sludge dewatering

An advantage of dewatering is that it makes the sludge odorless and non-putrescible, the simplest method of drying the sludge is to apply it on open drying beds, in a sludge-drying bed, part of the sludge water is removed by seepage and part is evaporated by sun's heat. When the thickened sludge is applied on the drying beds, the gases adhering to the sludge particles are released to atmosphere. As a result, the sludge particles rise to the surface and float. The sludge water settles down and seeps out of the bed. The drying beds are the best and most suitable type of dewatering of sludge. (Metcalf and Eddy, 1991).

1.7 Hydraulic Profile

Hydraulic profile: is the graphical representation of the hydraulic grade line through the treatment plant. The ***total available head*** at the treatment plant is the difference in water surface elevations in the influent of first treatment unit and that in the effluent of last treatment unit. If the total available head is less than the head loss through the plant, flow by gravity cannot be achieved. In such cases pumping is needed to raise the head so that flow by gravity can occur. Intermediate pumping in the plant is considered poor planning and design .It is expensive option and is unwarranted (Qasim et al., 2000).

The calculation of a water treatment plant hydraulic grade line involves much more than the simple summation of head losses through the processes. Coincident with determining the hydraulic profile, obviously needed to prevent spillage over the channel and tank walls, are other important hydraulic considerations. One important consideration is the necessity for equal distribution of flow among the various unit processes.
(Lane and Barthuly, 2004)

1.7.1 Hydraulic Design

There are many basic principles that must be considered when preparing the hydraulic profile through the plant. Some are listed below:

1. . The head losses through the treatment unit include the following:

   a. Head losses at the influent structure.
   b. Head losses at the effluent structure.
   c. Head losses through the unit.
   d. Miscellaneous and free fall surface allowance.

2. The total loss through the connecting piping, channels and appurtenances is the sum of following:
    a. Head loss due to entrance.
    b. Head loss due to exit.
    c. Head loss due to contraction and enlargement.
    d. Head loss due to friction.
    e. Head loss due to bends, fittings, gates, valves, and meters.
    f. Head required over weir and other hydraulic controls.
    g. Free-fall surface allowance.(Qasim et al., 2000)

2.1 The Computer Program

A computer program is written by using Visual Basic 6.0 software which is an event-driven programming language and associated development environment prototyped by Alan Cooper as Project Ruby, then bought and vastly improved upon by Microsoft.

2.1.1 Design and Operation of Treatment Plant

1. Inter the general information data which will be used to determine of future population (P_f), total average flow rate (Q_{avg}), maximum design flow rate (Q_m) .
2. Design intake unit
    - ❖ Design of intake, input data include maximum flow rate and maximum velocity through gate or pipe (according to type of intake structure).
    - ❖ Design screening chamber, Input data include maximum velocity through bar rack, bar spacing, bar width, and maximum velocity through fine screen.

- ❖ Design of storages units, input data include detention time, width to length ratio, selected depth.

3. Design of coagulation treatments units input data includes detention time, velocity gradient, length to width ratio, selected depth or width, width to depth ratio, type of flow created by impeller, impeller type.
4. Design of flocculation treatments units

   Input data includes detention time, velocity gradient, and length to width ratio , selected depth , width to depth ratio gear efficiency and bearing efficiency for agitation requirement. There are input data for flocculates equipment design include paddle wheel diameter to water depth ratio, width of blades, space between blades , and velocity of paddle to water velocity ratio.
5. Design sedimentation treatment units

   after select shape of sedimentation unit(circular or rectangular), forms of input data for each type must be entered, includes assuming values of surface overflow rate SOR, detention time, weir loading for determining volume of the basins, dimensions, actual SOR.
6. Design of filtration units.
   - ❖ For unit sizing design by assuming values of area of unit, average loading rate, length to width ratio.
   - ❖ For backwash system design by assuming backwash rate, surface wash rate, backwash time, surface wash time, filtration cycle.
   - ❖ For filter media design, input data include type of filter media then the program will choose number of layers, uniformly coefficient of media and effective size of media.
   - ❖ For under drain system design, by assuming size of opening in lateral then the program will automatically select the space for opening in

lateral, space between laterals, number of laterals and main header, number of opening in lateral, total opening in unit, all required check with standard design criteria

7. Design of Disinfection units:

   Input data includes detention time, length to width ratio, selected depth, width to depth ratio, and then the program will be work to determine the suitable dimensions, check detention time.

8. Design of sludge process system

The program provides sludge treatment system represents by filter back wash recovery basins, thickening units, and drying bed. Input data needs for design these system include (detention time and over flow rate for filter backwash recovery basin) and minimum and maximum hydraulic solid loading, solid loading) for thickening units.

2.1.2 Design Transition System and Hydraulic Profile Calculations

This program includes the required steps for:

2.1.2.1 Structure's design

Design the influent and effluent structure of each treatment units including transition pipes and channels of conventional water treatment plant.

2.1.2.2 Head loss calculations

The program will be calculated head loss in each unit including (influent, effluent and transition structures), then plus these losses to "**MWE**", main water elevation to calculate the water elevation in each segment of units, (main elevation that fixed in the beginning of design "water level at clear well").

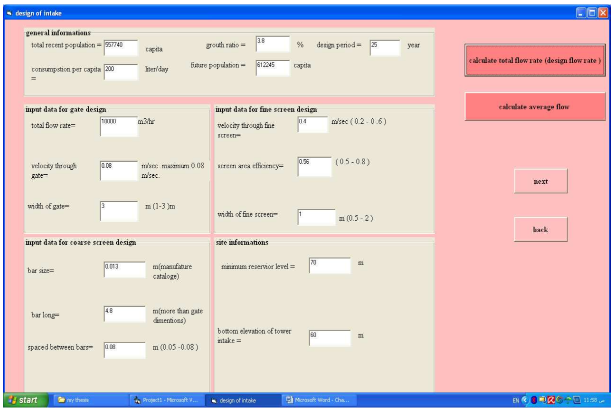

Fig.(1.1) General Information necessary for design the Conventional Water Treatment Plan

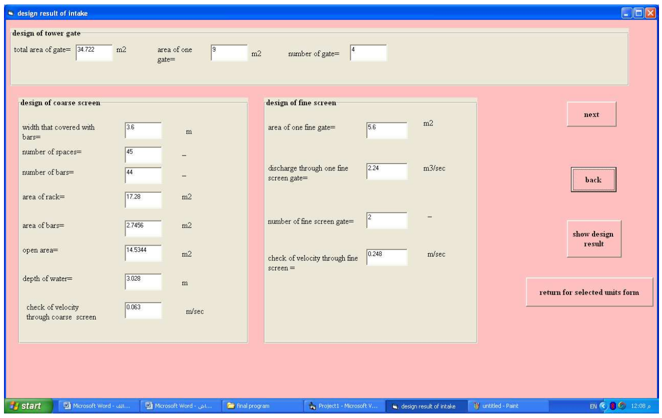

Fig. (1.2): Module for design Tower Intake

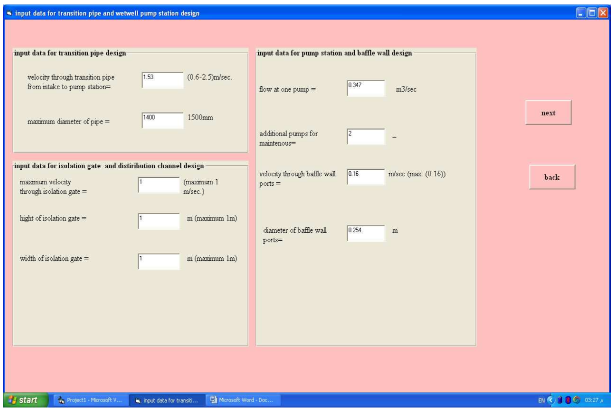

Fig. (1.3) input data needed to design transition pipes and wet well pump station

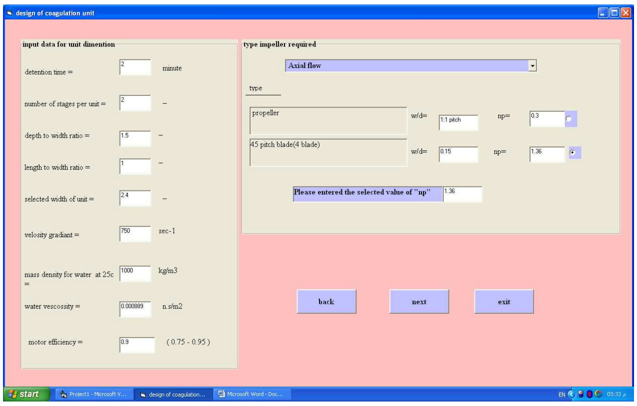

Fig. (1.4) input data needed to design coagulation unit

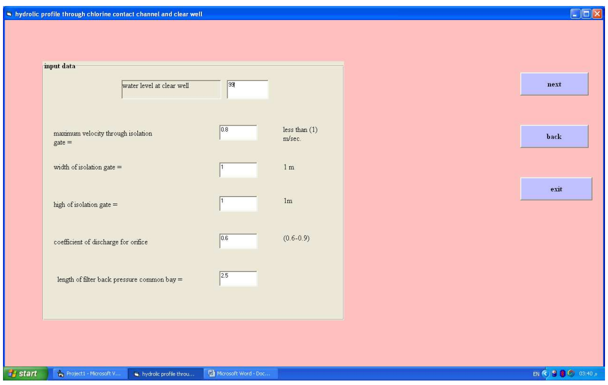

Fig.(1.5): General Information necessary for calculate Conventional water Treatment Plan hydraulic profile

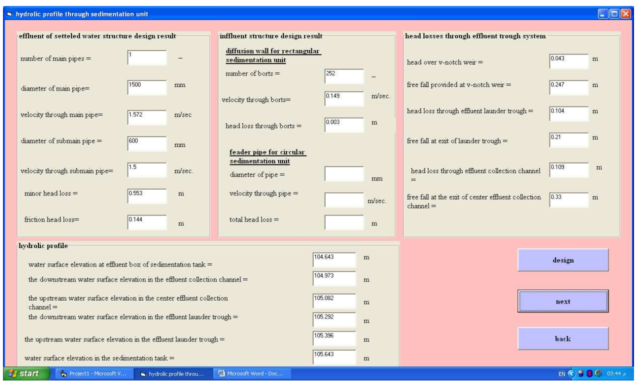

Fig. (1.6): Module for calculate hydraulic losses and hydraulic profile through sedimentation unit

2.2 Analysis of Result

For ensure the perfect operation for the program and the relations between the factors that affecting the design of the studied water treatment plants, the statistical models which are describe was established.

2.3 The Regression Analysis Technique

The relationship between a single variable Y, called dependent variable, and one or more independent variables, x_1, … x_k are explained or modeled by a multiple regression analysis. The regression analysis was done by using "Data Fit" program version 8.0.

2.3.1 The Dependent Variables (y)

In the present work, the volume of treatment units, required area and power required assumed to be the dependent variables (y)

2.3.2 The Independent Variables

Multiple independent variable (also named as explanatory variables or predictors) following table (1.1) shows these variables.

Table (1.1) Independent variables

Variable	Description
x_1	Population factor, capita
x_2	Design period, y
x_3	Growth rate
x_4	Consumption, l/c.d
x_5	Time of storage, min.
x_6	Coagulation time, sec.
x_7	Flocculation time, min.
x_8	Surface loading rate $m^3/m^2.d$
x_9	Filtration rate, m/h.

2.4 Regression Models for Designing water Treatment Plants

Multiple non-linear regression models in three forms were used for each one of design requirements to choose which form gives the best fitting of data, from these models we selected three models that give the best fitting of data.

Table (1.2): The Proposed Models

No.	Equation Description
A	$y = b_1 x_1 + b_2 x_2 + ... + b_k x_k + G$
B	$y = \exp(b_1 x_1 + b_2 x_2 + ... + b_k x_k + G)$
C	$y = b_1 x_1 + b_2 x_2 + ... + b_k x_k$

Where;

y = dependent variables. **$x_1, x_2, \ldots, x_k$ = the independent variables.**

$b_1, b_2, b_3, \ldots b_k$ = are model coefficients, and **G = model constant term.**

2.5 Result of Study: The result presented in table (1.3).

Table (1.3) result of study

Y	Models	R^2	Stand. Err
Opening area of intake	$y = 0.000083x_1 + 0.11x_2 + 0.707x3 + 0.108x4 - 34.874$	0.999	0.02
Volume of storage unit	$y = 0.001x_1 - 1.586x_2 + 11.382x3 + 1.553x4 + 139.052x5 - 928.37$	0.999	3.134
Volume of coagulation unit	$y_1 = 0.000x_1 - 0.442x_2 + 2.014_3 + 0.397x_4 + 1.973x_6 - 181.518$	0.902	13.395
Power of coagulation unit	$y_2 = 0.000x_1 + 0.235x_2 + 1.349x_3 + 0.215x_4 + 1.293x_6 - 127.29$	0.999	0.243
Volume of flocculation unit	$y = 0.012x_1 - 16.18x_2 + 101.724x3 + 15.685x4 + 141.153x7 - 9257.917$	0.999	2.547
Volume of sedimentation unit	$y = \exp\begin{bmatrix} 0.00000225 * x_1 + 0.0034 * x_2 + 0.027 * x_3 + 0.003 * x_4 \\ - 0.035 * x_8 + 9.602 \end{bmatrix}$	0.983	1223.24
Area of filtration	$y = \exp\begin{bmatrix} 0.0000023 * x_1 + 0.003 * x_2 + 0.023 * x_3 + 0.003 * x_4 \\ - 0.095 * x_9 + 5.866 \end{bmatrix}$	0.987	29.495

2.6 Verification of Computer Program Results

To make sure that the program works successfully, verification must be done. That achieved either comparison hand calculation results for specific design values with program result for same design values (that processes repeated many times then verification will be estimated), or comprised program result for specific condition with actual water treatment plant exists around us worked with same conditions.

3.1 Conclusions

From the present study the following conclusions can be obtained:

1. A computer program for the design of conventional water treatment plants was developed, user can design the different water treatment processes as well as maintain the plant operation. This application is simple through inter input data needed for each process that provided , the program provide feature that enable the user to change the input data needed for each unit from lists contained different type of these parameters .
2. The program had been designed to provide separate operation for treatment processes that we can pass one of the treatments which consider not required, dependent on the raw water quality and treated water quality required.
3. For present study computer program for design transition system between conventional water treatment plant units and calculate the head losses through the plant then compute the hydraulic profile for plant had been developed, then we can compute total available head provided for plant, that consider the controlled point in estimate the

type of flow that achieved in plant (gravity flow or needed for pumps).

4. The design was developed considering the effect of the environmental factors, by use data statistics program called (data fit), we can successfully produce an equations connect between these environmental factors and plant variables. The verification for the program had been adopted, shows a very good agreement.

References

- Alsaffar A. M., and Zheng Y. , (2007), "Water Intakes - Siting and Design Approaches" Bechtel Corporation 9801 Washingtonian Blvd.Gaithersburg, Md 20878, , Maryland, USA.
- Central Pollution Control Board, (CPCB), (2003), "Status of Water Treatment Plants In India" Ministry of Environment and Forests, India, Website: www.Cpcb.Nic.In, E-Mail: Cpcb@Nic.In.
- Fernández, e. and Gálvis, a., (2002), "Artificial Neural Networks Model Used for Clear Water Treatment Plants" Instituto Cinara, Universidad del Valle. Dirección Postal, 25157, Cali, Colombia.
- FSC Architects and Engineers, (2003) "Class I Water Treatment Plant Operator Program Manual "Government of the Northwest Territories Municipal and Community Affairs, 53 4910 rd Street P.O. Box 1777 Yellowknife, NT X1A 2P4.
- Hong, C. K., 2006, "Development Of A Decision Support System For Drinking Water Treatment Process Design (Water-Dss)" MSc. thesis, College of Engineering, Department of Environmental Management, University Technology, Malaysia.

- Lane, Th. J., and Barthuly, P. D., (2004), "Water Treatment Plant Design" McGraw-Hills, New York.
- Menéndez, D.et al. (2007), " Ojojona Plant Manual"
- Metcalf and Eddy, Inc., 1991 "Wastewater Engineering Treatment, Disposal, and Reuse", McGraw- Hill, New York.
- Najee, A. S., (2007), "Computer Program of Package Water Treatment Plants Design" MSc. thesis, College of Engineering, Department of Civil Engineering, Babylon University, Iraq.
- Parsons, S. A. and Jefferson, B., (2006), "Introduction to Potable Water Treatment Processes" School of Water Sciences Cranfield University, by Blackwell Publishing Ltd UK.
- Paulus J. G., (2004), "Diagnosing the Hydrodynamic Characteristics of A drinking Water Treatment Plant" School of Engineering Faculty of Engineering, Physical Sciences and Architecture, The University Of Queensland.
- Qasim, S. R., Motley, E.M. and Zhu, G., (2000), "Water Works Engineering", Chiang, Patel and Yerby, Inc., Dallas, Texas.
- Raymond D., Letterman, R. D., (1999), "Water Quality and Treatment" A handbook of community water supplies. American Water Works Association, McGraw-Hill. New York.
- Tebbutt, T. H. Y.; (1998), "Principles of water quality control", Butterworkh Heinemann.

الخلاصة

تُقدِم هذه الدراسة برنامج حاسوبي مصمم َبلغةِ فيجوال بيسكِ 6.0. إن البرنـامج مرن وسـهل الاستخدام من قبل المهندس المتمرس وكذلك دقيق فـي النتـائج لتصميم محطـه تقليديـه لمعالجـة ميـاه. كذلك يهدف البرنامج إلى تحليلُ العواملَ البيئية المختلفة المؤثرة علـى تصميم خطـوات معالجـة ميـاه الشرب.

يستطيع البرنامج استنتاج التصميم الهيدروليكي للمحطه التقليديه متضمنا نظام النقل ومنشات المداخل والمخارج للوحدات وحسابات خسائر الجريان.

تم إثبات دقة نتائج البرنامج بمقارنتها مع نتائج لمحطات فعليه مصممه بواسطة الطرق التقليديه وتفاصيل هذه المحطات تم الحصول عليها من التقارير ألمنشوره أو كتب ومصادر معتمده.

لإيجاد العِلاقاتِ الإحصائية بين عدد من المتغيرات المستقلِة والمتغيرات المعتمدة تم استخدام طريقة التحليل الانحدار اللاخطّي المتعدّد باستعمال برنـامج الإحصائي "Data Fit 8.0". وتشمل المتغيرات المستقلة كل من (عدد السكان المنطقة المخدومة، العمر التصميمي، الاستهلاك اليومي للشخص الواحد، نسبة نمو السكان في ألمنطقه المخدومة،زمن البقاء في كل وحدة معالجه ،معدل الحمل السطحي ومعدل الترشيح) بينما المتغيرات المعتمدة التي أُخِذَت بعين الاعتبار هي (حجم وحداتِ المعالجـةِ، الطاقه الازمـه للتشغيل).تم توضيح العلاقه بين المتغيرات المستقله والمعتمده بمعادلات كفوءة.

البرنامج المعد في هذه الدراسة سهل الاستخدام، ومرن من حيث اختيار الأنواع المختلفة من المعالجات داخل المحطة ، وإفادة المهندسين والباحثين في مجال الهندسة البيئية (الهندسة الصحية) بالنتائج المتعددة للارتقاء والتقدم في مجال البحث العلمي في سبيل خدمة الإنسان والبيئة.

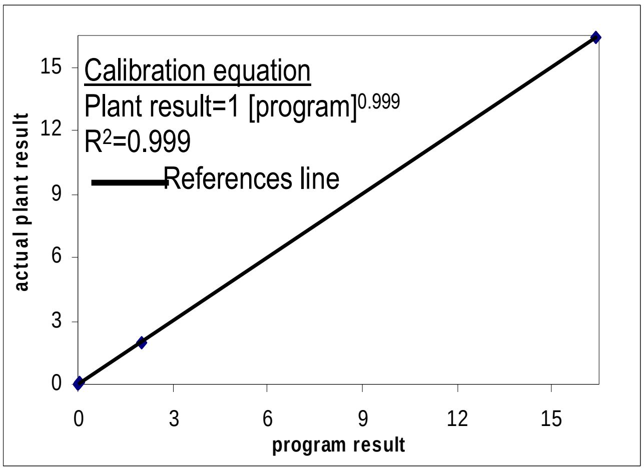

Fig. (1.7): verification of intake unit for conventional treatment plant model

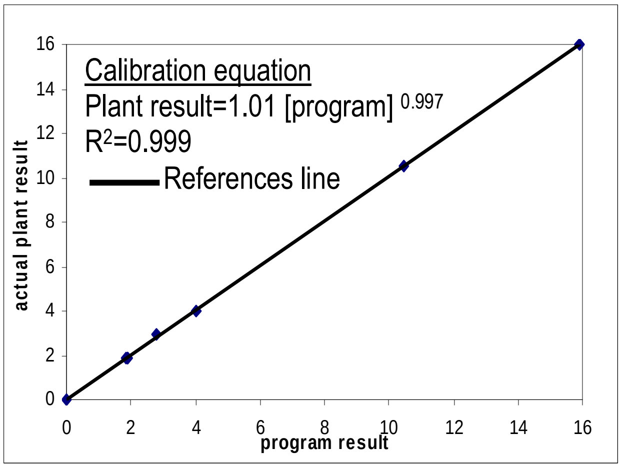

Fig (1.8): verification of coagulation unit for conventional treatment plant model

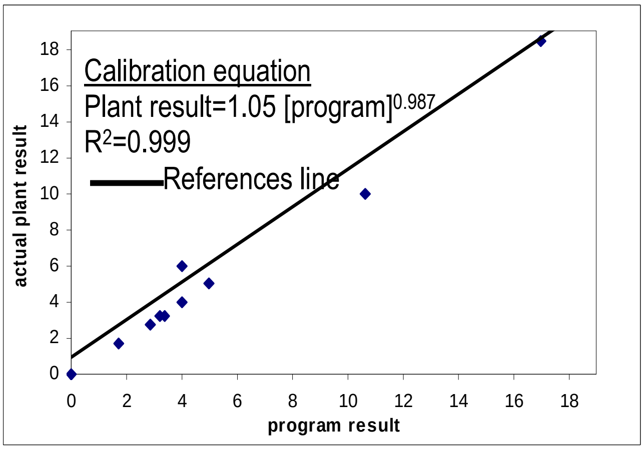

Fig. (1.9): verification of flocculation unit for conventional treatment plant model

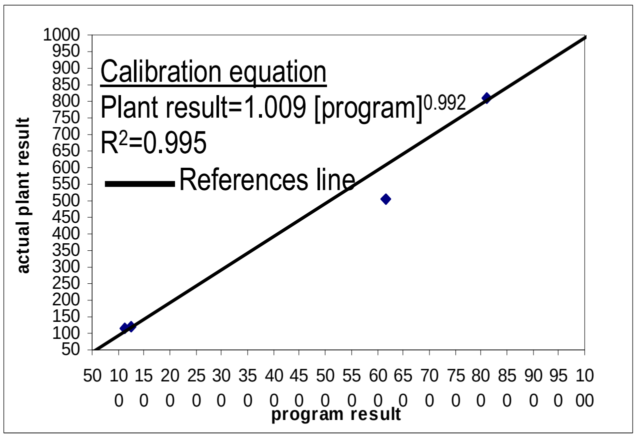

Fig (1.10): verification of sedimentation unit for conventional treatment plant model

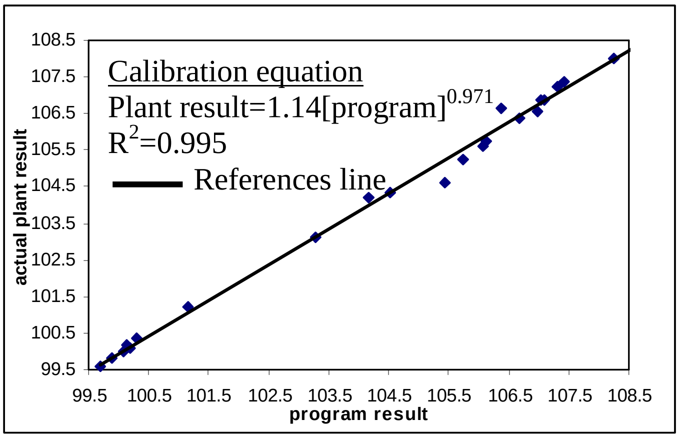

Fig. (1.11): verification of hydraulic profile for conventional treatment plant model

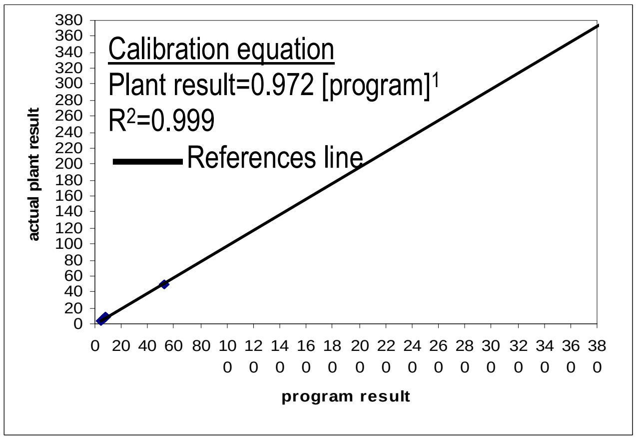

Fig (1.12): verification of filtration unit for conventional treatment plant model

Verification Result for Present Research

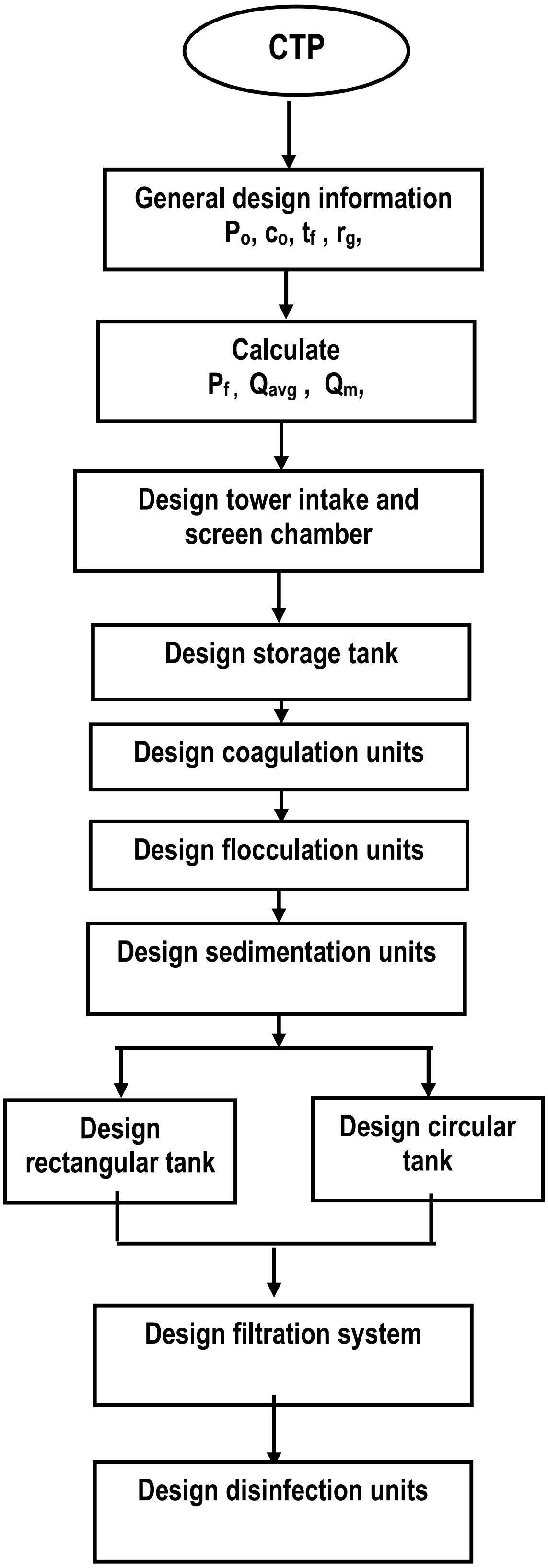

Fig.(1.13): Flowchart for Computer Program