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Comparison of the Design of Water Treatment Plant by Manual and by Software Method

S. P. Sharma, S. D. Kolte, N. S. Marape, S. D. Darshanwad, S. K. Dongare, H. S. Kumawat

***Abstract*— The primary objective of any water supply scheme is to provide safe and adequate water supply to the area for which it is designed. Water treatment plant is the key component of such a water supply scheme, which transforms the raw water into potable water by using the appropriate treatment processes. The selection of treatment processes depends upon the raw water quality and the finished water quality objectives. The design of components of water treatment plant, construction together with good operation is very essential for water treatment plant.**

In this project an attempt is made to design the conventional Water Treatment Plant of capacity is 100 MLD by manually and also by using the software. All the components of water treatment plant are included in this design. The results of design obtained by using manual method are compared with results of software method.The comparative study shows that which method is very accurate, easy and useful for the design of water treatment plant.

***Index Terms*— Aerator, Chlorination, Clariflocculator, Water treatment plant, WTPSOFT02**

I. INTRODUCTION

Water treatment is the process of removing contaminants from raw water. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants.

A. Classification of Most Common Water Treatment Plants

Water treatment plants can be classified as:

1. *Simple disinfection*

It is a direct pumping and chlorine injection, used to treat high quality water.

2. *Traditional filtration plants (surface water)*

Removes color, turbidity, taste, odor, and bacteria (sedimentation+ filtration plant)

3. *Direct filtration plants (Surface water)*

If the source water has better quality with lower solids, flocculation and sedimentation can be omitted; this modification is called direct filtration plant.

4. *Softening plants (ground water)* [1].

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S. P. Sharma, U. G Students, (All from) Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad, India.

S. D. Kolte, U. G Students, (All from) Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad, India.

N. S. Marape, U. G Students, (All from) Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad, India.

S. D. Darshanwad, U. G Students, (All from) Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad, India.

S. K. Dongare, U. G Students, (All from) Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad, India.

H. S. Kumawat, Asst. Prof., Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad, India.

B. Objectives of Project

Its objective is to provide potable water that is chemically and biologically safe for human consumption. It should also be free from unpleasant tastes and odors and to produce both *"Potable"* and *"Palatable"* water.

To design the conventional water treatment plant with more accuracy, without mistake and in less time. To compare the design of conventional water treatment plant by manual and by software method.

C. Overview of the Water Treatment Plant, Process and Design

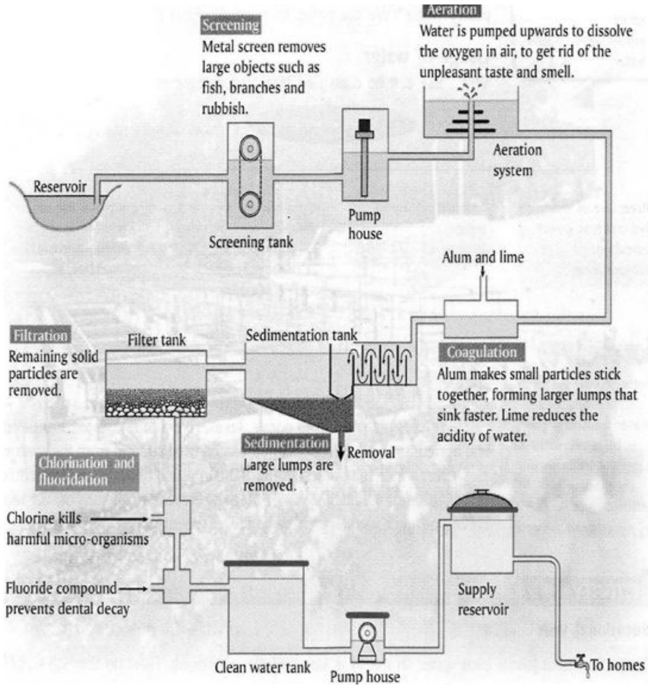

Fig.1 Water Treatment Process

The physical and chemical Quality of drinking water should not exceed the limits as per Drinking Water Quality standards IS-10500 (1991) [1, 2]. Water treatment plant is of 100 MLD capacity.

D. WTPSOFT 02 Software

Wtpsoft02 software is developed for the design of conventional water treatment plant. The design limit of software is 1MLD to 100 MLD.

The WTP02 Design Software can be used as a tool in the hands of Design Engineer. It gives the dimensions of various units of the treatment plant and their power requirement. Engineers can use this software to increase the productivity and profitability. Academic institutions can also use this software for teaching the students the approach for the design of WTP and also for their consultancy cell [3].

II. SYSTEM DEVELOPMENT

Manual design of following components and its comparison with WTPSOFT02 Software

1. *Cascade Aerator*
2. *Flash Mixer*
3. *Flocculator*
4. *Clarifier*
5. *Rapid Sand Filter*
6. *Parshall Flume*
7. *Chemical Storage Requirement*
8. *Chlorine and Underground Reservoir Requirement*

The design of water treatment plant is done by conventional method of water treatment plant design by assuming some constant values these values are shown in result table. All the data are then compared with WTPSOFT02 Software, the input is putted into the software and its output and input is compared with conventional design.

III. RESULT AND DISCUSSION

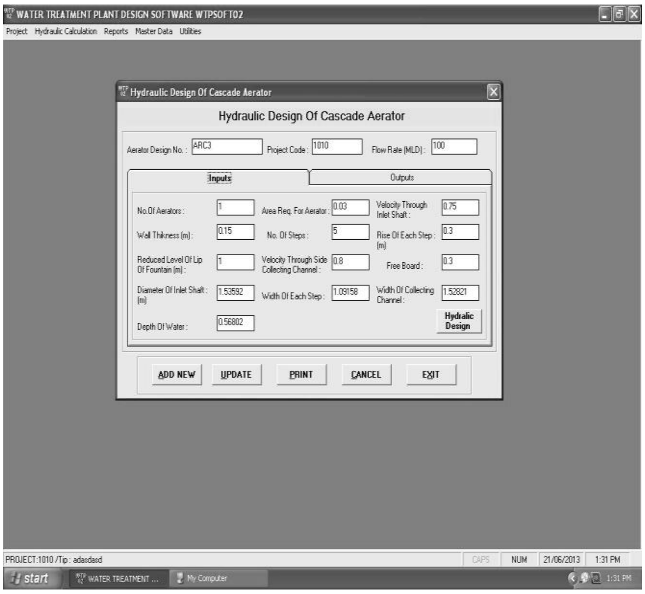

Fig. 2 hydraulic design of Cascade Aerator-input

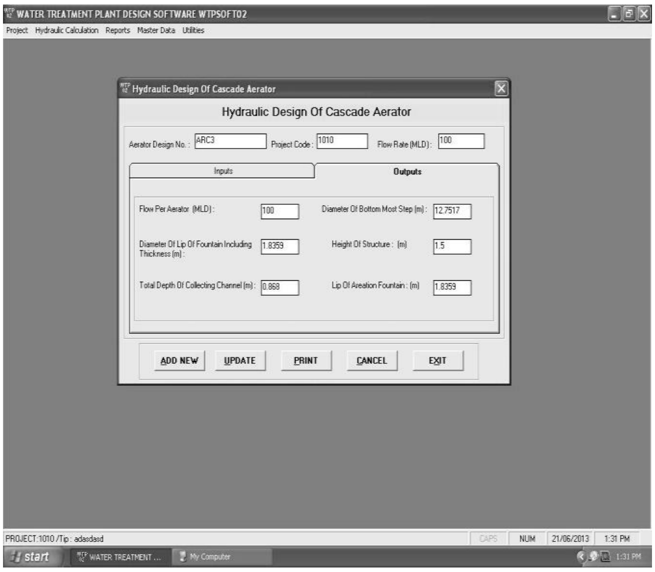

Fig. 3 hydraulic design of Cascade Aerator-output

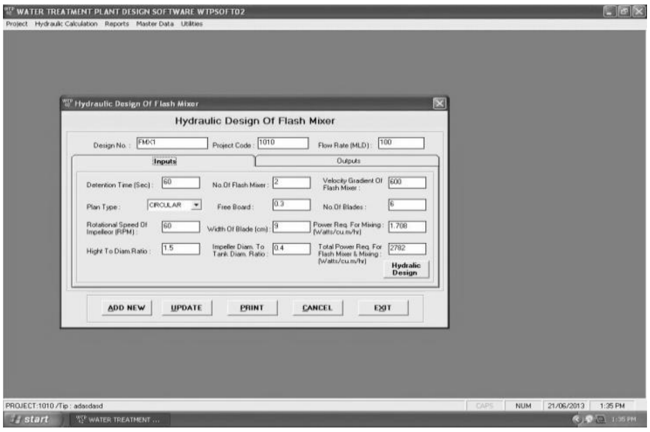

Fig. 4 Hydraulic Design of Flash Mixer-input

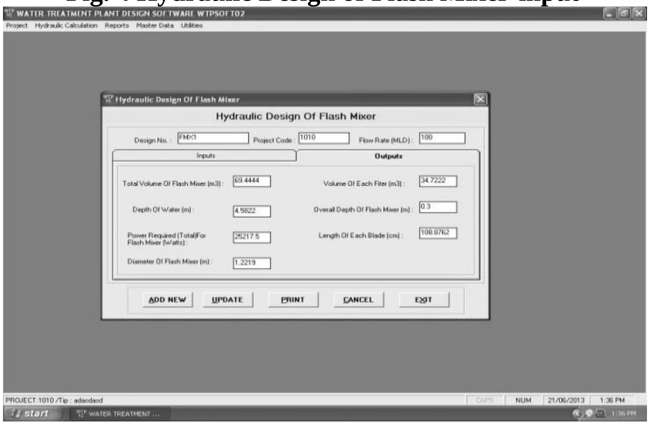

Fig. 5 Hydraulic Design of Flash Mixer-output

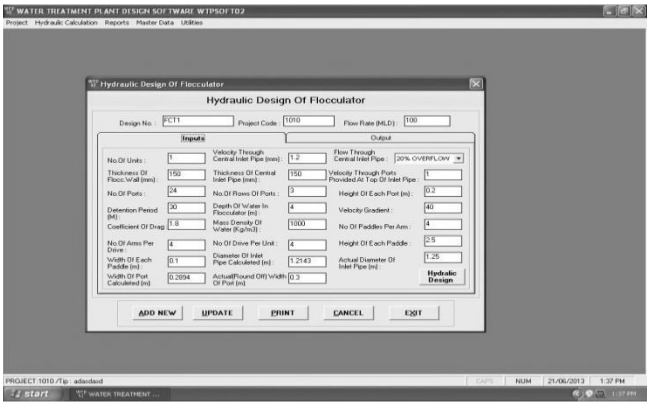

Fig. 6 Hydraulic Design of Flocculator-input

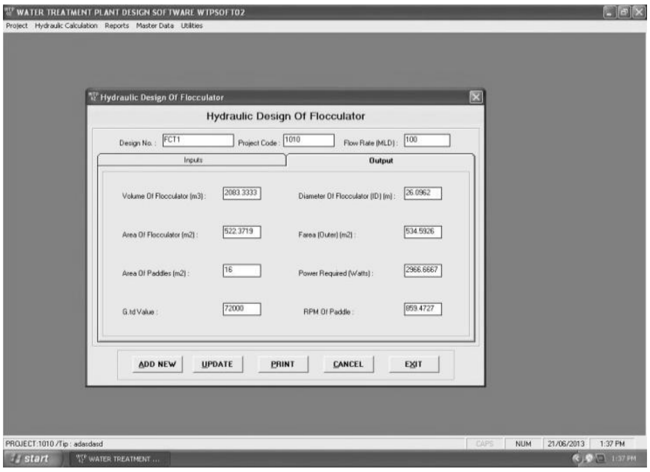

Fig. 7 Hydraulic Design of Flocculator-output

Fig. 2, 3 shows the input which is required for design of aerator are given to the software, and their respective output is shown. Likewise the different units/components are shown with their inputs and outputs in fig. 4, 5, 6 and 7.

Table –I Design summary

Sr. No	Unit	By Manual Design	By Software Design
1	**Cascade Aerator**		
	Inputs		
	No. of Aerator	1	1
	Area (m^2)	0.03	0.03
	Velocity (m/s)	0.75	0.8
	No. of steps	5	5
	Rise of each step (m)	0.3	0.3
	Reduced Level of lip of fountain (m)	1	1
	Diameter of inlet shaft (m)	1.6	1.5359
	Width of each step (m)	1.1	1.0916
	Width of connecting channel (m)	1.5	1.5282
	Depth of water (m)	0.6	0.5680
	Outputs		
	Flow per Aerator (m^3/sec)	1.39	1
	diameter of bottom most steps (m)	12.74	12.7517
	Diameter of lip of fountain including thickness (m)	1.8	1.8359
	Height of structure (m)	1.5	1.5
	Total depth of collecting channel (m)	0.9	0.868
	Lip of aeration Fountain (m)	1.8	1.8359
2	**Connecting Channel**		
	Inputs		
	Channel No.	1	1
	Flow Rate (MLD)	100	100
	Length of connecting channel (m)	5	5
	Velocity (m/s)	0.8	0.8
	Width (m)	0.83	0.8
	Computed Depth of water (m)	1.5	1.8085
	Actual Depth of water (m)	1.8	1.8085
	Free Board (m)	0.3	0.3
	Outputs		
	Total Depth (m)	2.29	2.1084
	Hydraulic flow in connecting channel	1.8	1.811
	Slope (m)	0.0005	0.0005
	Reduced level of Connecting channel		-0.0025
3	**Flash Mixer**		
	Inputs		
	Flow Rate (MLD)	100	100
	Detention time (sec)	60	60
	No of Flash Mixer	2	2
	Velocity (m/s)	0.6	0.6
	Free Board (m)	0.3	0.3
	No of Blades	6	6
	Rotational Speed of impeller (rpm)	60	60
	Width (cm)		9
	Power req. For mixing (Watts/cu.m/hr)	1.7	1.708
	Height to Diameter ratio	1.5	1.5
	Impeller dia. to tank dia. ratio	0.4	0.4
	Total power Req. for Flash Mixer & Mixing (kW)	3	2.782
	Outputs		
	Volume (m^3)	69.46	69.4444
	Volume of each filter (m^3)	34.73	34.7222
	Depth of water (m)	4.65	4.5822
	Overall depth of Flash Mixer (m)	0.3	0.3
	Power Required(kW)	2.5	2.5217
	Length of each Blade (m)	100	108.8762
	Diameter (m)	1.55	1.2219
4	**Flocculator**		
	Inputs		
	No. of units	1	1
	Velocity through central inlet pipe (m/s)	1.2	1.2
	Flow through central inlet pipe (overflow)	20%	20%
	No. of ports	24	24
	No. of rows of ports	3	3
	Height of each ports (m)	0.2	0.2
	Detention period (min.)	30	30
	Depth of water in Flocculator (m)	4	4
	Velocity gradient (m/s)	40	40
	No. of paddles per arm	4	4
	No. of arm per drive	4	4
	No. of drive per unit	4	4
	Height of each Paddle (m)	2.5	2.5
	Actual diameter of inlet pipe (m)	1.25	1.25
	Width of port (m)	0.3	0.3
	Actual round of width of port (m)	0.3	0.3
	Outputs		
	Volume of flocculator (m^3)	2084.44	2083.333
	Diameter (m)	18.25	26.0962
	Area (m^2)	521.1	522.3719
	Area of paddles (m^2)	16	16
	Power reqd.(kW)	2.968	2.9667
5	**Clarifier**		
	Inputs		
	No. of unit	2	2
	Detention period (hr)	2.5	2.5
	Depth (m)	3	3
	Max. overflow rate (m^3/m^2.d)	36	35
	Dia. of Flocculator (m)	18.25	18.25
	Velocity of launder (m/s)	0.6	0.6
	Width of launder (m)	0.8	0.8
	Outputs		
	Dia. of clarifier (m)	50.6	50
	Depth of clarifier at center (m)	5.8	5.8073
	Weir loading (m^3/d/m)	300	382.1656
	No. of projection	14	14
	Launder depth (m)	1.024	1.0234
	No. of orifices	530	666.6667
	No. of V-notches	299	--
6	**Rapid Sand Filter**		
	Inputs general		
	Filtration rate	5	5
	Length to width ratio	1.3	1.3
	Depth of gravel filter bed(cm)	45	45
	Depth of sand filter bed(cm)	75	75
	Depth of water over sand bed(cm)	2	2
	Effective size of sand (mm)	0.5	0.45
	Uniformity coefficient	1.5	1.4
	Orifice area reqd. in terms of % of filter area	0.3	0.3
	Under drainage system		
	Rate of back washing (m/hr)	36	36
	Time of back washing (min)	10	10
	Dia. of orifice(mm)	12	12
	Dia. of lateral (mm)	80	80
	Calculation dia. of manifold	0.7	0.6
	No. of lateral calculated	50	36
	Time req. for filling wash water tank (hr)	24	24
	Design of wash water trough		
	Max. horizontal travel of wash water	0.9	0.9
	Depth of water (m)	0.4	0.4
	% Expansion of sand bed during back washing	50	50
	Width of gullet (m)	0.6	0.6
	Free board for gullet	0.3	0.3
	Provide No. of through	5	4
	Design of wash water pump		
	Wash water tank height	8	8
	Assume suction head	4	4
	Length of delivery pipe (m)	25	25
	Dia. of delivery pipe (mm)	150	150
	Efficiency of pump (%)	70	70
	Efficiency of motor (%)	90	90
	Actual provided head	210	210
	Actual BHP provided	17.5	18.3164
	Design of pipes		
	No. of inlet channel to feed filter	2	2
	Velocity in the channel (m/s)	1	1
	Width of inlet channel (m)	1	1
	Provided dia. of inlet pipe each	0.4	0.3555
	Provided dia. of filter wash water	0.4	0.5507
	Outputs		
	Depth of filter (m)	3.7	3.2
	Total depth of trough (m)	0.5	0.55
	Dist. of trough from sand bed (m)	43	43.05
	Interval of backwash between any two bed (hr)	1.7	1.7143
7	**Flow Measurement Device**		
	Inputs		
	Value of manning	0.013	0.013
	Length of channel Parshall Flume (m)	5	5
	Velocity through channel (m/s)	0.8	0.8
	Outputs		

	Throat width of flume	300	300
	Length of conveying part (m)	1322	1322
	Width at diverging	600	600
	Width of converging	831	831
	Throat length of flume (m)	600	600
	Length of diverging part	900	900
	A	1350	1350
	K	75	75
	Z	225	225
8	**Chemical Storage Requirement**		
	Inputs		
	Average alum dose	40	40
	% solution strength for alum	5	5
	No. of tanks including 1 stand by	3	3
	operation time (hr)	8	8
	Outputs		
	Qty. of alum req (kg/day)	3111	4000
	Volumetric capacity		13.33
	Size of each tank	3	2.108
	Bag of alum req/month	2400	2400
	Area req. for alum storage	1270	1270.588
9	**Chlorine and Underground Reservoir Requirement**		
	Chlorine dose	2	2
	Detention time	60	60
	Depth of reservoir (m)	2	2
	No. of component	4	4
	Length of each component (m)	1.2	1.2
	Width of component (m)	1.2	1.2
	Component area	1.44	1.44
	Chlorine req. (kg/d)	200	200
	Volume of underground clear water	4166	4166.666
	Area of reservoir	2083	2083.333
	Comp. area	520	520.8334
	Weight of each cylinder	50	50

IV. CONCLUSION

The main objective of WTP is to provide potable water that is chemically and biologically safe for human consumption and it should free from unpleasant tastes and odors is fulfill by design of WTP , in which all process are included for purification of water.

The parameters or components which are needed for these processes are design by manual and software method.

By comparing the results of these two methods, we concluded that,

The results obtained by these two methods are approximately same. The manual method is lindy and tedious anther hand the software method is easy and interesting. The time consumption for design by software method is less than the manual method. The errors in manual method are more than of software method.

According to all above points, the software method is more accurate.

APPENDIX

MLD	Million Liter per day
W.T.P	Water treatment plant
cu. m	Cubic meter
cm	Centimeter
m	Meter
m^2	Square Meter
m/s	Meter per second
m^3/sec	Cubic Meter per second
sec	second
hr	hour
rpm	Revolution per minute
kW	Kilo watt
min.	minute
m/hr	Meter per hour
mm	Millimeter
kg/day	Kilogram per day

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AUTHORS PROFILE

Sumitchandra P. Sharma, Under Graduate Civil Engineering Student, Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad (India), Mobile No. +919767376255, Email-sumitps21@gmail.com

Sachin D. Kolte, Under Graduate Civil Engineering Student, Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad (India), Mobile No. +918275321007, Email-koltesd@gmail.com

Nilesh S. Marape, Under Graduate Civil Engineering Student, Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad (India), Mobile No. +919028042412, Email-nilmarape@gmail.com

Sainath D. Darshanwad, Under Graduate Civil Engineering Student, Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad (India), Mobile No. +918806258092, Email-saidarshanwad@gmail.com

Satish K. Dongare, Under Graduate Civil Engineering Student, Civil Engineering Department, Shreeyash College of Engineering & Technology, Aurangabad (India), Mobile No. +919404984028, Email-dongare.satish25@gmail.com

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