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# Comparison between Design of Water Treatment Plant Manually and by Using Software with Reference to Yavatmal City

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***Abstract:*** ***Water treatment is the process of removing contaminants from raw water. It includes various physical, chemical, and biological processes to remove the impurities from raw water.***
***The existing Chapdoh Water Treatment Plant is designed for 100 lpcd rate of supply to Yavatmal city. The water demand of Yavatmal city will increase with the development of the city.***
***The development leads to addition of industrial water demand and also there will be increase in living standards of people. Under these situations, the existing Chapdoh WTP will not be efficient. Hence, an attempt is made to design WTP by keeping the growth of Yavatmal city in near future with higher rate of supply.***
***The aim of present research work is to design WTP for Yavatmal city for design period of 30 years manually and using self-developed MS Excel program. After studying and comparing characteristics of raw water with Indian Standard Characteristics, design of various mechanical units of WTP along with chemical treatment processes like coagulation, water softening and disinfection are found to be essential.***
***The results obtained of WTP design manually are compared with MS Excel program design. MS Excel program developed for the complete design of WTP offers the function that, on entering design population, calculations are done automatically and complete WTP is designed. Also, the program minimizes the percentage of error that occurs in manual designing and it gives precise results in lesser time.***
***Keywords*: *Contaminants, Water Demand, Water Treatment Plant, Manual design, MS Excel program***

## I. INTRODUCTION

### *A. Water Treatment Plant (WTP)*

People like water to taste clear, look clear and smell clear; and it's the quality of the water source that will determine what kind of treatment it will need. 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 typical water treatment plant (WTP) comprises intake, pumping, pre-sedimentation (in some cases), coagulation, flocculation, clarification, adsorption, filtration, disinfection, storage, and pumping to treat water for consumption.

Generally, the water treatment design and planning process is driven by factors such as, water source availability and quality, sustainability assessments of treatment and source options that weigh financial, social and environmental parameters, legal regulatory requirements and the availability of land, skillsets and technology. In a conventional water treatment plant (WTP), raw water undergoes a series of processes which include the units below.

*1)* Intake and screening
*2)* Intake and screening
*3)* Flocculation
*4)* Clarification/sedimentation
*5)* Filtration
*6)* Chlorination/disinfection
*7)* Clear water reservoir

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*B. Existing WTP in Yavatmal City*

Yavatmal is the city in Maharashtra state having elevation above sea level 451 m (1479 ft.).The area of the Town is 12 Sq.km. and rural area is 19 Sq.km. The population as per 2011 census record is 2,54,853. Present population is 2,66,000. The water supply to the city is provided from Chapdoh treatment plant situated at village Nilona. Chapdoh Water treatment plant has capacity 17.40 MLD. The main source of supply to water treatment plant is Chapdoh dam at a distance of 18.71 km which is built across Waghadi river, nearest village to dam is Chapdoh in Yavatmal District of Maharashtra. The dam is an Earth fill Dam. Catchment area is 12.266 thousand hectors. Maximum / Gross storage capacity is 13.127 MCM. Live storage is 7.65 MCM. Dead storage is 0.93 MCM. About 51% of total water supplied to the city is from this plant.

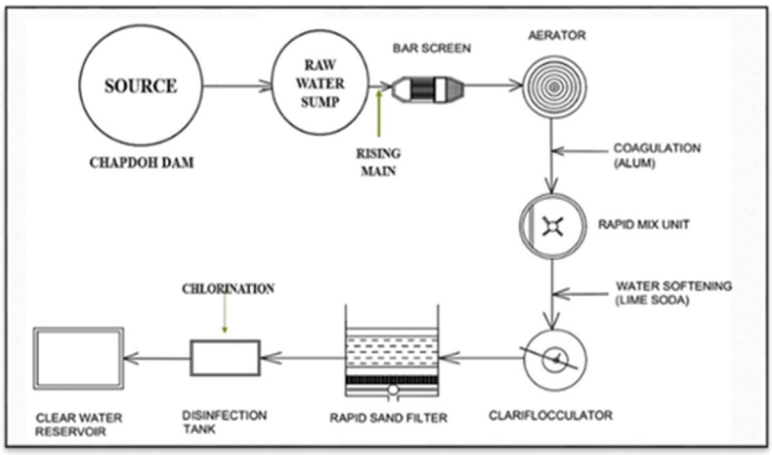



Fig. 1 Layout of Existing Chapdoh WTP

The plant operates for 22 hours and 17.40 MLD (725 m3/hr.) water is being treated and supplied to the city. Rate of water supply is 100 lpcd. The design and construction of the plant is conventional one and comprises of various units such as aerator, flash mixer, clariflocculator, rapid sand filters, chemical house, clear water sump and pump house.

*C. MS Excel*

Microsoft Excel is a spreadsheet program used to record and analyse numerical and statistical data. Microsoft Excel provides multiple features to perform various operations like calculations, pivot tables, graph tools, macro programming, etc. A Excel spreadsheet can be understood as a collection of columns and rows that form a table. Alphabetical letters are usually assigned to columns, and numbers are usually assigned to rows. The point where a column and a row meet is called a cell. The address of a cell is given by the letter representing the column and the number representing the row.

The main features of the MS Excel program in WTP design are as follows:

*1)* The software is completely user friendly.
*2)* Menu is displayed to select a particular unit for design.
*3)* Design procedures followed are according to BIS.
*4)* Permissible ranges of parameters are provided to guide user for entering the input data.
*5)* The software will not allow entering any data which is incompatible and prevents from obtaining erroneous results.

## II. LITERATURE REVIEW

Darshanwad S.D. et al. (2013) “Comparison of the Design of Water Treatment Plant by Manual and by Software Method”. In this study, an attempt to design conventional Water Treatment Plant of 100 MLD capacity by manual method and by using software. The physical and chemical Quality of drinking water does not exceed the limits as per Drinking Water Quality standards IS-10500 (1991). Conventional water treatment plant is designed using manual method and by using the software method. Manual design of Cascade Aerator, Flash-Mixer, Flocculator, Clarifier, Rapid Sand Filter, Parshall Flume, Chemical Storage Requirement and Chlorine and Underground Reservoir Requirement and its comparison with WTPSOFT02 Software was done. The manual method was lindy and tedious and on other hand the software method was easy and interesting. The time consumption for design by software method was less than the manual method. The errors in manual method were more than of software method.

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Mujeeburahiaman P.S. and Murthy B.M. (2015) "Design of Conventional Water Treatment Plant for the Comprehensive Water Supply Scheme to Mukkam and Adjoining Villages in Kerala using WATPLANT Software" they designed a conventional water treatment plant for four rural panchayaths in Kozhikode district of Kerala state, India. Water treatment plant was designed using the WATPLANT software and it was proposed about 1.80 km away from the intake well location. The level of water supply was not adequate in different places coming under the existing water supply schemes. For the design of scheme, they studied the present population, population forecast for the three decades, daily water demand, and survey of the villages. Aerator, flash mixer, flocculator, clarifier, chemical house, chemical tanks, filter beds, wash water tank was designed using WATPLANT software.

## III. OBJECTIVES

The specific objectives of the present study are:

*A.* To study the existing water treatment plant in Yavatmal city.
*B.* To design manually, the WTP for Yavatmal city for a design period of 30 years.
*C.* To develop a MS Excel program for any design population and using it for design of WTP for Yavatmal city.
*D.* To compare the WTP design obtained manually with self-developed MS Excel program design

## IV. METHODOLOGY

### *A. Data Collection*

For design WTP, the following data were obtained from Water Resource Department, Yavatmal

*1)* Details of existing WTP in Yavatmal city
*2)* Population records of past 3 decades
*3)* Raw water characteristics of Chapdoh reservoir

### *B. Population Projection*

The total population of Yavatmal city as per 2011 Census is 131317. The design period considered is 30 years. 2011 is taken as base year and the population forecast for year 2051 have been worked out by 1) Arithmetic increase method 2) Geometric progression method 3) Incremental increase method. The census population for the census year 1991 to 2011 is considered. The values obtained from all three methods are nearly equal. The highest value is obtained by the method of Incremental increase i.e. 191633 and is taken as design population.

### *C. Raw Water Characteristics*

The raw water characteristics of source i.e. Chapdoh reservoir is given in Table 1.

Table I
Raw Water Characteristics of Chapdoh Reservoir

| Sr. No. | Test Parameters | Raw water | BIS Specification | |
|---|---|---|---|---|
| | | | Desirable Limits | Permissible Limits |
| 1 | Physical Observation | Turbid | - | - |
| 2 | Odour | Odourless | - | - |
| 3 | Turbidity (N.T.U.) | 1.21 | 1 | 5 |
| 4 | pH value | 7.5 | 6.5 to 8.5 | No relaxation |
| 5 | Chlorides (as Cl) | 60 | 250 | 1000 |
| 6 | Nitrates (as $NO_3$) | 10.1 | 45 | - |
| 7 | Total Hardness (as | 140 | 200 | 600 |
| 8 | Alkalinity (as $CaCo_3$) | 20 | 200 | 600 |
| 9 | Permanent Hardness | 120 | - | - |
| 10 | Iron (as Fe) | 0.12 | 0.3 | No relaxation |
| 11 | Fluoride (as F) | 0.41 | 1 | 1.5 |
| 12 | Total Dissolved Solids | 272 | 500 | 2000 |

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*D. Methods of Design of WTP*

The design of WTP has been done manually and by using MS-Excel based program. Population of Yavatmal city for year 2051 is forecasted. The flow of water required is obtained by multiplying average daily water demand (135 lpcd.) with design population. The design flow is calculated by multiplying average flow required with peak factor. The raw water characteristics are compared with Indian Standards Characteristics for drinking water and the parameters such as turbidity, alkalinity, hardness, etc. which makes the raw water not suitable for drinking purpose are taken into account and treatment processes required are finalised accordingly.

All the necessary mechanical treatment units in advanced water treatment plant are designed along with chemical treatment processes to remove or lower the undesirable characteristics of raw water and make it safe and suitable for drinking purpose.

After studying and comparing characteristics of raw water, design of Intake well, Bar screen, Cascade aerator, Mechanical rapid mixer, Clariflocculator, Disinfection unit and Clear water reservoir along with chemical treatment processes like coagulation and water softening and disinfection were found to be essential and design for same is done manually as well as using Ms-Excel program.

## V. RESULT AND DISCUSSION

From raw water characteristics, permanent hardness of 120 mg/L is objectionable and undesirable. It is required to be removed and hence, lime soda process of water softening is adopted. Similarly, for reducing turbidity and removing solids, coagulation with alum is adopted.

MS Excel program saves the time and manpower. The input parameters for each subprogram are to be entered in the input box during the design run. This program is very simple one and easy to understand. To get accurate result the design parameters has to be entered correctly. Design results are displayed in output box on the screen at the different phases of the design so that the designer can evaluate the design results of individual design phases and decide on their acceptability.

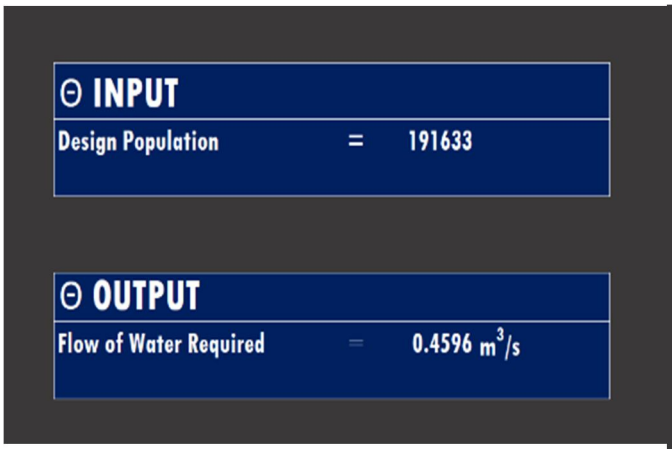



Fig. 2 Calculation of Design Flow

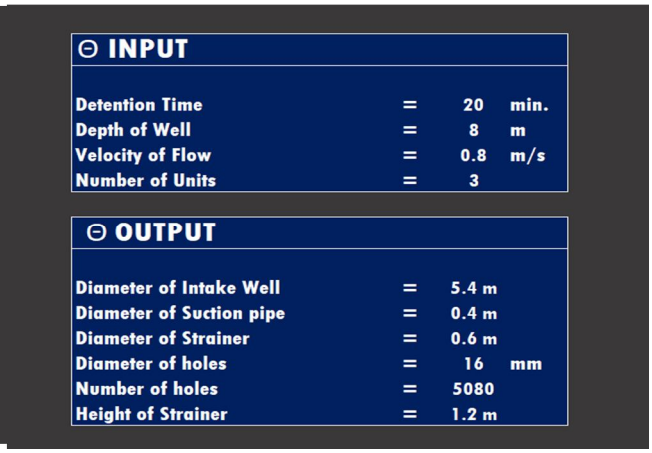



Fig. 3 Design of Intake Well

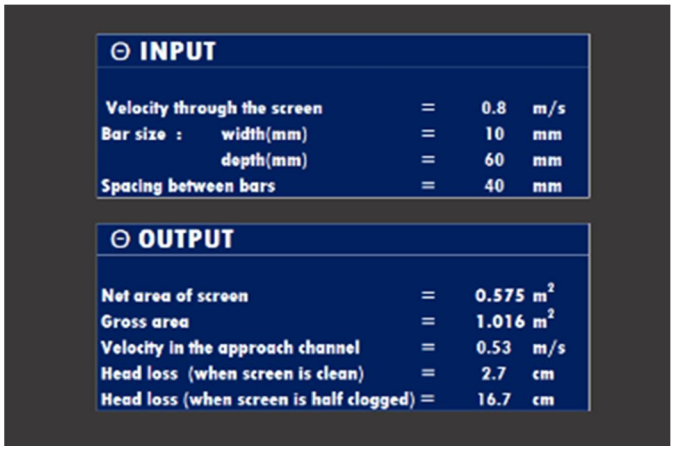



Fig. 4 Design of Bar Screen

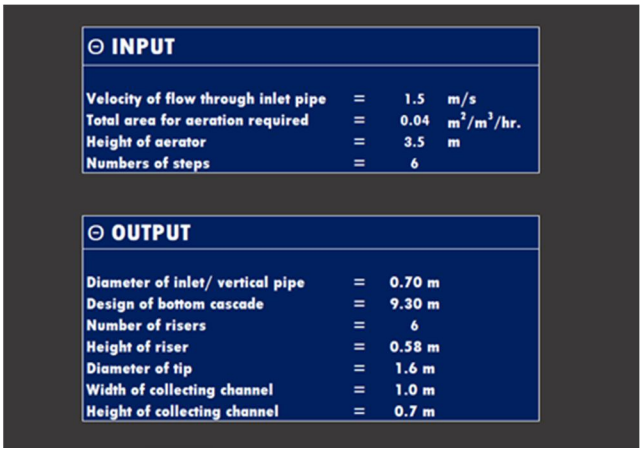



Fig. 5 Design of Cascade Aerator

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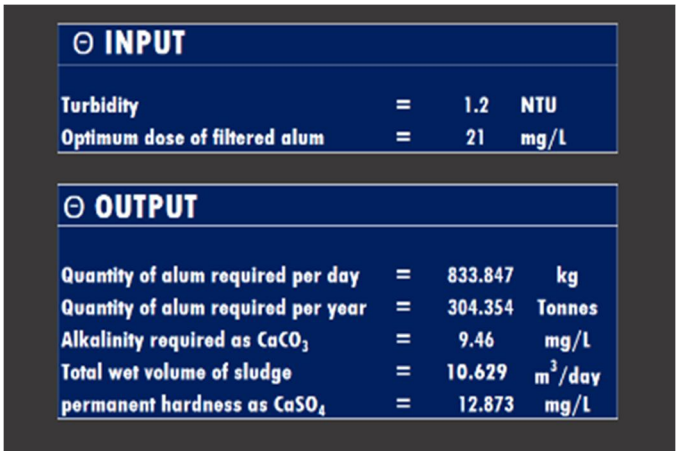



Fig. 6 Coagulation with Alum

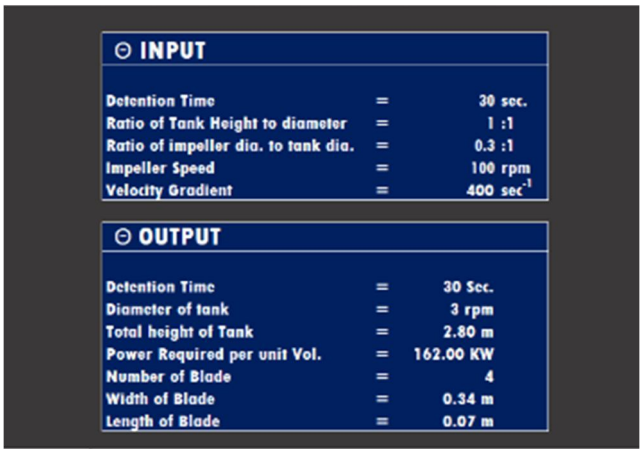



Fig. 7 Design of Rapid Mix Unit

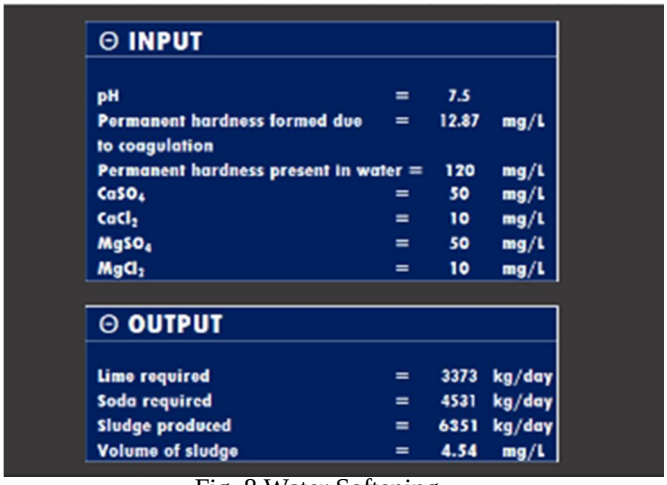



Fig. 8 Water Softening

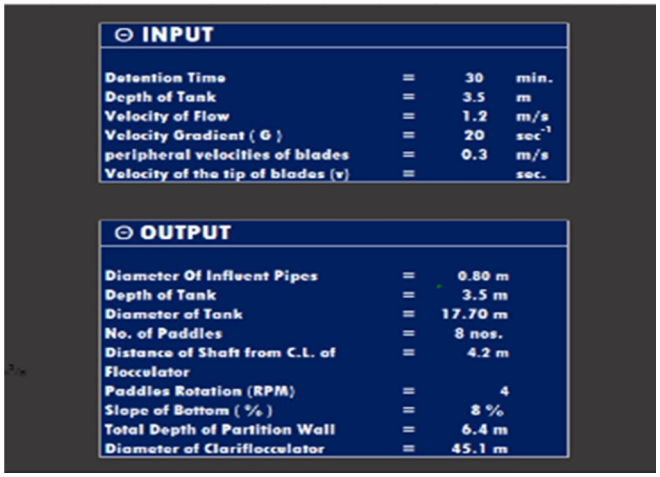



Fig. 9 Design of Clariflocculator

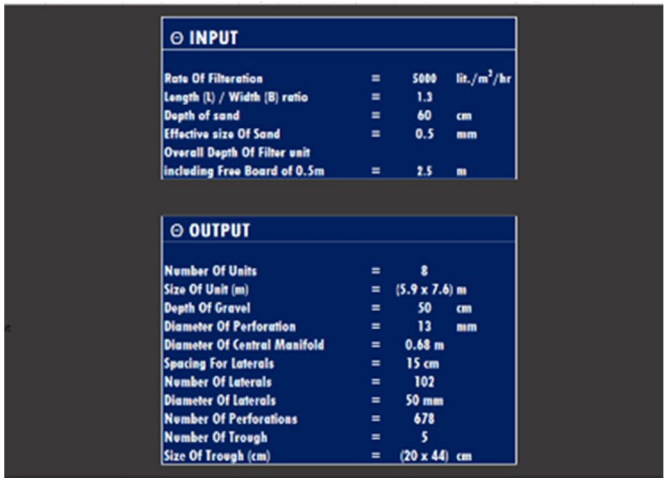



Fig. 10: Design of Rapid Sand Filter

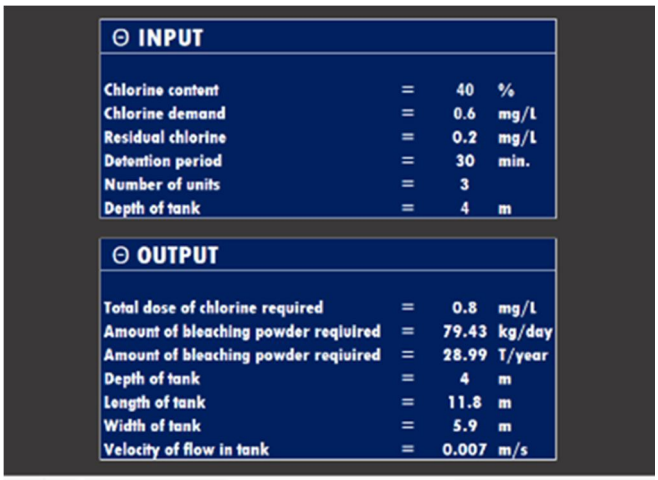



Fig. 11: Design of Disinfection Unit

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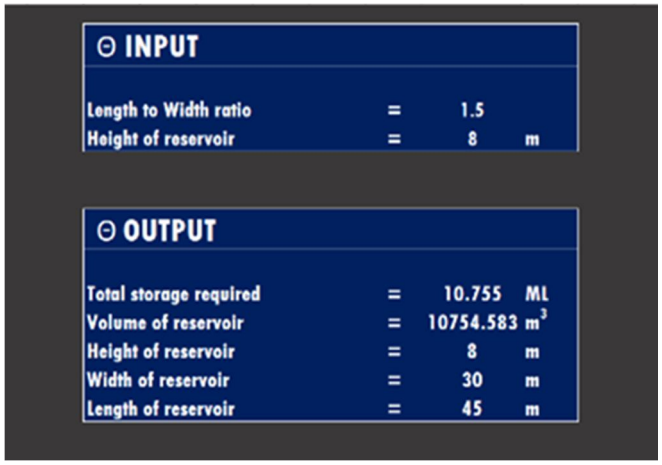



Fig. 12 Design of Clear Water Reservoir

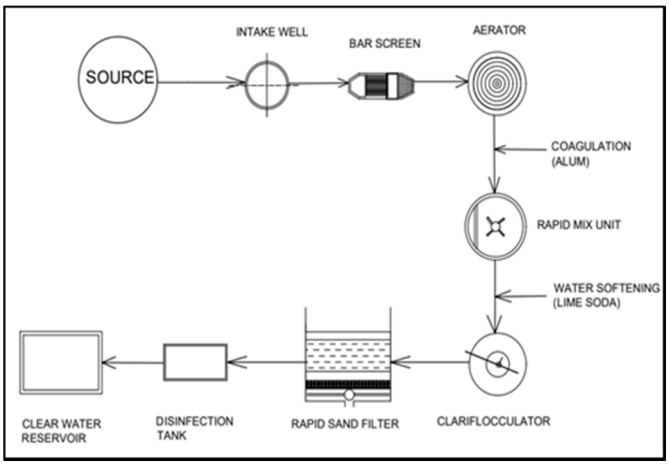



Fig. 13 Layout of Designed WTP

TABLE II
COMPARISON OF RESULTS

| S.N. | Details of Unit | By Manual design | By software design |
|---|---|---|---|
| 1 | Water demand | | |
| | Input | | |
| | Design population | 191633 | 191633 |
| | Output | | |
| | Flow of water required | 0.4595 $m^3/s$ | 0.4596 $m^3/s$ |
| | | | |
| 2 | Intake | | |
| | Input | | |
| | Detention Time | 20 min | 20 min |
| | Depth of Well | 8 m | 8 m |
| | Velocity of flow | 0.8 m/s | 0.8 m/s |
| | Number of Units | 3 | 3 |
| | Output | | |
| | Diameter of Intake Well | 5.4 m | 5.4 m |
| | Diameter of Suction pipe | 0.4 m | 0.4 m |
| | Diameter of Strainer | 0.6 m | 0.6 m |
| | Diameter of holes | 16 mm | 16 mm |
| | Number of holes | 5080 | 5080 |
| | Height of Strainer | 1.2 m | 1.2 m |
| | | | |
| 3 | Bar Screen | | |
| | Input | | |
| | Velocity through the screen | 0.8 m/s | 0.8 m/s |
| | Bar size : | 10 mm | 10 mm |
| | depth(mm) | 60 mm | 60 mm |
| | Spacing between bars | 40 mm | 40 mm |
| | Output | | |
| | Net area of screen | 0.575 $m^2$ | 0.575 $m^2$ |
| | Gross area | 1.015 $m^2$ | 1.016 $m^2$ |
| | Velocity in the approach channel | 0.53 m/s | 0.53 m/s |

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| | | | |
|---|---|---|---|
| | Head loss (when screen is clean) | 2.7 cm | 2.7 cm |
| | Head loss (when screen is half clogged) | 16.7 cm | 16.7 cm |
| | | | |
| 4 | Cascade aerator | | |
| | Input | | |
| | Velocity of flow through inlet pipe | 1.5 m/s | 1.5 m/s |
| | Total area for aeration required | 0.04 $m^2/m^3/hr$ | 0.04 $m^2/m^3/hr$ |
| | Height of aerator | 3.5 m | 3.5 m |
| | Numbers of steps | 6 | 6 |
| | Output | | |

| | | | |
|---|---|---|---|
| | Diameter of inlet/ vertical pipe | 0.7 m | 0.7 m |
| | Design of bottom cascade | 9.3 m | 9.3 m |
| | Number of risers | 6 | 6 |
| | Height of riser | 0.58 m | 0.58 m |
| | Diameter of tip | 1.6 m | 1.6 m |
| | Width of collecting channel | 1 m | 1 m |
| | Height of collecting channel | 0.7 m | 0.7 m |
| | | | |
| 5 | Coagulation | | |
| | Input | | |
| | Turbidity | 1.2 NTU | 1.2 NTU |
| | Optimum dose of filtered alum | 21 mg/L | 21 mg/L |
| | Output | | |
| | Quantity of alum required per day | 833.846 kg | 833.847 kg |
| | Quantity of alum required per year | 304.35Tonnes | 304.35Tonnes |
| | Alkalinity required as $CaCO_3$ | 9.46 mg/L | 9.46 mg/L |
| | Total wet volume of sludge | 10.629 $m^3$/day | 10.629 $m^3$/day |
| | Permanent hardness as $CaSO_4$ | 12.873 mg/L | 12.873 mg/L |
| | | | |
| 6 | Rapid mix unit | | |
| | Input | | |
| | Detention Time | 30 sec | 30 sec |
| | Ratio of Tank Height to diameter | 1 | 1 |
| | Ratio of impeller dia. to tank dia. | 0.3 | 0.3 |
| | Impeller Speed | 100 rpm | 100 rpm |
| | Velocity Gradient | 400 $sec^{-1}$ | 400 $sec^{-1}$ |
| | Output | | |
| | Detention Time | 30 sec | 30 sec |
| | Diameter of tank | 2.6 m | 2.6 m |
| | Total height of Tank | 2.8 m | 2.8 m |
| | Power Required per unit Vol. | 162 KW | 162 KW |
| | Number of Blade | 4 | 4 |
| | Width of Blade | 0.34 m | 0.34 m |
| | Length of Blade | 0.07 m | 0.07 m |
| | | | |

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| | | | |
|---|---|---|---|
| 7 | Water softening | | |
| | output | | |
| | Quantity of lime (Kg/day) | 3373.189 | 3373.189 |
| | Quantity of soda (Kg/day) | 4530.926 | 4530.926 |
| | Quantity of sludge (Kg/day) | 6351.135 | 6351.135 |
| | Volume of sludge (Kg/day) | 4.537 | 4.537 |
| | | | |
| 8 | Clariflocculator | | |
| | Input | | |
| | Detention Time | 30 min | 30 min |
| | Depth of Tank | 3.5 m | 3.5 m |
| | Velocity of Flow | 1.2 m/s | 1.2 m/s |
| | Velocity Gradient ( G ) | 20 $sec^{-1}$ | 20 $sec^{-1}$ |
| | Peripheral velocities of blades | 0.3 m/s | 0.3 m/s |
| | Velocity of the tip of blades | 0.3 m/s | 0.3 m/s |
| | Output | | |
| | Diameter Of Influent Pipes | 0.8 m | 0.8 m |
| | Diameter of Tank | 17.70 m | 17.70 m |
| | No. of Paddles | 8 | 8 |
| | Distance of Shaft from C.L. of Flocculator | 4.2 m | 4.2 m |
| | Paddles Rotation (RPM) | 4 | 4 |
| | Slope of Bottom ( % ) | 0.08 | 0.08 |
| | Total Depth of Partition Wall | 6.4 m | 6.4 m |
| | Diameter of Clariflocculator | 45.1 m | 45.1 m |
| | | | |
| 9 | Rapid sand filter | | |
| | Input | | |
| | Rate Of Filtration | 5000 lit./$m^2$/hr. | 5000 lit./$m^2$/hr. |
| | Length (L) / Width (B) ratio | 1.3 | 1.3 |
| | Depth of sand | 60 cm | 60 cm |
| | Effective size Of Sand | 0.5 mm | 0.5 mm |
| | Overall Depth Of Filter unit | 2.5 m | 2.5 m |
| | Output | | |
| | Number Of Units | 8 | 8 |
| | Size Of Unit (m) | (5.9 m x 7.6 m) | (5.9 m x 7.6 m) |
| | Depth Of Gravel | 50 cm | 50 cm |
| | Diameter Of Perforation | 13 mm | 13 mm |
| | Diameter Of Central Manifold | 0.68 m | 0.68 m |
| | Spacing For Laterals | 15 cm | 15 cm |
| | Number Of Laterals | 102 | 102 |
| | Diameter Of Laterals | 50 mm | 50 mm |
| | Number Of Perforations | 678 | 678 |
| | Number Of Trough | 5 | 5 |
| | Size Of Trough (cm) | (20 cm x 44 cm) | (20 cm x 44 cm) |
| | | | |
| 10 | Disinfection unit | | |
| | Input | | |
| | Chlorine content | 0.4 | 0.4 |

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| | | | |
|---|---|---|---|
| | Chlorine demand | 0.6 mg/L | 0.6 mg/L |
| | Residual chlorine | 0.2 mg/L | 0.2 mg/L |
| | Detention period | 30 min | 30 min |
| | Number of units | 3 | 3 |
| | Depth of tank | 4 m | 4 m |
| | Output | | |
| | Total dose of chlorine required | 0.8 mg/L | 0.8 mg/L |
| | Amount of bleaching powder required | 79.43 kg/day | 79.43 kg/day |
| | Amount of bleaching powder required | 28.99 T/year | 28.99 T/year |
| | Depth of tank | 4 m | 4 m |
| | Length of tank | 11.8 m | 11.8 m |
| | Width of tank | 5.9 m | 5.9 m |
| | Velocity of flow in tank | 0.007 m/s | 0.007 m/s |
| | | | |
| 11 | Clear water reservoir | | |
| | Input | | |
| | Length to Width ratio | 1.5 | 1.5 |
| | Height of reservoir | 8 m | 8 m |
| | Output | | |
| | Total storage required | 10.577 ML | 10.577 ML |
| | Volume of reservoir | 10754.582 $m^3$ | 10754.583 $m^3$ |
| | Height of reservoir | 8 m | 8 m |
| | Width of reservoir | 30 m | 30 m |
| | Length of reservoir | 45 m | 45 m |

## VI. CONCLUSION

The MS Excel program developed offers the function that, on entering design population, calculations are automatically done and complete WTP is designed. This program reduces the percentage of error that occurs in manual designing and also software automates most of the task and thus, the amount of effort required is also reduced.

For WTP design it gave precise results without consuming time in lengthy calculations. The results obtained from MS Excel are accurate and approximately same as the results obtained from manual design.

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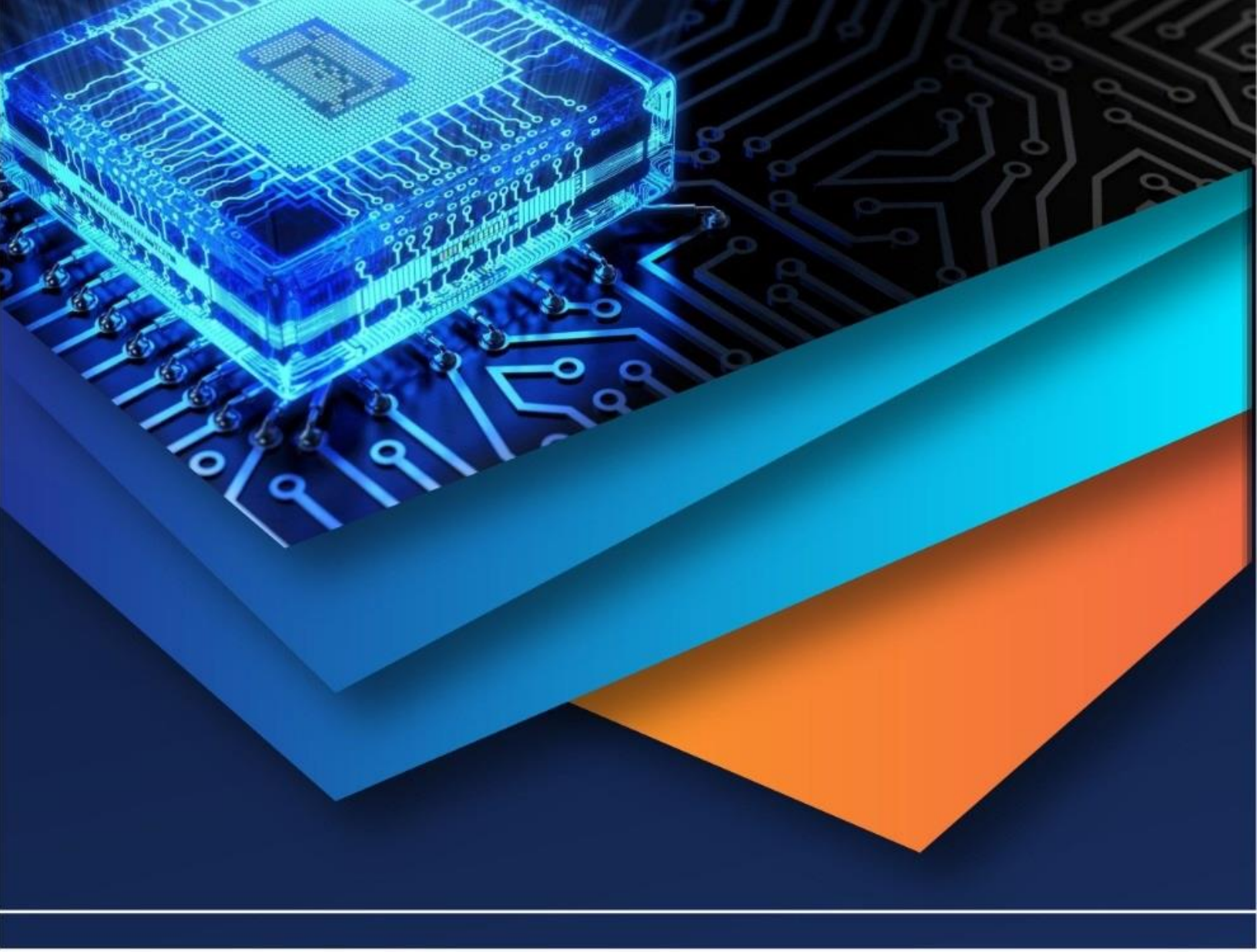
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