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Design of Water Treatment Plant for Musiri Town (Tiruchirapalli)

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ABSTRACT

Water-Decision Support System (DSS) tools encourage the participation towards improved water supply in a given region. The complexity in the manual design of conventional water treatment plants can be eliminated using softwares. Current paper work pivots on the improvement for the design of treatment plant in Musiri town, Trichy district of India through the Water DSS. Population in the year of 2045 is forecasted using the census by Incremental Increase Method. The manual reckoning for water demand and dimensions of processing units was carried out. Coding is written in C-language for easy design. Development of Decision Support tool for the design and selection process of drinking water treatment plant is carried out using C-Programming technique. The results obtained by the manual calculation and C-Programming were compared. The process by designed tool is intelligible and gives an accurate, effortless output which is versatile for any region demanding similar conventional treatment plant.

Keywords: C-language, Decision Support System, Water Quantity, Water Treatment Plant

I. INTRODUCTION

The concept of DSS emerged in the 1970s, as a family of interactive computer-based systems in the field of decision theory and assisting in utilizing data models to solve unstructured problems, especially with great potential in the field of environmental management **[1]**. C-programming has emerged as one of the most widely used languages for software development and for DSS. C language has become the language of choice of two decades among system programmers and application programmers. It is popular because it is powerful and flexible; it is portable; efficient; programmer-oriented; and can be modularized for step-wise refinement **[2]**. The overall efficiency of a Water Treatment Plant depends largely on its design and the functionalities of the Unit Processes constituted in it **[3].**

The ultimate aim of this study is to develop and employ a DSS tool in the general design of Conventional Water Treatment Plants. For each and every design, two factors are considered as important **[4].** They are the accuracy of the result and time consumption for the design. The accuracy of the result plays a vital role for any problems. Like that it plays a major role in the design of Water Treatment Plant (WTP). By manual calculation, it is not possible to get the more accurate value. Increasing dimensions of processing units' results in increasing cost of construction of processing units. By getting the accurate value through software, it is possible to provide the appropriate dimensions of the processing units. Manual calculation takes more time for the design of WTP. So it is needed to neglect more time consuming in the design of WTP. The study area chosen is located at Trichy district, Tamilnadu, India. An attempt has been made to develop the designs of various treatment units using C- programming and comparison was done with the manual design. The results obtained were accurate and can be adopted to overcome the manual design difficulties.

II. METHODS AND MATERIAL

2.1. Study Area:

The study area is Musiritown (**Figure 1**) which is located on the North bank of River Cauvery and falls under the coordinates of 10.93°N and 78.45°E. The average elevation of the town is 82 meters (269 ft). The town has a number of natural drains opening into River Cauvery, thus creating a gentle slope towards the southern direction of the town. The Climate is moderate throughout the year. There is not much of variation between maximum and minimum temperatures in this region. The town receives the maximum rainfall from North east Monsoon. The average annual rainfall for the town is 260 mm. The maximum rainfall occurs during the months of October to December. According to 2001 census, it has a population of 27941 people.

Figure 1: Study Area

2.2. Design Process:

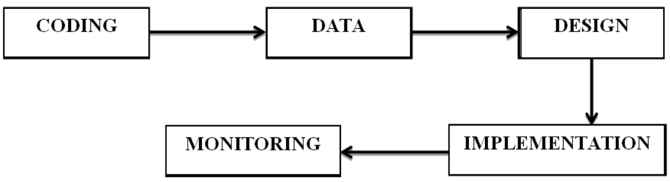

Figure 2 : Flowchart - Design Process

There are five steps in Design process. They are Coding, Data, Design, Implementation and Monitoring. Figure 2 shows the flowchart of the design process.

2.3. Water Treatment Plant Units:

Theprocess involved in thetypical water treatment plant are aeration, plain sedimentation tank, sedimentation aided with coagulation, flocculation, settling, filtration, disinfection etc. Figure 3 displays the flowchart of water treatment plant.

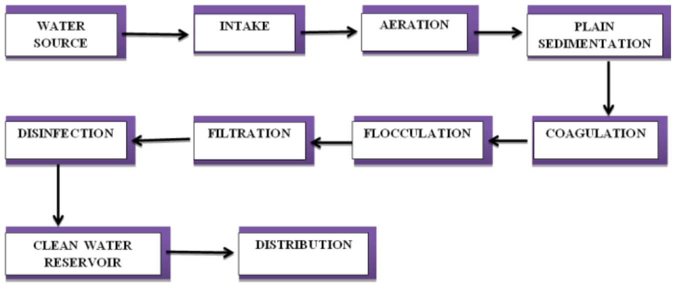

Figure 3 : Flowchart –Water Treatment Plant

2.4. Manual Design of Water Treatment Plant:

2.4.1.Population Forecasting

The Conventional Water Treatment Plant is being designed for the next 4.4 decades. The Population of study area will be forecasted by using Incremental Increase Method.

According to Incremental Increase Method, the following formula is used to forecast the population.

$$P_n = P_o + n\overline{x} + [n(n+1)/2]\ \overline{y}$$

Where, Pn – Population after n decades; Po – Present population;

n – number of decades

$\overline{x} = 15955 / 5 = 3191$; $\overline{y} = 4783 / 4 = 1196$

$P_{2045} = P_{2001} + (4.4 \times \overline{x}) + [(4.4(4.4 + 1)1196)/2] = 56190$

From **Table 1**, the Expected Population of Karkala by 2043 is 38,396 people.

Water Demand

Per capita demand of Musiri = 100 LPCD (BIS Code).
Thus, water requirement per day = 56190 × 100 = 5,619,000 = 5.62 MLD.

TABLE 1 : Population Forecasting

YEAR	POPULATION	INCREASE IN POPULATION	INCREMENTAL INCREASE
1951	11986		
1961	13001	1015	
1971	14287	1286	+ 271
1981	17781	3494	+ 2208
1991	22143	4362	+ 868
2001	27941	5798	+ 1436

2.4.2. Aeration process

Assuming number of steps = 5
and that tread width, t = 250 mm
Dia of the first step, D1 = 1 m (including the diameter of pipe)
Dia of the second step, $D_2 = D_1 + 2t = 1 + 2 \times 0.25 = 1.5$ m
Dia of the third step, $D_3 = D_2 + 2t = 1.5 + 2 \times 0.25 = 2$ m
Dia of the fourth step, $D_4 = D_3 + 2t = 2 + 2 \times 0.25 = 2.5$ m
Dia of the fifth step, $D_5 = D_4 + 2t = 2.5 + 2 \times 0.25 = 3$ m
Dia of aeration tank (collector) = D5 + 2(1) = 3 + 2 = 5 m
Further assuming that:
Rise of 1st step, $R_1 = 0.3$ m
Rise of 2nd step, $R_2 = 0.4$ m
Rise of 3rd step, $R_3 = 0.5$ m
Rise of 4th step, $R_4 = 0.6$ m
Rise of 5th step, $R_5 = 0.7$ m
Overall Dimension of Aeration tank of diameter 5 m and total height of Cascade is 2.5 m.

2.4.3. Plain Sedimentation Tank

Quantity of water to be treated in 24 hours = 5.63×10^6 liters = 5630 m^3.
Assume detention period as 6 hours
Quantity of water to be treated by the sedimentation tank during detention period

= (5630 × 6) / 24 = 1407.5 m^3
Therefore the capacity of the sedimentation tank required = 1407.5 m^3.
Assume the velocity of flow = 0.003 m/s.
Length of the tank required = Velocity of tank (m/s) × Detention period (s)
= 0.003 × (6 × 60 × 60) = 64.8 m.
Cross section of tank required = Capacity of tank required (m^3) / Length of tank (m)
= 1407.5 / 64.8 = 21.72 m^2
Assume the depth of water = 4m(which includes allowable depth for sludge to be made as 80 cm)
Therefore width of tank = 21.72 / 3.2 = 6.79 m.
Providing 0.5m for free board
Therefore total depth of the tank = 4 + 0.5 = 4.5.
Therefore the dimensions of the tank are = (64.8 × 6.79 × 4.5) m.

2.4.4. Sedimentation tank aided with coagulants

(i) Chemical Feeding

Using alum as coagulant, the optimum quantity of dose will be determined actually by jar test in the laboratory.
Let the optimum dose be 5 - 8 mg/liter.
The average quantity of alum required = ($1407.5 \times 10^3 \times 5$) / 10^6 to ($1407.5 \times 10^3 \times 8$) / 10^6 = 7.04 to 11.26 kg/day.
The maximum requirement in summer will be 1.5 times more
Therefore quantity of alum required = 10.56 to 16.89 kg/day.
This quantity of alum shall be first mixed with the water to form a solution of 5 strength and then will be added through solution feed device which is given as = 16.89 × 20 liters/day
= (16.89 × 20) / (60 × 24) = 0.2346 liters/min.
Minimum dose which will be fed during average demand = 0.2346 / 1.5 = 0.1564 litres/min.
Quantity of solution to be fed in 8 hours/day = 0.2346 × 60 × 8 = 112.61 litres = 0.11261 m^3.
Therefore provide solution tank of capacity = 0.113m^3.
Assume the depth of solution in the tank as 0.35m and 0.15m as free board.
The sides of the square tank = √(0.113 / 0.35) = 0.6m.
So the designed size of Solution Tank = (0.6 × 0.6 × 0.5) m.

(Ii) Approach Channel

The flow of channel = 5630 / (24×60×60) = 0.065 m^3/s.
Providing a velocity of 0.4 m/s
Therefore cross sectional area of approach channel = 0.065 / 0.4 = 0.162 m^2.
Provide (0.175 × 0.930) m channel with 0.175m water depth and 0.5m free board.

(iii) Mixing tank

Mechanical flash mixers will be used for mixing the coagulant solution with the water.
Assume detention period as 60 seconds.
Capacity of flash mixer = 0.065 × 60 = 3.9 m^3.
Providing depth of 1m, the sides of the square plan mixing tank = √(3.9 / 1) = 1.97 m.

Therefore provide (2 × 2 × 1) m size of mixing tank with flocculator.

(iv) Flocculating Tank

Provide flocculating tank with mixing slow moving paddles with variable speed electric motors.
Assume the flocculating time is minutes,
Capacity of each flocculating tank = 0.65 × 30 = 117 m^3.
Provide depth of water as 1.6m and length of channel as 10m
Therefore width = 117 / (1.6 × 10) = 7.31 m
Therefore provide channel of size (10 × 7.4 × 1.6) m with water depth of water 1.4 m and 0.2 m as free board in continuation on flash mixer.

(v) Settling Tank

Provide a rectangle sedimentation tank with surface loading of 2000 litres/hour/m2 plan of area.
Surface loading of each tank = (0.065 × 60 × 60× 10^3) / 2000 = 117 m^3
Assume length = 15 m.
Therefore width becomes = 117 / 15 = 7.8 m
Weir loading in the settling tank at average flow is given as = Q / Perimeter
Weir loading = 5630 / (15 × 7.8) = 48.12 m^3/m/day.
Providing a detention period of 2.5 hours at a time of maximum flow.
Capacity of tank = (5630 × 2.5) / 24 = 586.46 m^3
Depth of tank = 586.46 / (15 × 7.8) = 5.01 m
Provide 0.5 m for storage and 0.5 m for free board, say overall depth = 3 m.
Therefore provide rectangular settling tank (6 × 3.3 × 3) m.

(vi) Rapid Gravity Filter

Quantity of water to be treated = 5.63 × 10^3litres/day. Assume the rate of filtration of rapid gravity filter as 2000 litres/m^2/hour and also assuming that 30 minutes shall be utilized daily in the back-washing of the filter.
Therefore area of filter required = (5.63 × 10^3) / (23.5 × 2000) = 119.79 m^2

Provide 4 units of rapid gravity filters with two numbers of stand-by units.
Surface area of each unit = 119.79 / 2 = 59.89 $m^{2.}$
Therefore size of each unit = (7.74 × 7.74) m.

(vii) Chlorination Plant

The dose of the chlorine to be added will vary from 0.5 to 1.0 ppm depending on the quantity of water and the chlorine demand tests.
Quantity of chlorine required = (5.63 × 10^3 × 0.5) / (24 × 10^3) = 0.12 kg/hour.
Therefore liquid chlorinator having capacity 0.15 to 5 kg/hour will be installed.

(viii) Underground Reservoir Water

Underground clear water reservoir having capacity of about 8 hours will be provided.
Quantity of water to be stored = 5.63 × $10^3$$m^3$
Provide the depth of underground clear water reservoir as 5m.
Area of clear water reservoir = (5.63 × 10^3) / 5 = 1126m^2.
Provide length as 40m.
So, the dimensions of the designed underground clear water reservoir = (40 × 28.15 × 5) m.

(ix) Design of Pumps (Centrifugal Pumps)

Adopt two pump stations, one is at source and another is in the middle.
Maximum daily water requirement = 1.5 × 5.63 × 1000 m^3/day = 8.445 × $10^3$$m^3$/day.
Pumping time is 8 hours per day, Therefore Q= (8.445 × 10^3) / (8 × 60 × 60) = 0.293 m^3/day
Assume: Velocity in pipe, *V* = 2 m/s.
$V = Q/A \implies V = 4Q / \pi d^2$
$d = \sqrt{(4Q/\pi V)} = \sqrt{((4 \times 0.293) / (\pi \times 2))} \implies d = 0.432m$

Calculation of total head loss:

Loss of head due to friction, $H_f = flV^2 / 2gd$ = (0.03 × 2000 × 2^2) / (2 × 9.81 × 0.432) = 28.316
Suction head, *Hs* = 2.5 m.
Delivery head, *Hl* = 12.5 m.
Total head, *H* = 28.316 + 2.5 + 12.5 = 43.32m.
Power of pump = QwH / 75μ = (0.293 × 1000 × 43.32) / (75 × 0.8) = 211.546 ≅ 212 HP
Therefore provide eight numbers of 41 HP Centrifugal Pumps in that two numbers are standby at each pump station.

III. RESULTS AND DISCUSSION

3.1 Results:

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POPULATION FORECASTING
Enter the number of census:
6
Enter the year and the corresponding population:1951
11986
Enter the year and the corresponding population:1961
13001
Enter the year and the corresponding population:1971
14287
Enter the year and the corresponding population:1981
17781
Enter the year and the corresponding population:1991
22143
Enter the year and the corresponding population:2001
27941
After how many decades you want population:4.4
Enter the last year population:27941
The population is 56177
What is the percapita demand:100
The proposed water treatment plant design is of approximately 5.627700 MLD
AERATION PROCESS
Number of steps=5
Enter the tread width in metre:0.25
Enter the diameter of first step in metre:
1_
Enter the rise of 1 step in metre:0.3
Enter the rise of 2 step in metre:0.4
Enter the rise of 3 step in metre:0.5
Enter the rise of 4 step in metre:0.6
Enter the rise of 5 step in metre:0.7
Overall Dimension of Aeration tank of diameter 5.000000 and total height of casc
ade is 2.500000
PLAIN SEDIMENTATION TANK
Enter the detention period of sedimentation tank in hours:6
Enter the velocity of flow in m/s:0.003
Enter the depth of water in metre which includes allowable allowance for sludge:
4_
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Providing 0.5m for free board
Dimensions of the sedimentation tank are 64.800003 X 6.784939 X 4.500000
SEDIMENTATION TANK AIDED WITH COAGULANTS
CHEMICAL FEEDING
Let the optimum dose be 8mg/lit
The depth of solution in the tank as 0.35m and 0.15m as free board
The designed size of solution tank = (0.567083 X 0.567083 X 0.5)m
APPROACH CHANNEL
Providing a velocity of 0.4m/s
Provide (0.175000 X 0.930506)m channel with 175mm water depth and 50cm free boar
d
MIXING TANK
Assuming the detention period of 60sec
Providing depth of 1m
Provide (1.976898 X 1.976898 X 1)m size of mixing tank with flocculator
FLOCCULATING TANK
The flocculating time is 30 minutes
Providing 1.6m depth of water with free board and 10m length of channel
Provide channel of size (10 X 7.527734 X 1.6)
SETTLING TANK
Provide a rectangle sedimentation tank with a square tank with surface loading o
f 2000litres/hour/m^2 plan of area
Enter the length in metre:15
Providing a detention period of 2.5 hours at a time of maximum flow
Provide rectangular settling tank = (15.000000 X 7.816250 X 6.000000)m
RAPID GRAVITY FILTER
Enter the rate of filtration of rapid gravity of filtration of rapid gravity fil
ter in litres/m^2/hour:2000
Assuming that 30minutes for back washing of the filter
Provide 2units of rapid gravity filter with one number of stand-by unit
Each unit size = (7.737516 X 7.737516)m
CHLORINATION PLANT
Enter the dose of chlorine to be added in ppm:0.5
Liquid chlorinator having capacity 0.167244 to 4.117244 kg/hour will be installe
d
UNDERGROUND RESERVOIR WATER
Underground cleanwater reservoir having capacity of about 8 hours will be provid
ed
Enter the depth in metre:5
Enter the length of the underground clearwater reservoir in metre:40
Dimensions of the underground clearwater reservoir = (40.000000 X 28.138500 X 5.
000000)m
DESIGN OF PUMPS (CENTRIFUGAL PUMPS)
Adopt two pump stations, one is at source and another is in the middle:
Enter pumping time in hours per day:8
Enter velocity in pipe in m/s:2
Diameter=0.43
Calculation of total head loss:
Enter the suction head and delivery head in metre:2.5
12.5
Provide 41HP Centrifugal pumps of 8 numbers in that two numbers are standby at e
ach pump station_
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3.2 Discussions

Table 2: Comparison of C-Program Output Values And Manual Design Values

Process/Design Criteria	Manual Calculation	C-Programming output value
Expected Population	56190	56177
Water demand	5.63 MLD	5.6277 MLD
Aeration tank	Diameter = 5m and Height of Cascade = 2.5m	
Plain sedimentation tank	64.8 × 6.79 × 4.5 m	64.800003 × 6.784939 × 4.500000 m
Sedimentation tank aided with coagulation (i)Chemical feeding (Size of solution tank) (ii)Approach channel (iii)Mixing tank	 0.6 × 0.6 × 0.5 m 0.175 × 0.930 m 2 × 2 × 1 m	 0.567083 × 0.567083 × 0.5 m 0.175 × 0.930506 m 1.976898 × 1.976898 × 1 m

Flocculating tank	10 × 7.4 × 1.6 m	10 × 7.527734 × 1.6 m
Settling tank (Rectangular)	15 × 7.8 × 6 m	15 × 7.816250 × 6 m
Rapid gravity filter (Each unit size)	7.74 × 7.74 m	7.737516 × 7.737516 m
Chlorination plant (Liquid chlorinator capacity)	0.15 to 0.5 kg/hour	0.167244 to 4.117244 kg/hour
Underground Clearwater reservoir	40 × 28.15 × 5	40 × 28.1385 × 5 m
Number of pumps (Centrifugal pumps)	8 Numbers of 41HP Centrifugal Pumps	

While comparing the output of the C-Programming and the manual design C-Programming gives accurate values upto six decimals because of **"float"** datatype whereas in the manual design the values are rounded off (**Table 2**). It is possible to get the dimensions of particular processing units by using **"switch-case"**. This facility further denotes that C-Programming was user-friendly.

IV. CONCLUSION

Design of Water Treatment Plant has been done by using C-language which is more efficient and reliable. C-language gives effortless output, accurate value and it consume less time compared to manual design. It is possible to use for a particular operation which gives more effective results to the user. It is suitable to similar type of water treatment plant as like as Musiri plant. Hence this technique is recommended for general use in ultimately alleviating water supply challenges.

V. REFERENCES

[1] Ngyyen Kim Loi, **"Decision Support System (DSS) for Sustainable Watershed Management in Dong Nai Watershed, Vietnam: Conceptual Framework and Proposed Research Techniques".**

[2] Mahaganesha, P.V., Thippeswamy, M.R., Anand, R. and Sharath, B.P. (2014) **Design of Conventional Water Treat. ment PLANT for Karkala Town Using C-Programming**. B.E Project Report, Department of Civil Engineering, NMAM Institute of Technology, Nitte.

[3] Gorry, G.A. and Scott Morton, M.S. (1971) **A Framework for Management Information Systems**. *Sloan Management Review*, 13, 55-70.

[4] K P Tripathi, **"Decision Support System is a Tool for Making Better Decisions in the Organization"**,Indian Journal of Computer Science and Engineering (IJCSE).

[5] D. J. Power, **"A Brief History of Decision Support Systems".**

[6] Kerry J. Howe, David W. Hand, John C. Crittenden, R. Rhodes Trussell George Tchobanolous, **"Principles of Water Treatment"**.

[7] S.K.Garg, **"Water Supply Engineering, 19th Revised Edition,Khanna Publishers"**.

[8] Samson O. Ojoawo and Joseph A. Ogunrombi, "**A pre-upgrading performance evaluation of Ogbomoso waterworks, Nigeria",**International Journal of Innovative Research in Engineering & Science.

[9] YashavantKanetkar, **"Let us C", 13th Edition, BPB Publications"**

[10] City Corporate cum Business Plan for Musiri Town Panchayat **,**Tiruchirappalli District, Tamil Nadu.

[11] Indian Standard Code of Basic Requirementsfor Water Supply, Drainageand Sanitation (Fourth Revision) – **(IS1172:1993)**