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Design of Water Treatment Plant for Al-Bsaber City

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Abstract: ***Water treatment is a process of changing the quality for potable drinking water & domestic uses. This water treatment plant is designed for the city of Al-Bsaber. The supply of water comes from the Nile river, which passes near the city and extends across many countries. The treated water will be supplied to the residents of Al-Bsaber and the treatment plant is designed for 36 years. The treatment units of water treatment plant (WTP) were designed with step-by-step calculations and according to the quality of the water the future population of Al-Bsaber city from 2022 to 2058 was projected as 37736 and the average discharge for the population of 36years was estimated as 4339.6 m^3/d. The detailed calculations and drawings were displayed, the results of each unit of WTP were tabulated. It is concluded that it is possible to use this work as a source for other WTP units to build. The removal performance of the WTP units was significantly affected by a variety of factors, such as the age of WTP, repair, economic and political circumstances, technical problems, and water demand. Keywords: Water treatment plant; design calculation; treatment units; water demand; water supply.***

I. INTRODUCTION

Water is very important to our everyday life and key to our survival and undubiously is a basic human need. Providing safe and adequate quantities of the same for all rural and urban communities is perhaps one of the most important undertakings, for the public works Dept. Indeed, the well-planned water supply scheme is a prime and vital element of a country's social infrastructures as on this peg hangs the health and wellbeing of its people. Sudan2020population is estimated at nearly 40000000 people with growth rate of 3.0%**.** Sudan's main water resources are surface water, including rainfall, rivers, seasonal wadis and khors, lakes and wetlands.

Groundwater is also widely used, in addition to wastewater reuse and desalination as non-conventional resources In Sudan, only 68 percent of households have access to basic improved water, with disparities in access between rural and urban populations at 64 and 78 per cent respectively. There are also disparities between states, with just around a third of households having access to safe water in Red Sea, White Nile and Gedarif compared to 90 per cent access in Khartoum and the Northern States. Lack of funding, inadequate management and inadequate community participation are among the main reasons behind the system's low functionality levels.

An estimated 13 million people are still using unimproved drinking water source (UNICEF, world water day) .The Al-Bsaber area is considered one of the agricultural areas, but there are difficulties that the Al-Bsaber area suffers from due to the lack of water from the Nile due to the lack of modern methods of water delivery, and the residents still use primitive methods to get water from Nile. In addition to what was mentioned, there are health problems resulting from the lack or lack of water use, which causes some diseases and bacterial contamination for the area's population who are 13,000 persons.

A. Objective

The objective of design of water treatment plant is to treat the water and supply it to each and every house, commercial, public places etc. for AL-Bsaber. This design of treatment plant is proposed to treat the water up to the desired levels. This water treatment Plant design is proposed for up to 36 years including construction and settlement time of the treatment plant. The plant construction time may be 2 to 3 years, starting from the beginning of 2022 to the end of 2022 and it will be running from the end of 2022 to 2058 and it will provide the treated water to the people of Al-Bsaber city. This plant is designed to treat the water and supply it for present and future population as well. The plant is designed according to the characteristics of water, present and future water demand, present and future population, design period and design flow, and design criteria, design calculation and drawing of each component. This plant is consisting coagulation, flocculation, sedimentation, filtration, disinfection and storage. The water is supplied to the plant through the influent pipe to the sump, coagulation, flocculation tank, sedimentation tank, filtration system, disinfection, contact tank, clear well and then effluent.

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B. Study Area

Al-Bsaber area is located in the River Nile State, north of the national capital, Khartoum, at a distance of 110 km between longitude N (16 5167516) and latitude (32.9916478) to the east. To 25 mm in the north per year and the temperature ranges from 47 degrees in the summer as a maximum to 8 degrees as a minimum in the winter, and its population is estimated at about 13000 people, and the livestock in large numbers estimated at 10,000 heads. We find that most of the population depends on agriculture as a main source for their income, it is inhabited by the tribes of the Ja'aliyn, the Kababish, the Shaiqi, the Batahin and some other tribes, and it has many service facilities, where there is a large mosque and a police point to extend security, 2 km from the Nile River, and the residents obtain water from the Nile through the use of primitive methods such as fetching Water by animals, and this process takes a lot of time.



Fig. 1 Water Treatment Plant Site

C. Population Forecasting

There are different methods of population forecasting like geometric increase method, arithmetic increase method, incremental increase method etc. Here, we use the simplified method for population forecasts.

$$P_n = p_0 \times (1 + r)^n$$

Where
Pn= future population
Po = initial population
r = probable rate of population increases per year
n= number of years considered

Using the formula and by considering population of 2022, we will find the population of 2058and considering 3% yearly change (population growth)

$$P_n = p_0 \times (1 + r)^n$$

$$P_{2058} = 13000 \times (1 + \frac{3}{100})^{36} = 37667\text{capita}$$

$$P_{2058} = 37667\text{capita}$$

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D. Design Period

The plant is considered for 36 years and it will run in the end of 2022 after its completion, because many months will be taking by plant to be constructed, so the construction of the plant will start from the begging of 2022 to the end of 2022 that is why I did not consider this construction period with running time of the plant. So, population which was projected 13000 and the future population for 36years was projected 37667

E. Types of Demands

There are so many factors involved in demand of water; it is not possible to determine the actual demand. Based on certain empirical formula and thumb rules are employed in determining water demand which may be nearly to the actual demand. Following are the various types of water demand of a city or town

F. Current Water Use in Sudan by Sector

There are no official data on the total water use by sector or region, and data collected by international institutions and United Nations' (UN) agencies are scant. Agriculture is the main consumer, although cultivated areas have shrunk significantly. For example, only a seventh of the area of the Gezira Scheme is currently being farmed, whereas the Blue Nile and the White Nile Schemes have been dismantled (Figure 1 and Table 1

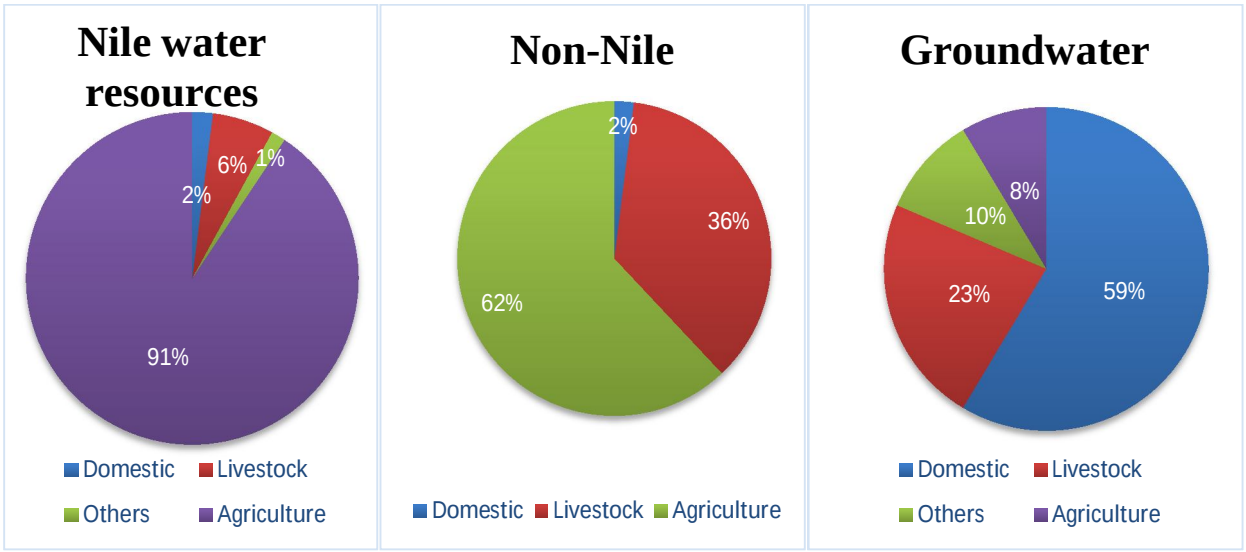


Fig. 2 Water Sectors' Use from Different Resources.

Table 1: Water Demand Projection To 2027 (BCM)

Year	Irrigation	Animals and others	Domestic	Total
2010	27.1	3.9	1.1	32.1
2020	32.6	5.1	1.9	39.6
2025	40.3	5.3	2.5	48.0
2027	42.5	7.3	2.8	52.6

This is the total water requirement for different purposes, as international institutions and United Nations' (UN). This demand is for domestic and irrigation, livestock, and, agriculture. If we want to know the requirement for the whole present and future population then multiply these above values with present and future population.

G. Present Population Demand

PPD = (Total consumption per person per day) × (Total present population)

= (115 l/c/d) ∗ (13000capita)

= 1495000l/d or

= $1495 m^3/d$

H. Future Population Demand

FPD = (Total consumption per person per day) × (Total future population)
= (115 l/c/d) × (37736capita)
= 4339640l/d or
= 4339.7m^3/d

I. Maximum Daily Demand

MDD = 1.8 × average daily demand
= 1.8 × 115 l/c/d
= 207 l/c/d
= 0.207m^3/c/day

The maximum daily demand factor is 1.8 times the average demand. The maximum daily flow rate is:

1) The maximum daily flow rate for present community is:

Qm = 1.8 × (1495m^3/d)
= 2691m^3/d

2) Similarly, the maximum daily flow rate for future community is:

Qm = 1.8 × (4339.7m^3/d)
= 7810.2m^3/d

Table. 2 Raw Water Parameters

Parameter	Units	Max	Min
Turbidity	NTU	15000	45
Colour	Hazen	75	10
Temp	C	35	19
PH	pH	8.7	7.9
Conductivity	µs/l	240	150
Total Hardness	Mg/l	70	50
Alkalinity	Mg/l	120	70
Phenoph.Alkalinity	Mg/l	10	Nil
Calcium	Mg/l	30	18
Magnesium	Mg/l	4.8	2.6
Chloride	Mg/l	10	4
Sulphate	Mg/l	16	6
Iron	Mg/l	0.1	0.03
Nitrite	Mg/l	0.001	0.0005
Nitrate	Mg/l	2.4	Nil
Copper	Mg/l	Nil	Nil
Manganese	Mg/l	0.04	Nil
Silica	Mg/l	4.2	2.8
Total Suspended Solids	Mg/l	17540	40
Total Dissolved Solids	Mg/l	120	60
Total Coliform per 100 ml		20	Nil
Total count Per 100 ml		1700	170

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II. WATER COLLECTION WORKS

The aim of water treatment is to produce and maintain water that is hygienically safe, aesthetically attractive and palatable, in an economical manner. Albeit the treatment of water would achieve the desired quality, the evaluation of its quality should not be confined to the end of the treatment facilities but should be extended to the point of consumer's use. The method of treatment to be employed depends on the characteristics of the raw water and the desired standards of water quality

A. Design of Intak

The intake used is the pipe Intak for collecting water, and given the available data, as well as because the source is the Nile River, which must extend the Intak to a third of the stream. Use Pipe Intake, because the source is the Nile and it is navigable.

B. Conduit pipe design

$$Q_{avg} = \frac{population \times q_{avg}}{1000 \times 24 \times 3600} = \frac{37736 \times 115}{1000 \times 24 \times 3600} = 0.050\ m^3/s$$

And to calculate the consumption that will be designed, the design safety factor will be added by 40% as well as 10% to avoid malfunctions.

$$Q_{des} = 1.1 \times 1.4 \times Q_{ave} = 1.1 \times 1.4 \times 0.050 = 0.077\ m^3/s$$

Calculating the amount of fire water:

$$Q_{fire} = 3182\sqrt{\frac{Pn}{1000}} = 3182 \times \sqrt{\frac{37736}{1000}} = 0.33\ m^3/s$$

$$Q_{All} = Q_{des} + Q_{fire} \ : \ Q_{All} = 0.33 + 0.077 = 0.407\ m^3/s$$

We assume the velocity of the water passing through the pipes, as well as the number of pipes through which the diameter of the pipes will be known.

Q_{All}<0.9 Only two pipes will be charged

Assume Number of pipes=2

Assume V=1m/sec

Calculate the diameter of one pipe

$$Q = N \times A_{pipe} \times V \quad : \quad 0.407 = 2 \times A_{pipe} \times 1$$

$$A_{One} = 0.204m^2 = \frac{\pi \times D^2}{4} \gg D = 0.509m$$

Choose Pipe Diameter = 500mm

After determining the diameter of the pipe, we must make sure that the real speed is in the correct range (0.6 - 1.5)

$$V_{Act} = \frac{Q_{All}}{n \times A_{Pipe}} = \frac{0.407}{2 \times \frac{\pi \times 0.5^2}{4}} = 1.04\ m/sec\ [0.6 - 1.5] ok$$

C. Design of Screen

To design the filters on the outlet that prevent the entry of large impurities into the transmission pipes and are placed at the beginning of the pipes

1) Spacing Between Bars S=5-2cm
2) a (Bar Width) = 3-1cm
3) distance between pipes= 50cm
4) The initial velocity does not decrease is V_{app} 0.2 m/s
5) The velocity between the filters is no more for Vth 1.5 m/s

Length of the screen=$2 \times 0.5 + 2 \times 0.5 = 2m$

Assume S= 3cm= 0.3m & a= 0.01m

Assume bars embedded in concrete

$$L = (N \times S) + a \times (N - 1)$$

$$2 = (N \times 0.03) + 0.01 \times (N - 1) \rightarrow N = 50\ bars$$

Take the number of openings (S)= 100 & Number of bars =50 bars

Actual Spacings $\rightarrow 2 = 50 \times S + 0.01 \times (50 - 1) \rightarrow S = 0.03m$ (ok)

D. Design of the Sump

For the design of the sump we consider the following:
The time for the water to stay in the well = 5 minutes
Width of the sump= 3-1 meters.
The length of the well = the number of pumps expected in the future * the distance between each two pumps.
The distance between two pumps = 1-3 meters
The area of the yard must be greater than 5 the area of the conveying pipes

$\text{Assume } R_t = 5\text{minutes}$

$\text{Volume} = Q \times Rt = 0.407 \times 5 \times 60 = 122m^3$

To calculate the depth of the sump, which is calculated by calculating the depth of water, we add one meter to it so that a meter of water remains in the well because the pumps do not draw air. The amount of pressure lost in the pipe is deducted because the pressure did not reach the same capacity from the beginning of the pipe

H.W. L= 10m Bed Level=5m

$\text{Depth of sump} = (H.W.L - \text{Bed level}) + 1 - H_{\text{conduit}}$

$\text{Head loss through conduit of pipe} = \frac{2 \times F \times L_{\text{conduit}} \times V^2_{act}}{2 \times g \times \Phi}$

$= \frac{2 \times 0.03 \times 100 \times 1.04^2}{2 \times 9.81 \times 0.5} = 0.66m$ $F = 0.03$: $g = 9.81$

Depth of slump= 10-5-0.66 +1= 5.34m

In order to calculate the surface area of the sump in order to find its dimensions = dividing the volume by the depth, meaning length * width, and often the second is assumed to be 2m

Area of sump=$\frac{122}{5.34}$= $22.8m^2$ Assume width of sump=2m

Length of the sump= $\frac{22.8}{2} = 11.4m$ Take dimension of the sump $(2 \times 11.4 \times 5.34)$

E. Design of low lift pumps

Calculate the number of pumps required to raise water
Assume the discharge from pumps from (200 to 500) let 200 liter/sec

$Q_{All} = 0.407\frac{m^3}{sec} = 407liter/sec \quad \because \text{Number of pumps} = \frac{Q_{All}}{200 \rightarrow 500} = \frac{407}{200}$

2 pumps for save pumps from problems add numbers of pumps 10%=

$\text{Total number of pumps} = 1.5(\text{stand by Factor}) \times 2 = 3 \text{ pumps}$

We calculate the distance between the pumps and it should not decrease 1.5m

$\text{Spacing between pumps} = \frac{11.4 \text{ total Length of pumps}}{3 \text{ number of pumps}} = 3.8\,m > 1.5\,ok$

We check again the speed of the water in the conveying pipes from the pumps to the rapid mixing units, so that the speed does not exceed 1.5m/s

Assume Velocity in Rising main=1.5 m/sec

$Q = A \times V \rightarrow A_{pipe} = \frac{Q}{V} = \frac{0.407}{1.5} = 0.271m^2 \rightarrow \emptyset = 0.590m \rightarrow 590mm$

$V_{Act} = \frac{Q}{A_{Act}} = \frac{0.407}{\pi \times 0.59^2/4} = \frac{1.4m}{s} < 1.5\,m/s$

Calculating the pressure force acting on one pump, and in order to calculate this, the pressure losses are calculated, as well as the water height difference from the rapid mixing units

$\text{Total Head} = H_{static} + H_{\text{minor losess}} + H_{friction} + H_{\text{velocity Head}}$

Head of pump static = Ground Level -L.W. L +Rapid mixing tank level

Assume L.W. L=9m

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Assume rapid mixing tank level=5m Assume Ground Level =12m

Head of pump static=$12 - 9 + 5 = 8m$

$$H_{friction} = \frac{F \times L \times V^2}{2 \times G \times D} = \frac{0.03 \times 900 \times 1.5^2}{2 \times 9.81 \times 0.59} = 5.2m$$

$$H_{minor\ losses} = 0.1 \times H_{friction} = 0.1 \times 5.2 = 0.52m$$

Assume $H_{velocity} = 0.2\ m$

Total Head $= 8 + 5.2 + 0.52 + 0.2 = 13.9m$

We calculate the required power for each pump and take into account that the value of n1, n2 is fixed at 0.65 and the gamma value of water is at 1 and Q is the disposal of one pump

Power required for the pumps= $\frac{\gamma \times Q \times H_t}{75 \times \eta_{1\times}\eta_2} \rightarrow \eta_{1\times}\eta_2 = 0.63$ ‘ Constant & $\gamma = 1$

$$Q_{pumps} = \frac{200liters}{sec} \text{ as Assumed : power required} = \frac{1 \times 200 \times 13.9}{75 \times 0.63} = 58.9H_p$$

To calculate the electricity consumption of the pump

$$K_W = \frac{1.1 \times H_P}{1.3 \times \eta_t} = \frac{1.1 \times 58.9}{1.3 \times 0.6} = 82\ kw$$

III. COAGULATION

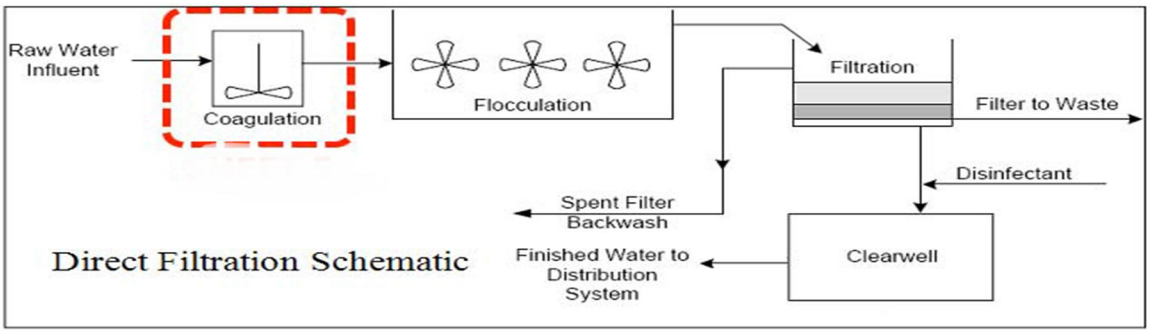


Fig. 3 Coagulation Process

Types of materials used in coagulation:

Aluminum sulphate (Alum) $AL_2(SO_4)3H_2O$

Ferric chloride $FeCL_3$

Ferric sulphate $(Fe_2(SO_4)_3$

Ferrous Sulphate and Lim $FeSO_4{+}Ca(OH)_2$

Sodium Aluminate $Na_2AL_2O_4$

(Hydrated)Lime Ca $(OH)_2$

Jar Test Apparatus is used to determine materials dose of coagulation

A. Design of Alum Tanks

1) Calculation of Alum Required Per Day

Alum required per day= $\frac{\text{Discharge rate} \times 1000\ (\text{to liter}) \times \text{Alum dose}}{(\text{to tone})10^9} = \frac{35164.8 \times 40}{10^6} = 1.4\ \text{ton\day}$

Calculation of Volume of Solution needed:

Concentration of alum solution = 10%

Volume alum solution tank = $1.4 \times \frac{10}{100} = 0.14\ \text{tone} = 0.14m^3$

Take 3 tanks (each tank) =$\frac{0.14}{3} = 0.046\ m^3$

2) Calculation of Alum Tank Dimensions

To determine the dimensions of the tank, we assume that the depth is 2m (3-1 m)

Assume the depth =2m

Area of one tank $= \frac{\text{Tank Volume}}{\text{Tank depth}} = \frac{4.7}{2} = 2.34\text{m}^2$

Assume L =2m : B = 2.34/2 =1.172m

Take dimension of tank (Depth × Length × Width) = 2 × 2 × 1.17

To determine the desired dose that is added every hour to the water

$$\text{Rate of dosing of alum solution} = \frac{\text{Capacity of one tank}}{\text{Usage time (8 hours)}}$$

$$= \frac{4.68}{8} = 0.58\text{m}^3/\text{hours} = 0.58 \times \frac{1000 \text{ to liter}}{60\times60 \text{ to sec}} = 0.16 \text{ lit/sec}$$

B. Design of outline pipe

$$A = \frac{Q}{V} = \frac{14}{0.8 \times 24 \times 60 \times 60} = 2.02 \times 10^{-4}\text{m} : A = \frac{\pi \times \emptyset^2}{4} \rightarrow \emptyset = 0.014\text{m} \cong \text{take } \emptyset = 1 \text{ Inch}$$

C. Design of Rapid Mixing Tank

Retention time = (5 to 60$second$) →$Take\ Rt$=30 Sec

Capacity of one tank =Discharge ×Retention time $= \frac{35164.8}{24\times60\times60} \times 30 = 12.2\text{m}^3$ /sec

1) Calculation of Tank Dimension

Choose two tanks. Volume of each $= 6.10\text{m}^3$

Depth of Rapid mixing tank =2−3 $meter$→$Choose\ 2m$

Surface Area of one tank $= \frac{6.10}{2} = 3.05\text{m}^2$

The better type of tank is circular $A_{one} = 3.05 \rightarrow \emptyset = 1.97\text{m}$

2) Check of Tank Retention time (5 to 60) Second

Actual Retention time $= \frac{\text{Tank Volume}}{\text{Discharge(Q)}} = \frac{6.10}{35164.8} = 1.73 \times 10^{-4}$ day

$= 1.73 \times 10^{-4} \times 24 \times 60 \times 60 = 15 \text{ sec: } 60 > 15 > 5 \text{ sec}$ ok

To calculate the energy required for the mixing motors

$P = G^2 \times V \times \mu = 700^2 \times 12.2 \times 1.002 \times 10^{-3} = 5989 \text{ Watts} = 5.989\text{kw}$

G→Velocity gradient =700 Constant for machine

V= →Volume of mixing tank

μ→Viscosity ($Ns\backslash m2$)

IV. FLOCCULATION

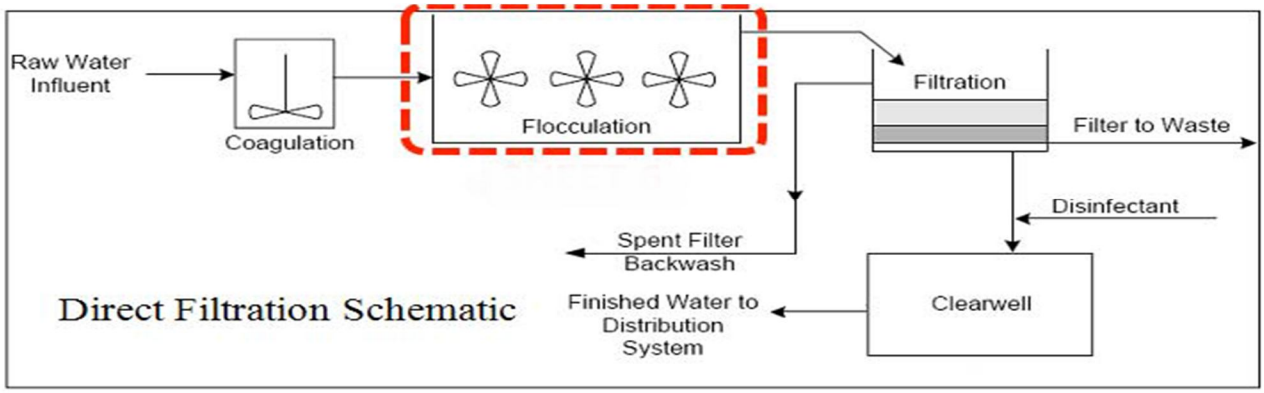


Fig. 4 Flocculation process

A. Calculations for outer tanks [Sedimentation tank]

Assume Retention time for water in tanks

- $T1\ (Flocculation\ tank)$ =0.5 $Hour$= 30 $minutes$
- T2 (Sedimentation tank) = 3.5 Hour
- $Total\ Retention\ time$=$T1$+$T2$=4 $Hours$

1) Calculation of Tank Capacity [Volume]:

To calculate the volume of the tank, the disposal will be multiplied by the number of hours the water will remain in the tank, which is estimated by 16 hours

∵Working hours per day =16 $hour$s

$$\therefore \text{Capacity} = Q \times \frac{\text{Total retention time}}{\text{total working hours per day}} = 35164.8 \times \frac{4}{16} = 8791 m^3$$

2) Calculation of Outer Tank Dimensions:

Assume depth of settling zone→4 meters

Calculate the required total surface area

$$\text{Total surface area of units} = \frac{\text{Capacity}}{\text{depth}} = \frac{8791}{4} = 2197 m^2$$

Calculating the area of one tank based on an imposed diameter. Assume diameter of units = 20m

$$\text{Area of units} = \frac{\pi \times \emptyset^2}{4} = \frac{\pi \times 20^2}{4} = 314 m^2$$

3) Calculation of Outer Tank Number of units & New dimensions:

$$\text{Number of units} = \frac{2197}{314} = 6.99 \rightarrow \text{Take Number of units} = 7 \text{ units}$$

Calculation of Actual Diameter of units

$$\text{Actual area of one unit} = \frac{2197}{7} = 313 m^2: \qquad \text{Area} = \frac{\pi \times \emptyset^2}{4}$$

$$\text{Actual diameter}(\phi) = \sqrt{\frac{313 \times 4}{\pi}} = 19.9\ m$$

Calculations Inner tank [Flocculation chamber]

1- Calculation of discharge for each tank

$$Q_{unit} = \frac{Q_d}{\text{number of units}} = \frac{35164.8}{7} = 5023 m^3/day$$

2-. Calculation each tank capacity [Volume]

$$\text{Capacity} = Q\text{unit} \times \frac{\text{Retention time}}{\text{Total Working hours}} = 5023 \times \frac{0.5}{16} = 157 m^3$$

3- Calculation Inner tank dimensions

Depth of inner tank= Depth of upper tank −[0.5→1m] =4−0.5=3.5m

$$\text{Area Total} = \frac{157}{3.5} = 44.9 m^2$$

$$\text{For circular tank} \rightarrow \text{Tank diameter } (\phi) = \left(\sqrt{\frac{\text{Area} \times 4}{\pi}}\right) = \sqrt{\frac{44.9 \times 4}{\pi}} = 7.6 m$$

4- Check chosen dimensions

A) Check Diameters: $\frac{1}{2} > \frac{\phi inner}{\phi outer} > \frac{1}{3}$:

$$\frac{\phi inner}{\phi outer} = \frac{7.6}{19.9} = 0.38 > 0.33 : 0.38 < 0.5 \quad \text{OK}$$

B) *Check O.F. R* [25→ 40]

$$O.F.R = \frac{\text{Qunit}}{\text{Area}_{outer} - \text{Area}_{inner}} = \frac{5023}{313 - \frac{\pi \times 7.6^2}{4}} = 19 < 25 \text{ (Unsafe)}$$

$$\text{Use } \emptyset_{inner} = 12m \rightarrow \frac{5023}{313 - \frac{\pi \times 12^2}{4}} = 25.1 \text{ (ok)}$$

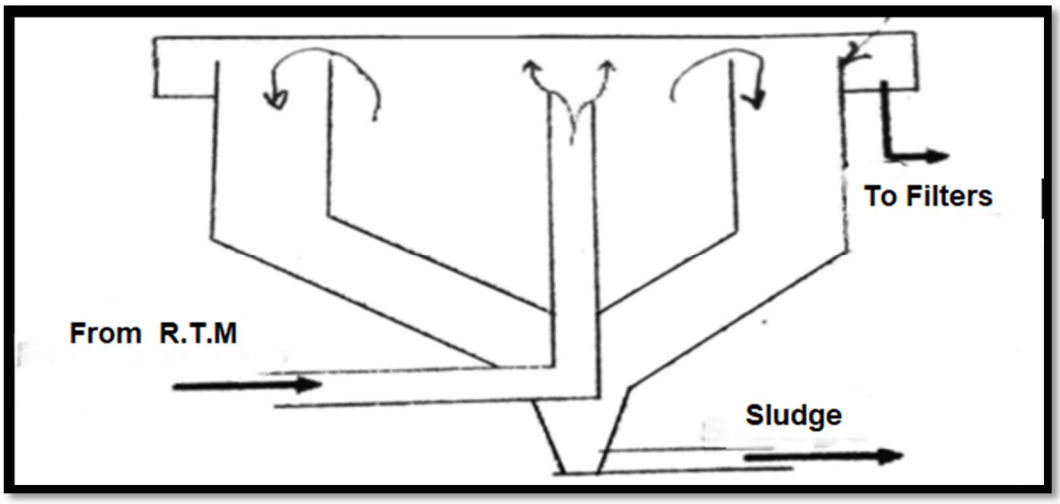


Fig. 5 Sedimentation tank

V. FILTRATION

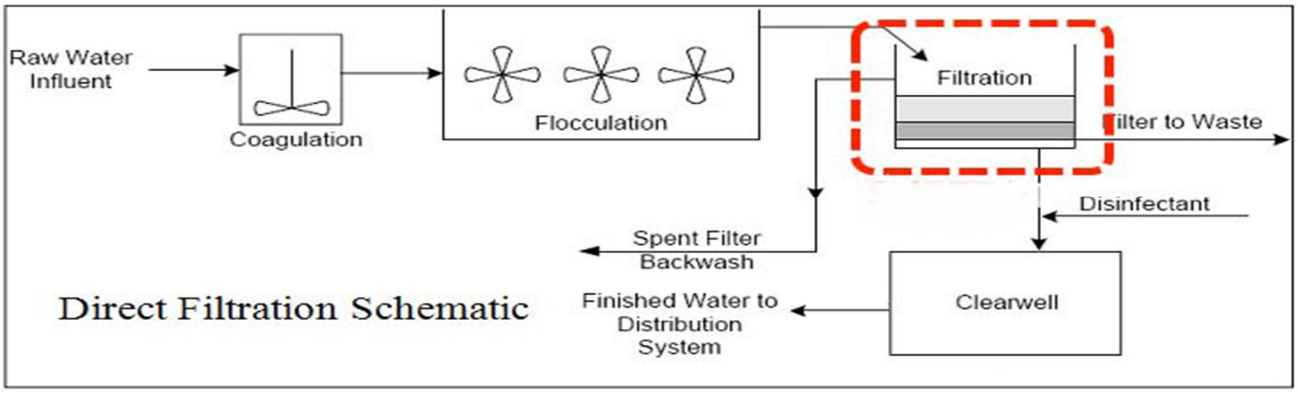


Fig.6 Filtration Process

Filtration process: It is the process of removing the remainder of the suspended materials in water, it did not sediment inside basins.

A. Determination of filters number

1) Calculation of Rate of Filtration

Rate of filtration = [100→150] = 130 *m*3/*m*2/*d*

2) Calculation of number of filters:

Total Area filters $= \frac{Q_{ALL}}{\text{Rate of filteration}} = \frac{35164.8}{130} = 270 m^2$

Assume Filter Dimension $(6m \times 8m)$

Number of $^{\text{Required}}$ filters $= \frac{\text{Total Area of filters}}{\text{Area of one filter}} = \frac{\text{Total Area}}{\text{Area of one filter}} = \frac{270}{48} = 6 \text{ Filter}$

Add 2 filters if the number of filters more than 8 and add 1 filter if the number of filters is less than 8 to avoid the broken-up problems (6 + 1 =7 filters)

Calculate the water capacity per filter based on the new number after rounding it

Actual rate of Filtration $= \frac{Q_{ALL}}{\text{Actual Total Area}} = \frac{35164.8}{7 \times 6 \times 8} = 104.7 m^3/m^2/d$

B. Calculation of amount Washing Water for Tank

Rate of washing = (5→6) time of filtration $= 6 \times$ Actual rate of filteration $= 6 \times 104.7 = 628 m^3 \backslash m^2 \backslash d$

C. Design of Wash Water Gutters

Spacing =1→2m ($Take$ 1m)

To calculate the number, we assume that the distance between each bank is one meter, and given the width of the whole filter, we calculate the number as follows

Filter Width$= N \times 0.5m + N \times 1m$

6=1.5N→Number of Gutters =4, Spacing =1m

$$Q_{gutter} = \frac{\text{Rate of washing} \times \text{area of filter}}{\text{Number of gutters} * 24 * 60} = \frac{628 \times 48 \times 1000}{4 \times 24 \times 60} = 5233.3 \text{liter/min}$$

The pipe height is calculated as follows

$Q_{gutter} = 0.76 \times \text{width} \times H^{\frac{3}{2}}$

$Width$=25→50cm ($Take$ 40cm)

$5233.3 = 0.76 \times 40 \times H^{\frac{3}{2}} \rightarrow H = 30cm$

D. Design of Wash water tank & Washing Pipes

1) Design of Wash water tank:

$Time\ of\ washi(T)$=8→15 min

$Amount\ of\ wash\ water(Q)$=Rate of washing × Area of one tank $= \frac{628}{24 \times 60} \times 6 \times 8 = 20.9 m^3 \backslash min$

$Tank\ Capacity$= Q × Time $= 20.9 \times 13 = 272.1 m^3/min/Filter$

$Assume\ d$=4 m

$Area = \frac{\text{Volume}}{\text{depth}} = \frac{272.1}{4} = 68.03 m^2$

$\phi = \sqrt{\frac{Area \times 4}{\pi}} = \sqrt{\frac{68.03 \times 4}{\pi}} = 9.30m$

2) Design of Washing pipe:

V= [1.5→3] =$TAKE\ V$=2$m\backslash sec$

$Q = 2 \times Rate\ of\ washing \times Area\ of\ filter = 2 \times \frac{6 \times 104.7}{24 \times 60 \times 60} \times 6 \times 8 = 0.698 m^3/sec$

Q=A×v: 0.698=A × 2= A=0.349m^2

$\phi = \sqrt{\frac{0.349 \times 4}{\pi}} = 0.66m \rightarrow A = 0.349m^2$

$V = \frac{Q}{A} = \frac{0.698}{0.349} = 2m/s$

E. Design of Under Drainage System

1) Design of Perforation

Total surface area of perforation= $0.002 \times Area\ of\ one\ filter = 0.002 \times 6 \times 8 = 0.096m \rightarrow 960cm^2$

Take diameter of hole =1cm

Area of one perforation=$\frac{\pi \times \emptyset^2}{4} = \frac{\pi \times 1^2}{4} = 0.78cm^2$

NO .of perforation= $\frac{Total\ serface\ area\ of\ perforation}{Area\ of\ one\ perforation} = \frac{960}{0.78} = 1215 \sim 1200$

2) Design of Laterals

Spacing between branch = (15-<30cm) take 20cm

No. of Laterals=$\frac{1}{spacing} = \frac{8 \times 2}{0.2} = 80laterals$

Divide the number of holes in each pipe

No of perforation per pipe= $\frac{1200}{80} = 15$

Calculate the diameter of the required discharge pipe, based on the total area of the holes in it

Area of holes in one lateral= $15 \times 0.78 = 11.7cm^2$

Cross-sectional area of lateral =$(2 \rightarrow 4) \times Area\ of\ holes\ served\ by\ lateral = 3 \times 11.7 = 35.1cm^2$

ϕ=6.73 cm

The design of the main pipe assembled for the branch pipes located in the middle of the filter to calculate its diameter, and this will be a percentage of the area of the branch pipes, and it can be circular or square

3) Design of Manifold

Area of main fold area of manifold = $(1.7 - 2) \times Area\ of\ laterals$

Area of main fold area of manifold = $1.8 \times 80 \times \frac{\pi \times 6.73^2}{4} = 5119.9\ cm^2$

If circular $\rightarrow \phi$=80.8 cm

If square $\rightarrow L$=67.6cm

Configuration of hole

To calculate the length of the water drainage pipe, it is subtracted from the width of the total filter, the thickness of the main pipe Manifold, and also 20 cm as safety distances on the outer ends of the pipes, and then divided by 2 because it is on both sides.

Length of laterals= $\frac{Width - Manifold - 0.2}{2} = \frac{6 - 0.76 - 0.2}{2} = 2.52m$

The number between two holes in the pipe is calculated and made sure that it is in the correct range from 8 to 24 cm, and this is by dividing the length of the pipe by the number of holes in the pipe.

Distance between holes =$\frac{252}{15} = 16.8\ (8 \rightarrow 24) OK$

4) Design of Inlet and Outlet Pipes for Filter

First: The pipes entering the filter, which are the pipes that emerged from the sedimentation basins, and these were actually designed in an earlier stage, and we do not need to count them again, and the calculated diameter was 700 mm

Inlet pipe the ape outlet pipe from clariflocculator

Inlet pipe = 700mm

Second: The design of the external pipes from the filter to the ground tank, the conduction of the pipe is the same as the discharge of the water inside the filter, but by converting this value to 3 m / sec and then assuming the velocity of the water, and from it we get the diameter of the pipe reservoir Outlet pipe to ground :

$Q_{ALL} = \frac{35164.8}{24 \times 60 \times 60} = 0.407m^3/sec$

$Assume\ V$=1$m\backslash sec$

Q=$A*v$

A=$\frac{0.407}{1} = 0.407m^2 \rightarrow \emptyset = 0.720m = 720mm$

VI. DISINFECTION

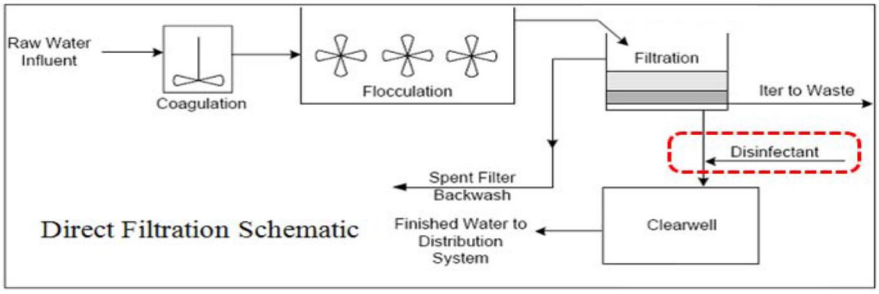


Fig.7 Disinfection Process

A. The most common disinfections used in water works

1) Chlorine gas
2) Ozone gas
3) UV-light

B. Disinfection by Chlorine gas process

Chlorine is the most used material in the sterilization process, due to its efficiency in not adding it in many concentrations It is in water and is also relatively cheap and safe if used within the permissible limits, where the single dose is ranging from 1 to 0.25 milligrams per liter.

$CL2+H2O \rightarrow HOCL+HCL$

$HCL \rightarrow HCL+O$

Water requirement of the town=$35164.8 m^3\backslash day$

Dose of chlorine required for disinfection=0.25 $mg\backslash l$

$$Quantity\ of\ chlorine\ required = dose\ of\ chlorine \times Water\ requirement\ for\ town$$

$$Quantity\ of\ chlorine\ required = 0.25 mg\backslash l \times \frac{1}{1000000(kg)} \times 35164.8 m^3\backslash day \times 1000 lit = 8.791 kg\backslash d$$

To calculate the required amount of powder from the disinfected material, knowing that every 10 parts of the powder contains 6 parts of chlorine. Therefore, if we want to ask for the amount of chlorine that he needs, it is multiplied by the ratio of 100 to 60.

$$Quantity\ of\ bleaching\ required = 8.791 \times \frac{100}{60} = 14.652 kg\backslash day = 8.791 \times \frac{365}{1000} = 5.347 ton\backslash year$$

VII. GROUND RESERVOIRS

A. Design of Ground Reservoirs

What are the main usages of ground tanks?

- Emergency storage
- The required contact time for disinfection
- Four fifth of the water required for fire fighting

1) Calculations of Maximum & Design water consumption:

$$Q_{MAX\ monthly} = 1.4 \times 37736 \times \frac{115}{1000} = 6075.4 m^3\backslash day$$

$$Q_{MAX\ daily} = 1.8 \times 37736 \times \frac{115}{1000} = 7811 m^3\backslash day$$

$$Q_{design} = 1.1 \times 6075.4 = 6682.94 m^3\backslash day$$

2) Calculations of Volume of storage tank:

Take the highest value from the following capacities then add to it firefighting requirements

$C1 = (Q_{MAX\ daily} - Q_{MAX\ monthly})$ for one day

$C1 = 7811 - 6075.4 = 1735.6 m^3 \backslash day$ $C2 = Q_{design} \times (6 \rightarrow 10)$hours for emergency storage

$$C2 = 6682.94 \times \frac{8}{24} = 2227.6 m^3 \backslash day$$

$$C3 = Q_{design} \times \frac{0.5}{24} \text{ for disinfection}$$

$$C3 = 6682.94 \times \frac{0.5}{24} = 139.22 m^3 \backslash day$$

$Maximum\ capacity = 2227.6 m^3 \backslash day$

3) Calculations Tank dimensions:

Assume depth (d)=5m

$$Surface\ area = \frac{2227.6}{5} = 445.5 m^2$$

Assume 3 tanks

$$Area\ of\ one\ tank = \frac{445.5}{3} = 148.5 m^2$$

Assume L=20m& $B = \frac{148.5}{20} = 7.5m$

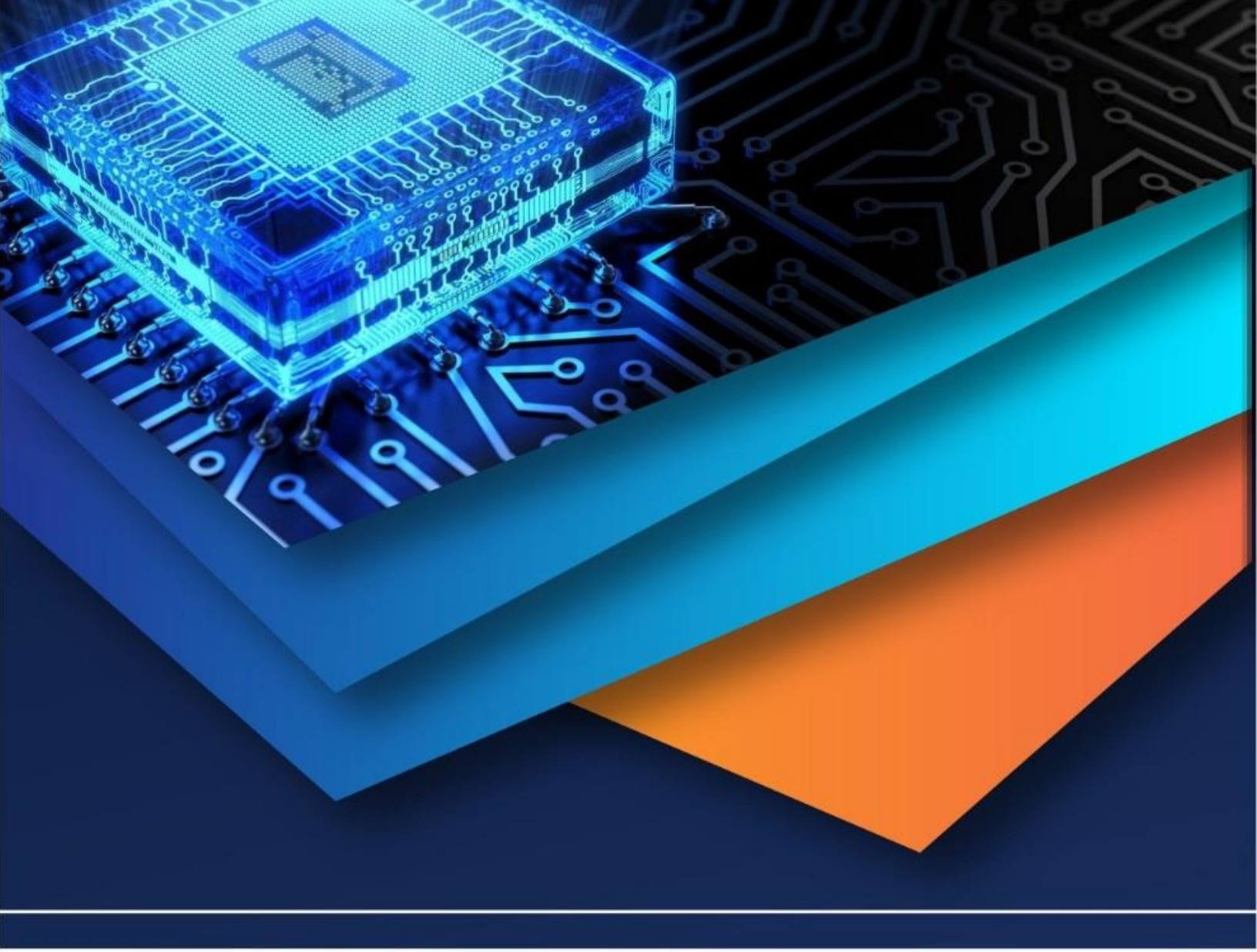
Choose 3 tanks with dimensions 5m × 20m × 7.5m

VIII. CONCLUSIONS

An exemplary design for WTP units was presented. Procedures and detailed calculations were made. The average discharge of 4339.64m^3/day and a population of 37736 were used in the design of WTP. The quality and quantity of the surface water source affected the WTP design. Surface water resource such as the water coming from the Nile river to Al-Bsaber city through a pipeline needs treatment due to the concentration of pollutants. The parameters of each unit and the whole WTP by using the pilot scale should be optimized. Populations should be predicted using various methods to use WTP services without any problems. Based on the obtained calculations and details it is concluded that, the study can be used as a base reference for the future works and to design of any WTP units. Several factors such as age of WTP, maintenance, economic and political situations, technical problems, and water demand had a great impact on the removal efficiency of the WTP units.

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