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# Analysis and Design of Water Treatment Plant

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***Abstract***

*Narrowly, the provision of safe drinking water is dependent upon being able to recognize the health risk of hazardous substances or microbes present in drinking water. Monitor drinking waters for the presence of these hazards and remove these hazards. Challenges to providing safe drinking water include a diminishing supply of usable water.*

***Keywords:*** *Filter media, chlorine, screening, water quality and alum.*

## 1. Introduction

All surface water and some ground waters require treatment prior to consumption to ensure that they do not represent a health risk to the user. Health risks to consumers from poor quality water can be due to microbiological, chemical, physical or radioactive contamination.

However, microbiological contamination is generally the most important to human health as this leads to infectious diseases which affect all populations groups, many of which may cause epidemics and can be fatal. Chemical contamination, with the exception of a few substances such as cyanide and nitrate, tends to represent a more long-term health risk.

### Description of Treatment Measures

### Raw water intake and flow measurement

Water treatment plants normally have a raw water intake, pumping and convey a system and flow measurement. Although these systems do not provide any treatment, they are necessary as a part of the overall treatment process train. Raw water intakes are built to withdraw water from a river, lake or reservoir over a predetermined range of water levels.

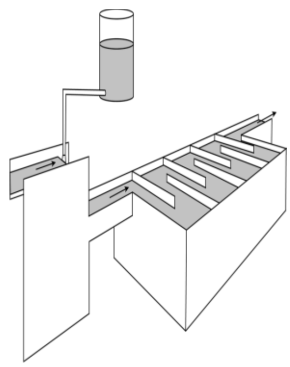
The raw water conveyance or transport system is designed for the flow of bulk quantities of water from the intake to the treatment plant. The connecting conduit may be a canal, a flume, a pressure pipeline, or a combination of these.

### Coagulation

Coagulation is the process by means of which the colloidal particles in water are destabilized (i.e. the nature of the colloidal particles is changed) so that they form flocs through the process of flocculation that can be readily separated from the water. Destabilization is achieved through the addition of chemicals (called coagulants) to the water. In water treatment, coagulation flocculation involves the addition of compounds that promote the clumping of fines into larger floc so that they can be more easily separated water.

### Flocculation

Flocculation follows coagulation (and is often regarded as part of one process: coagulation-flocculation). The objective of flocculation is to cause the individual destabilized colloidal particles to collide with one another and with the precipitate formed by the coagulant in order to form aggregates that could easily be removed by means of sedimentation or flotation. Flocculation involves the stirring of water to which a coagulant has been added at a slow rate, causing the individual particles to "collide".



### Pre-filtration

As many secondary filtration processes, and in particular slow sand filtration, require low influent turbidities, some form of pretreatment to reduce suspended solids load is required. One way to achieve this is by using pre-filtration of water through coarse media, usually gravel or coarse sand. Pre-filters can have many different configurations: horizontal; vertical up flow; and vertical up flow-down flow. Vertical pre-filters have become increasingly popular as they require far less land than horizontal pre-filters and can take faster flow runs through them. An alternative are pressure filters, through which water is pumped at pressure to remove the suspended solids load. Pre-filters have an advantage in that they do not require chemicals, have limited working parts and are robust.

**Sedimentation**

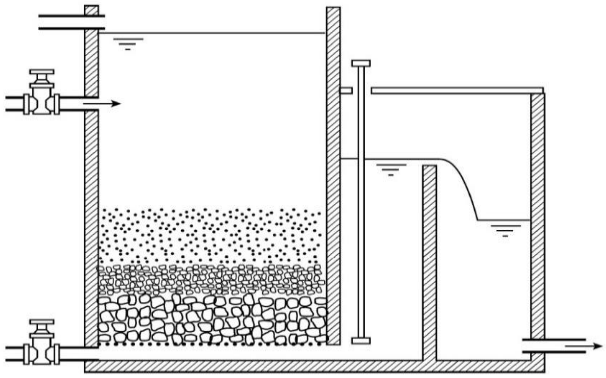
Sedimentation is the removal of suspended solids through the settling of particles moving through a tank at a slow rate. There are a number of forms of sedimentation. In water treatment plants treating source water a high proportion of suspended solids of coarser grades (e.g. sand and coarse silt) a grit chamber may be used to remove the largest particles through simple sedimentation. In this process, water is passed through a tank at a slow rate and suspended solids fall out of suspension. In small supplies, simple sedimentors may also be used, which functioning in a similar fashion to grit chambers, although with a slower rate of water through flow. Simple sedimentation will not remove fine grained particles because the flow rates remain too high and the retention time is insufficient. A further common fault with simple sedimenters is that design flow rates are rarely achieved in practice and a certain element of 'short-circuiting' can occur unless construction, operation and maintenance is very careful.

**Filtration**

Sand filtration can be either rapid or slow. The difference between the two is not a simple matter of the speed of filtration, but in the underlying concept of the treatment process. Slow sand filtration is essentially a biological process whereas rapid sand filtration is a physical treatment process.

**Slow sand filters**

Slow sand filters operate at slow flow rates, 0.1 - 0.3 meters per hour. The top layers of the sand become biologically active by the establishment of a microbial community on the top layer of the sand substrate. These microbes usually come from the source water and establish a community within a matter of a few days. The fine sand and slow filtration rate facilitate the establishment of this microbial community. The majority of the community are predatory bacteria who feed on water-borne microbes passing through the filter.



**Filter media**

The Place where filter media is packed and water is passed through filter media.
Classification of filters

1. Based on force with which filtration is carried out
   a) Gravity filter
   b) Pressure filter

2. Based on rate of filtration of filters (efficiency)
   a) Slow filters (90-99%)
   b) Rapid filter (lower than slow sand filter)

3. Based on number of filter media employed
   a) Single media filter
   b) Dual media filter
   c) Multimedia filter

**Disinfection**

All water supplies should be disinfected in order to protect public health. Disinfection inactivates any remaining bacteria in the water after previous treatment steps and provides a residual disinfectant to inactivate bacteria introduced by any subsequent ingress of contaminated water during storage or distribution.

At present, the principal disinfectant used worldwide is chlorine, although alternatives are being increasingly investigated and process such as ozonation are becoming more important in industrialized countries. It is important to note that all disinfectants produce by-products and that the greater knowledge about the by-products formed from the use of chlorine because it is this most widely used disinfectant should not compromise it's use. It is also important that disinfection of water supplies is never compromised because of a risk of potential health effects from by-products in the final water.

**Test results**

1. Population forecast = 14,854.
2. Collection of water,

Pipe diameter(d) = 0.1718m

3. Peak flow = 2 MLD.
Size of channel = Total depth × gross width.
= 265 × 1250 mm.
Discharge(Q) = 0.023 $m^3$/sec.
Total depth of channel = 265mm
4. Size of channel = 265X1250 mm.
Alum Dose = 14mg /L.
Length(l) = 10.5m
Breadth (b) = 5.27m
Depth (d) = 3m.
Coagulation = 28.074 kg/day.
5. Sedimentation = 3.23 hr.
Sedimentation tank size = 16.9m x 4.302m x 4.5m
6. Slow sand filter = 278.51$m^2$
Gravel bed = 30-40cm
Filter media = 90-100 cm
Filter box = 2.5 m

**Water Quality**

The term "water quality" describes the physical, chemical and micro biological characteristics of water. These properties collectively determine the overall water quality and the fitness of the water for a specific use. In the case of water to be treated(raw water) the overall quality as well as the values of specific quality parameters determine which processes must be employed to produce water that is fit for its intended use and what the operating parameters should be.

**Drinking Water Quality Criteria and Guidelines**

There are many lists of quality criteria, standards and guidelines according to which the quality of drinking water is assessed. The most prominent include the Safe. Drinking Water Act in the USA with its National Primary Drinking Water

Regulations, the World Health Organization's Guidelines for Drinking Water Quality and the European Union's Directive related to the quality of drinking water in tended for human consumption. Each of these includes lists of many substances with different maximum contaminant levels. Substances are also continuously added to the lists as required by legislation processes in the USA and in the EU.

**Design procedure**

Population forecast = 14,854
= 135 lit/day
Total quantity = 14,854 × 135
= 20,05,290
= 2MLD.

**Stage – 1**

❖ Collection :

Source to treatment plant = 100 mts
For meetong our estimated population,
we required discharge = 835.553 $m^3$/hr.
Let the velocity of water in pipe between source to plant = 3600 m/hr.
Discharge = A × V
835.553 = $\frac{\pi}{4} d^2 \times 3600$
Diameter(d) = 0.1718m.
∴ we require the pipe diameter is 17.18 cm to convey water from source to treatment plant.

**Stage – 2**

❖ Screening :

Peak flow = 2MLD
= 2 × $10^6$ lit/day.
= 2 × $10^6$/1000 $m^3$/day.
= 2000 $m^3$/day.
Discharge(Q) = 2000/24 ×60×60
Discharge(Q) = 0.023 $m^3$/sec.
Assume,
Velocity of the flow through the screen = 0.8m/s
Q = A × V.
A = Q / V
= 0.023 / 0.8
= 0.03 $m^3$
∴ Provide clear spacing between bars = 50mm
Size of the barn = 10mm × 70mm.

➢ Gross area required = 0.03×70/50
= 0.042 $m^2$

As the screen is 45° inclined with horizontal gross area of screen = 0.042/sin45
= 0.06 $m^2$

➢ Net submerged area = Peak flow / velocity through the screen
= 0.023/0.8
= 0.028 $m^2$

➢ Submerged area = Net submerged area × sinØ
= 0.28 × sin45°
= 0.019 $m^2$

➢ Velocity of flow above the screen bar = 0.8m/s × 50mm/70mm
V = 0.57 m/sec.

➢ Head loss ($h_L$) = 0.729 × ( $v^2$ – $v^2$ )
= 0.729 × ( $0.8^2$ – $0.57^2$ )
= 0.0229 m.

➢ Velocity of flow in screen chamber = Peak flow / submerged of screen
= 0.023/0.019
= 1.28 m/sec.

➢ Liquid depth ,

Size of bar 70 × 10mm & clear spacing =50mm.
Provide 20no of bars.
Gross width of screen chamber = ( 20 × 0.01 ) + ( 20 × 0.05 )
= 1.25m.
Liquid depth = submerged area of screen/gross width
= 0.019/1.25
= 0.015m.

➢ Total depth and size of channel :-

Total depth of channel = liquid depth + free board
= 0.0152 + 0.25 = 265mm.

Size of channel = Total depth × gross width.
= 265 × 1250 mm.

**Stage – 3**

❖ Coagulation :

Alum Dose = 14mg /L
Total alum required per day = Q x 14
= 2.0052 X 14
= 28.074 kg/ day.
Detention time for tank(t) = 2 hrs.
Volume of tank(V) = Q × t
= 83.55 × 2
= 167.1 $m^3$
Let,
Depth(d) = 3 m
Breadth(b) = b
Length(l) = 26m

- Velocity = d × b × l

167.1 = 3 × $26^2$
Breadth(b) = $\sqrt{27.85}$
= 5.27 m
Length(L) = 10.55m
Size, Length = 10.5m
Breadth = 5.27m
Depth = 3m

**Stage – 4**

❖ Sedimentation :

Assume,
Length = 15 m
Breadth = 06 m
Height= 03 m
Velocity ($v_o$) = 83.55×$10^3$ / 15×6
= 928.33 lit/hr/$m^2$
DT = $\frac{V}{Q}$
= 15×6×3/83.553
= 3.231 hr.
With coagulation
Aluminum sulphate dose = 14mg/l
Total aluminum sulphate required/day = 2.00529 × 14
= 28.024 mg/day.
Discharge(Q) = 835.553$m^3$/day
Capacity of tank = $\frac{2000 \times 2}{24}$
= 166.6$m^3$
Assume, depth = 3m, length = 36
Volume of the tank(V) = 36 × b × 3
$\frac{166.6}{9} = \frac{9\,b2}{9}$
$b^2 = \sqrt{1851}$
b = 4.302m
l = 36
l = 12.906m
Provide for inlet and outlet
Total length L = 4 + 12.906
= 16.906m
Length = 16.9m
Breadth= 4.302m
Depth = provide 1m for sludge and 0.5 for free board.
= 3 + 1 + 0.5
D = 4.5m

**Stage – 5**

❖ Filtration:

Slow sand filter,
N = 80-90%
Rof = 100 lit/hr/$m^2$
Total surface area required = Q / ROF
= 83553.75 / 100
= 835.5375$m^2$
Number of filters 'n' =3
Area of each filter required = 835.5375/3
= 278.51$m^2$
Each filter :-
Gravel bed =30-40cm
Filter media =90-100 cm
Filter box = 2.5 m
$A_s$ =100$m^2$
Bed slope = 1 in 100
% of water required to clean water = 0.2-0.6% of filter water

**Stage – 6**

❖ Disinfection:

Disinfection is done after filtration. The water is transfer to the overhead tank and it is disinfected in the tank and supply to the village. Chlorination is done in this stage to remove parasites, bacteria and viruses. Using chlorine in a small amount not cause health effects and provides protection against water born disease outbreaks. Safe chlorine levels up to 4 milligrams per liter.

## Conclusion

In the first stage we have done analysis of treatment process successfully. Designed plant successfully to provide the safe drinking water to yamnampet village. completed the requiring details and information that is related and hence the process. Proper design, engineering, operation and maintenance are absolutely imperative for successful and satisfactory performance of a treatment plant in the long run. The design will supply the treated drinking water to the village for future population. We are proposed this project to the yamnampet village panchayati office.

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