Waughter

AKTION CONSULTANCY

Volume 1 : Edition 5 – Pre-treatment Technology, Process & Design Tools *May 31, 2021*

Dear Water Warriors,

Complexity of high purity water production where we aim to remove almost everything from water leads us to expensive equipment such as Reverse Osmosis, IX based DM plant or CEDIs. Pre-treatment aims at better life of such assets.

Technology that removes almost all the particulate impurities (TSS), and microbial loads & Minor Oxidants are thus clubbed and referred as Pre-treatment.

The issue of '**Waughter**', walks the Pre-treatment Technology, Process & Design Tools.

Nidhi Jain – Civil Engineer

In this edition of water, while we cover Sedimentation, Filtration and Carbon Filtration, based on user Feedback we also ATTACH the link to the relevant design files that me useful to reader.

HRSCC Design in XLS

Water Balance Diagram Clarification

Tube Settler Design in XLS

Sand & Carbon Filter in XLS

While we have taken care that these design tools are best, users may find clarification or an error or any update need. Please feel free to suggest us. Further we update these tools time to time so you can send your mail ID so that we always send you updated file.

Q. Which are target Impurities in PT?

Pre-treatment aims at full or partial removal of impurities shown below.

Parameter	Unit	Typical Feed	Pre-Treatment
pH		7	Yes
TSS	mg/l	210	Yes
Turbidity	NTU	104	Yes
Oil & Grease	mg/l	12	Yes
Colloids	SDI	>7	Partial
Color - Soluble	Pt Co	12	Yes
Fe	mg/l	6	Yes
Pb	mg/l	2	Yes
Zn	mg/l	1	Yes
Ca & Mg	mg/l	120	No*
SO4, CO3	mg/l	125	No
Na, K	mg/l	170	No
Cl, NO3, HCO3	mg/l	310	No
SiO2	mg/l	22	No
CO2	mg/l	6	No
COD - Organics Soluble	mg/l	12	Partial
COD - Organics Particulate	mg/l	5	Yes
Pathogens - Bacteria, Virus	TBC / 1000 ml	10^5	Yes
Endotoxins - Bacteria Dead Body	EU/100 ml	200	No
* Unless Lime Soda Process used in Clarification			

Figure 1_PT Impurity Removal Goals

Benefits of Water Pre-Treatment Process:

Here are some of the key benefits provided by water pre-treatment:

- Extends the life of subsequent reverse osmosis (RO) plant membranes.
- Ensures that the water delivered to the RO or EDI (electro deionisation) system meets the required quality standard.
- Supports the delivery of a continuous and dependable water supply.
- Maximises the overall water processing plant lifecycle, thus reducing costs.

Remember, the pre-treatment objectives shall always be predefined with respect to the treated water quality. Various main processes such as UF, IX Resins, NF. RO CEDI or PW & WFI production need different feed water limiting conditions w.r.t. to TSS, PH, Turbidity, O&G and Microbial Counts, FRC & Oxidants etc.

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Website : www.purewaterent.net

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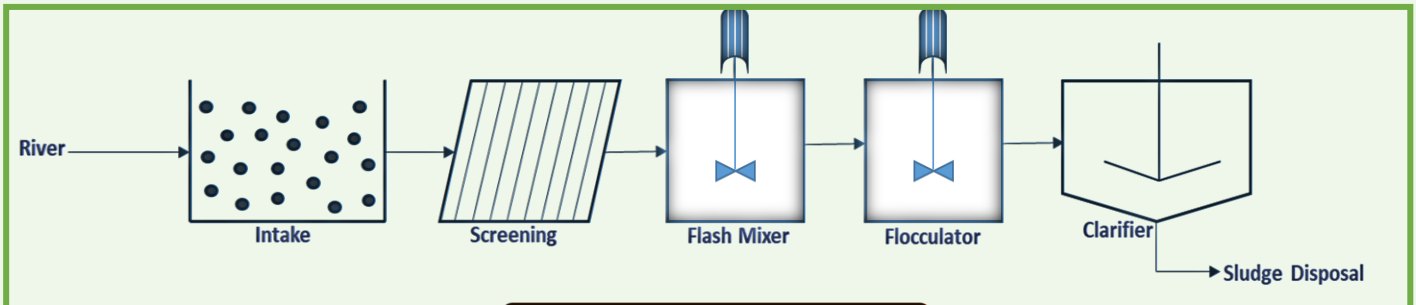

Fig. Clarification

This is the complete overview of Clarification of water. If you are going through these steps, you get the treated water Quality as shown in below Example.

Feed Water Quality

pH: 6.0 - 8.5

TSS: 75 - 2500 ppm

Organics: yes

Iron: 0.2 - 3 ppm as Fe

Colloids: yes

Turbidity: 3000 NTU

Treated water Quality

TSS: 25 ppm

Iron: 0.3 ppm

Hence, these steps are especially important to get the better treated water Quality.

Before going through the Process of Pre-Treatment In-take is one of the important steps. So, here is the **Expertise of Intake & Jack Well.**

No.	Component	Expertise
01	Civil Structure	Knowledge of Water Velocity Impact
02	Screens	Debris Removal Efficiency, Life
03	Pumps	Service Needs, Lubrications
04	Electrical	Safety & Efficiency
05	Automation	Demand, 24*7 Operation, Feedback

Here we show some images related to components of Intake & Jack well:

After Knowing about Expertise of Intake & Jack well, we must know about the first step of Pre-water treatment process which is **screening.**

Initially, Wood chips, leaves, aquatic plants and floating impurities are removed by the Screening Process.

After the screening, high specific Gravity suspended matter e.g., metal caps, large sand etc. Will be settled on its own and displaced through flow.

Screening helps to restrict the entry of large particles to prevent pump damage, settling in pipe and avoid under deposit corrosion.

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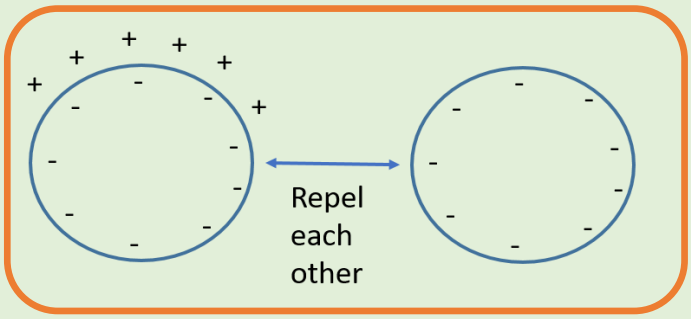
After Screening, Let's Moving forward to Coagulation Process.

Coagulation is the process of Charge neutralization. Impurities present in water carry -Ve charge.



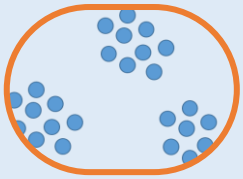
$Al_2(SO_4)_3 + H_2O \rightarrow Al(OH)_3 + H_2SO_4$, suggests how Alum dissolves in Water. While this reaction is progressing $Al(OH)^{++}$ and $Al(OH)_2^{+}$ is formed, this +ve charge helps in neutralization. Common Coagulant Chemicals used in this Process are:

1. Alum
2. Ferrous Sulfate
3. Ferric Chloride
4. Poly Aluminum Chloride.
5. Bentonite Clay

Alum or FeCl3 at 50 ppm and 10% concentration mixed rapidly at rom > 350 rpm for 1-2 minutes is enough to achieve coagulation. The mixing energy depends upon Zeta Potential barrier. The exact dose of Coagulant is established by Jar test.

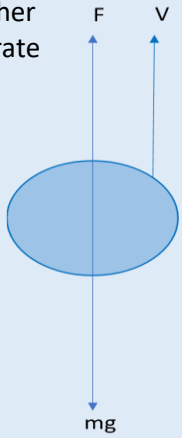
Be aware, the First three will lower the alkalinity and thus pH of the water; that necessitates addition of Lime or NaOH to maintain alkalinity.

Agglomeration:



Once Charge is neutralized the particles some together to agglomerate, why? The answer is in Vander Wall force of attraction, where like solids attract each other. This is a weak force and not effective when stronger repusion due to charge was governing relation. Once neutral, it comes in effect.

Q. Why Particles Settle🤔



First, they sink in because they have higher sp Gravity than water. Next they accelerate in fluid due to g and their down ward velocity increases. (mg)

This velocity is opposed by Fluid layers and the resistance in opposite direction is called Drag Force F.

Once F = mg, particle do not accelerate further and keep traveling down at a velocity known as "Terminal Settling Velocity".

Mr Stoke found out the relation.

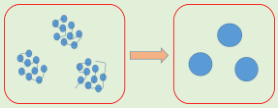
$$V_{tsv} = (\rho_1 - \rho_2)\, a^2 g / 18\mu$$

V_{tsv} = Terminal Settling Velocity
ρ_1 = sp Gr of Particle
ρ_2 = sp Gr of Fluid
a = Dia. of Particle

Since we do not control g, ρ_2 or μ, Pre-treatment objectives aim at ρ_1 and a. thus Dia of particle is of extreme importance.

Flocculation:

Is the process where an additional material "Flocculants" is added to water to ensure the agglomerated particles are binding together to make bigger dia Flocs.



Flocculants can be cationic, Anionic, or non-ionic based on Poly Acryl Amide or Poly Acrylic Acids.

This delicate process needs low agitation ~ 60 rpm, very low dose of Polyelectrolyte ~ 2 ppm at concentration < 1%, 10-15 mins of time is enough.

Be careful not to make fluffy floc (alter ρ_1, as if it is $< \rho_2$, V_{tsv} will become negative & the particle will start floating (going up).

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Many Options of Mechanical Separation of Flocculated Suspended Matter

HRSCC (High Rate Solid Contact Clarifier)

The Clarifier here has a distinct chamber where sludge is drafted back using a impeller. The Feed meets the previously coagulated, flocculated and settled sludge and thus bigger globules are formed, that help in better settling, higher rise rate and thus better treated water quality and reduced diameter.

HRSCC

Typical design criteria For HRSCC:

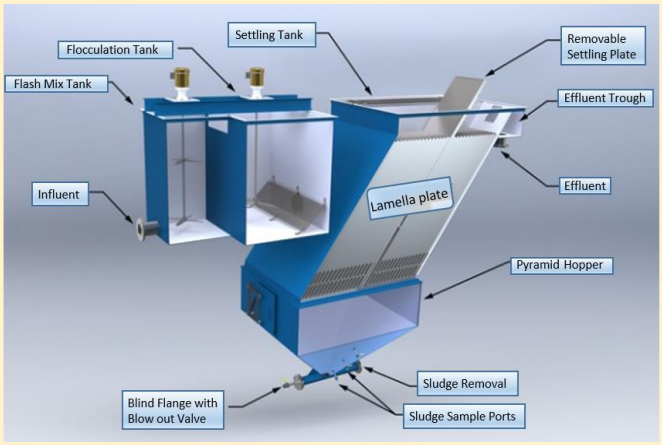
1. Flow Rate : 100 - 2500 m^3/h
2. Flash Mix : 1 min
3. Flocculator : 15 - 20 min
4. Rise Rate : 2.0 - 2.4 $m^3/h.m^2$
5. Retention : 95 - 135 min.

Benefit of HRSCC

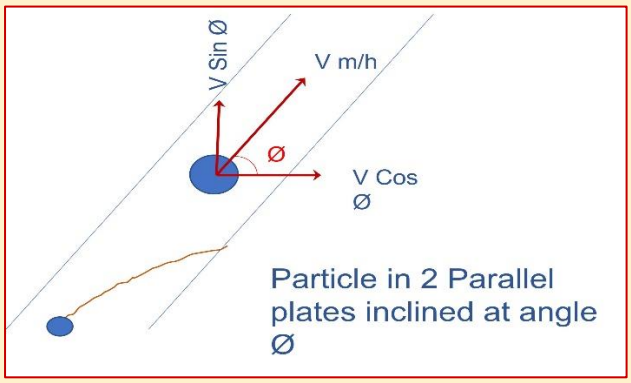
- Internal Sludge Recirculation and hence lower chemical consumption.

The Inclined Plate Clarifier (Lamella Clarifier)

The Clarifier employs a unique combination of Sedimentation knowledge with Cohesive and Adhesive forces of sludge and plate. Further law of Trigonometry is used to guide flow and forces to do positive work.



To understand this, we have a look at picture below:



While water rises in Plates, under laminar conditions, if we assume plug flow, the velocity of water that acts as a Force on smaller particles to go up has 2 vectors. 1. That takes it up and 2. That takes it towards the plate.

If the rising particle, hits the plate, the cohesive force between settled particle and FRP plate comes in Force. The sludge sticks to the plate and nearby water cannot take it up.

Once more and more particle hit the FRP plate, they add and slide down the plate as very large sludge globules.

The designer must understand the point where sludge leaves the plate, same place the feed water is entering hence the velocity shall be Laminar: Lamella Clarifier.

Each parallel plate, act as a surface area projected as Area Cos Ø, if we have n plates the PESA = n.A.Cos Ø. Since the area projects (overlaps) one on another, this clarifier takes $1/8^{th}$ the area as compared to HRSCC.

Since Sludge falls as big globules, we do not need a scrapper mechanism. Further the detention time is < 30 mins to support quick start & stop of plant.

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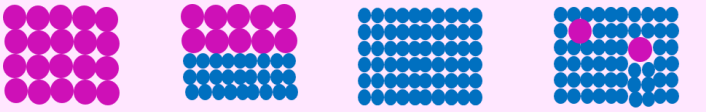
Filtration with Media

In this process we have two major technologies. While the media filtration aims at Occlusion Filtration where water passes through the 'Void Space' and impurities are trapped in it, the Activated carbon has pores in its structure.

The clean water (already Filtered through media) enters the channels created within activated carbon structure and the impurities such as organic matter or some colored species are adsorbed on the surface of carbon. Additionally Activated carbon also neutralizes FRC by simple reaction of C with HOCl and releases CO_2.

Let's understand a few things First.

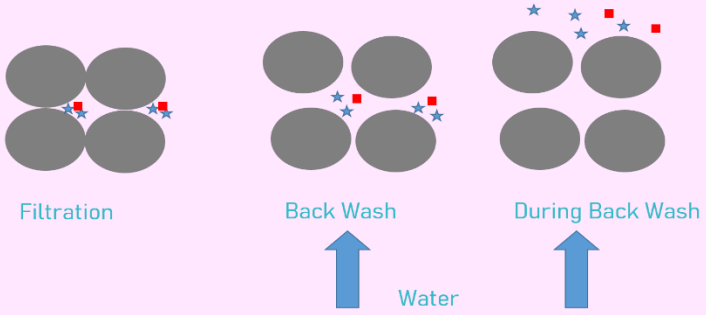


Coarse Sand | Duel Media - Layered Anthracite + Sand | Fine Sand | Duel Media – Mixed Sand + Anthracite

For Big beads the void size is large and therefore poor Filtration (Pink). For small void space the pore size is small and therefore good Filtration (Blue).

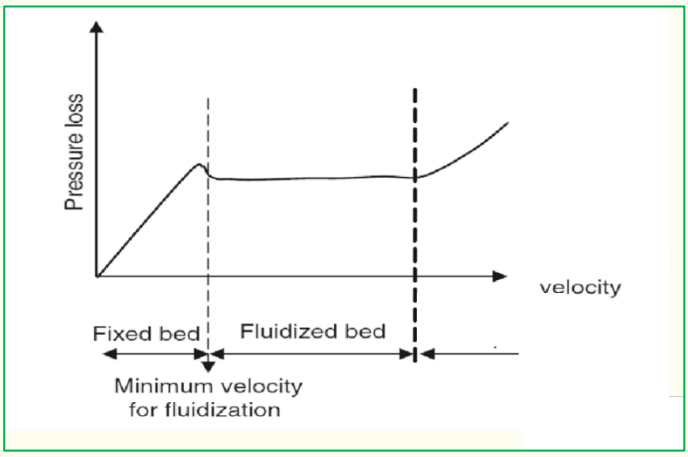
When water passes through Fine or Coarse media, Pressure Drop across the Coarse Media shall be lower in comparison to the fine media due to lower resistance. Further, fine Media arrests most impurities at the surface, but the Coarse Media will allow some to get in its depth.

Therefore, in surface filtration we have low rate of filtration (6-12 m3/h.m2), lower bed depth (~ 550 mm) & fine quartz sand (typical -16+31 Mesh). With time the impurities accumulate and the filter needs backwash to loosen the sand bed and remove the TSS deposited. See below:



Why we have different configurations

To backwash we need to reverse the flow and feed clean water from bottom of the bed that rises up. See figure below, when the water velocity increases ΔP increases in linear proportion and the bed expansion is observed.



At a point, we observe the sudden reduction in ΔP. It's the condition in which theoretically the particles are "Hung" and do not touch each other. Experiment suggest almost all media achieve Fluidization at ~ 40% expansion. The velocity of water to achieve fluidization is ~ 40 m3/h.m2 for quartz sand. For activated carbon since it's lighter than sand it's just 9 m3/h.m2.

With time, utilities observed better rate of filtration if we have coarse layer of anthracite 200 mm on top of fine sand of just 300 mm during rapid gravity filtration.

If we have some oil impurities e.g. typically that found in metal processing waste water, the oil binds sand in filter and creates "mud balls". Engineered experienced that Anthracite mixed with sand (not layered) helps in reduction of Mud balls and better operation.

An Indian company invented Multigrade Sand Filter for non-critical filtration applications e.g. Cooling Tower Side Stream Filtration where 5-10% coarse sand (-6+14 Mesh) is mixed with fine sand (-16+32 Mesh). The idea was to create a filter that has high rate of filtration ~ 24 m3/h.m2, can also be backwashed thanks to channel created by coarse sand at ~ 24 m3/h.m2.

For surface filtration, we may use air scouring ~0.66 m3/min @ 0.2 kg/Cm2 and backwash at 24 m3/h.m2.

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COVID 19.. Teams for Future..

It's testing time for all of us and the current situation is seriously challenging for young graduates and college interns as they lose opportunity.

Thanks to supports from our customers, team Aktion is marching forward with new competence added every month.

We welcome in team;

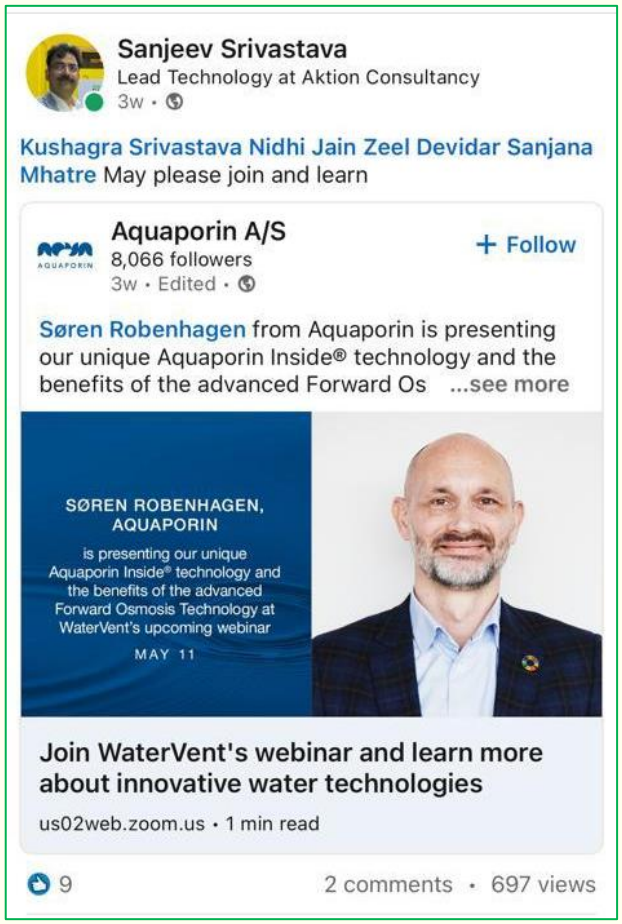
Ms Twinkle Mewad, masters in Chemical Engineering from the reputed LD Engineering College in Ahmedabad with specialization in Computer aided Process design. After initial induction, she would focus on the design of WTPs and ETPs for optimum cost.

Ms Vanshika Thakor, our F&A intern is pursing commerce and accounts and shall assist us in company formation, internal audits and taxation.

While the world looks at Pandemic, Youth looks for opportunities. We request all our readers to spread this message and try to provide opportunities to this year's graduates in form of employments, internship, special projects, site visits, pilot studies, assessment of existing plants etc. and ensure that the industry is not deprived of the intellectual capital that's needed in future. Please contact it@aktionindiaa.com if you wish to sponsor an intern.

Good times are sure to return!!

जल जीवन जननी !!



Our world is Waughter

The technical knowledge share attempt of Aktion Consultancy and the contents in the magazine shall be qualified by Sanjeev Srivastava our Technology Lead.

Our next edition focuses on: Ion Exchange, Resin, Softening, DM Plant & CPU, and Regeneration etc.

Please feel free to write or contact Ms Nidhi Jain technology@aktionindiaa.com +91 95128 55227

Aktion Consultancy
C 1305, Rajyash Rise
New Vasana,
Nr Vishala Circle,
NH-08,
Ahmedabad - 380 051
India

Alka Srivastava – Founder