

TRAINING OF TRAINERS PROGRAMME ON CAPACITY DEVELOPMENT OF ETP OPERATORS

Promotion of Sustainability in the Textile and Garment Industry in Asia - FABRIC



Day 2: Presentation 4

Aeration Devices & Systems for Biological Treatment



Contents



Introduction to aeration



Surface aeration systems



Submerged aeration systems



Diffused aeration

Aeration, why & how?



- Aerobic biological treatment needs continuous oxygen supply and hence need artificial aeration.
- Provided by a set of mechanical units, 'aerators'.
- Consume electric power, provide mechanical action (aeration)
- Depending on characteristics & process, different designs
- Natural aeration systems (e.g. reed beds) and cascade aerators, not relevant in our context - not discussed.
- Oxygen transfer rate : between 0.7 and 1.4 kg of oxygen per kilo Watt-hour with actual wastewaters.

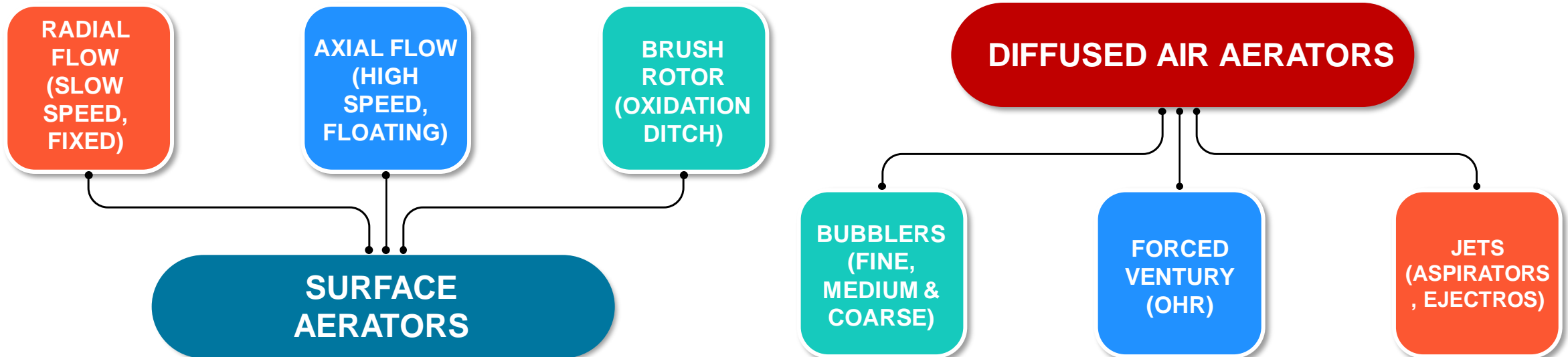
Aeration, why & how?



- First purpose - increase the dissolved oxygen - achieved by dispersing air in water.
- Second purpose - provide sufficient mixing to (a) ensure contact of bacteria with organic matter, (b) prevent settling.
- Dispersal of air by (a) splash water in air to entrap air in water or (b) bubble air through water.
- First type is surface aerators, installed and operated at surface of water.
- Second type: submerged aerators.

Aeration devices commonly used in Textile ETPs

There are dozens of aeration units in the market working on different principles. However, the common ones are the following type.

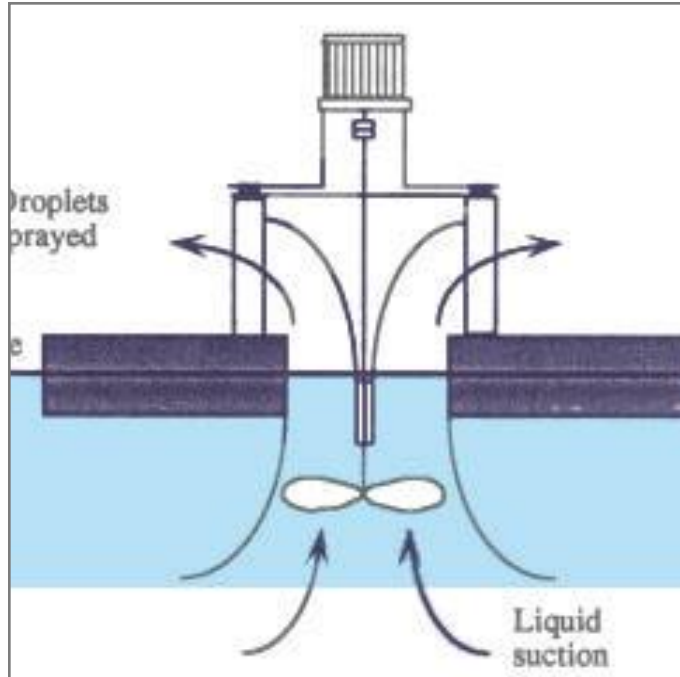




SURFACE AERATORS

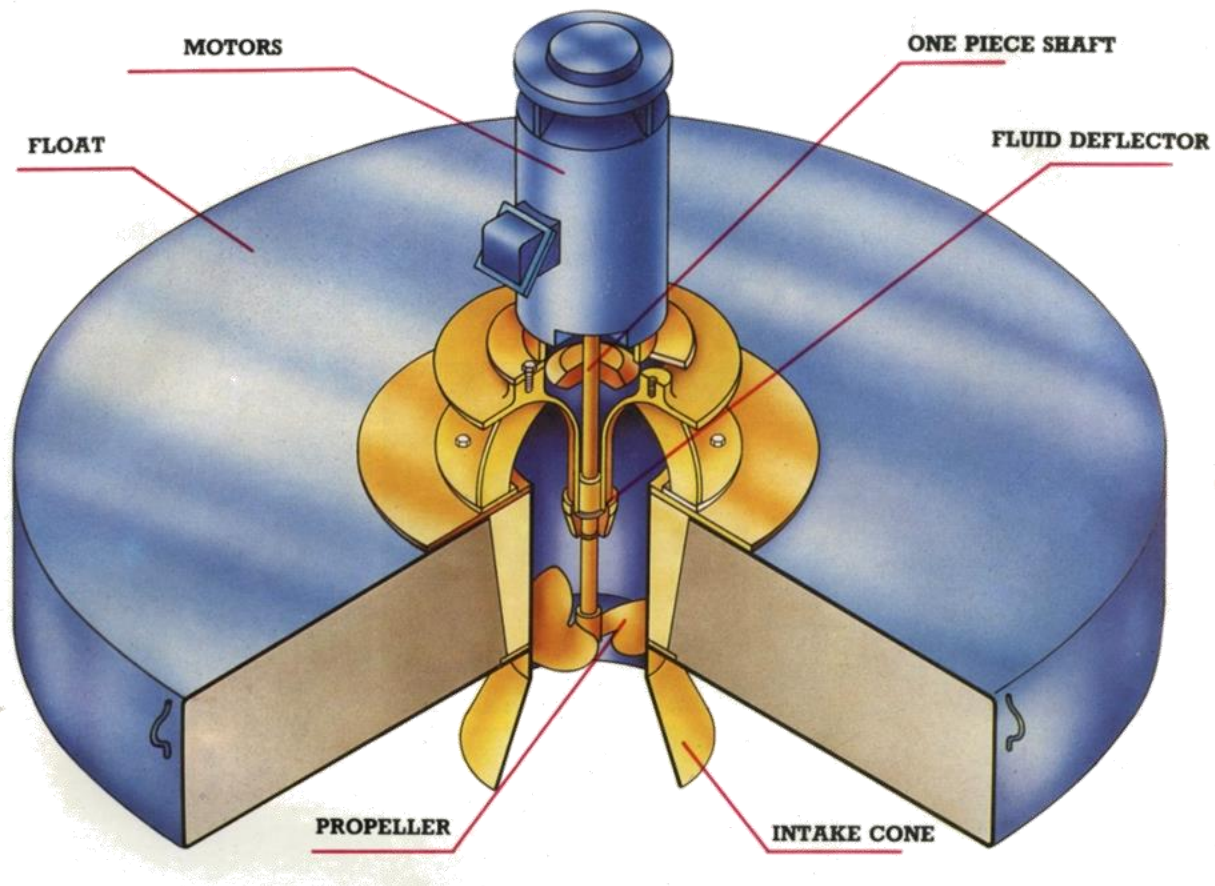
Image credit: Dutch Water Sector

Floating aerators



- Popular surface aeration unit.
- Mounted on a float and consist of a propeller in a rising tube driven by a non-immersed motor.
- Propeller draws the liquid from below and sprays it above at surface of the tank.
- Oxygen transfer takes place from air to droplets sprayed and to turbulent surface of the liquid.
- Also ensure mixing in tank - creates convectional water currents through the tank.

Floating aerators



Floating aerators



Floating aerator - surface aerator mounted on floats



Fixed Surface aerators



- Design similar to agitator, but blades designed to splash the water around.
- Splash water into air, create powerful waves: Water drops splashed entrains the air into water.
- Aerator blades installed at surface to throw maximum water. Immersion of blades important.
- Too less immersion will result in less water sprayed and reduce aeration efficiency.
- Too deep immersion will result in no throw of water -act more like an agitator. Load also increases.

Fixed surface paddle aerators



Cage rotors



- Cage rotors/brush aerators normally used in oxidation ditches.
- These are basically blades mounted on a cylinder which rotates through the liquid.
- Oxidation ditches usually has baffles to direct flow & ensure turbulent velocity.
- Some has additional aeration - surface aerator, jet aerator and diffused aeration or flow boosters.
- Apart from the water spray, turbulent flow through ditches encourage better aeration.

Cage rotors/brush aerators in the oxidation ditch



Cage rotors (a) create turbulence causing aeration and (b) promote flow through the ditches

Cage rotors/brush aerators in the oxidation ditch



Bottom diffusers in the oxidation ditch and ABS flow boosters



Bottom diffusers in the oxidation ditch and ABS flow boosters



Jet aerator mounted on floats



- Used in low aeration ETPs and aqua culture.
- They are mounted on floats on both sides with a hollow shaft extended into water.
- Impellers at end rotates & jet of water created sucks air too and discharge air-water mixture.
- More suited for oxidation ditches since the water jet has uni-directional flow. Multiple units used for rectangular tanks.
- Jet aerators are normally used for shallow aeration tanks and also in small ETPs.

Jet aerator mounted on floats (Blowtac, Taiwan)



A photograph of a submerged aerator in a tank of water. The aerator is a cylindrical device with a motor and a diffuser. The water is dark blue, and the aerator is partially submerged. The text 'SUBMERGED AERATORS' is overlaid on a blue rectangular background.

SUBMERGED AERATORS

Image credit: IndiaMart

Principle of submerged aeration

Submerged aeration involves bubbling of air at tank bottom. When air bubbles rise it pass through water column, get dissolved in water.

Efficiency of dissolution of air (i.e., the aeration) in diffused aeration depends on the contact time the air gets with water.

One can see clearly, why fine bubble diffusers are more efficient than coarse bubble aeration.

To achieve more contact time of air bubbles with water three ways used

increase the depth of the tank, i.e, increase time taken for the bubbles to come to top,

deflect the movement of air horizontally also so that it will take some extra time to rise up.

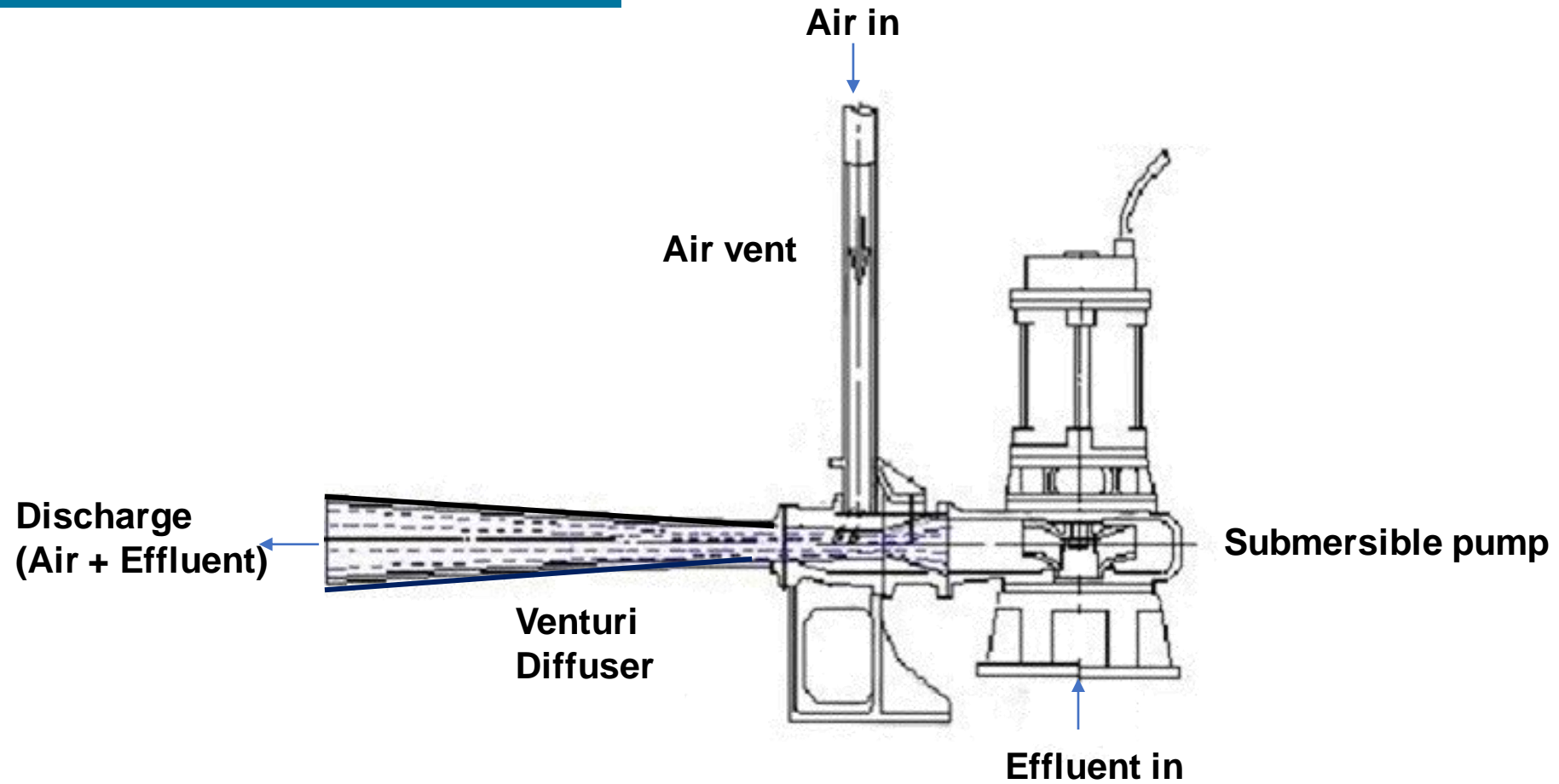
reduce the size of air bubble. If air bubble is smaller, it takes more time to rise up and increase the water contact

Ejectors



- The ejector is basically a submersible pump, where an air inlet line is attached to the outlet.
- Like other pumps, water suction is from the bottom and the discharge is towards the side.
- A vent pipe attached to discharge line suck in air due to force of water pumped.
- Often with venturi arrangement immediately after water-air joint to ensure sufficient diffusion of air
- Due to the system configuration, the mixing power of the system is higher and aeration power is less.

Submersed aerator scheme

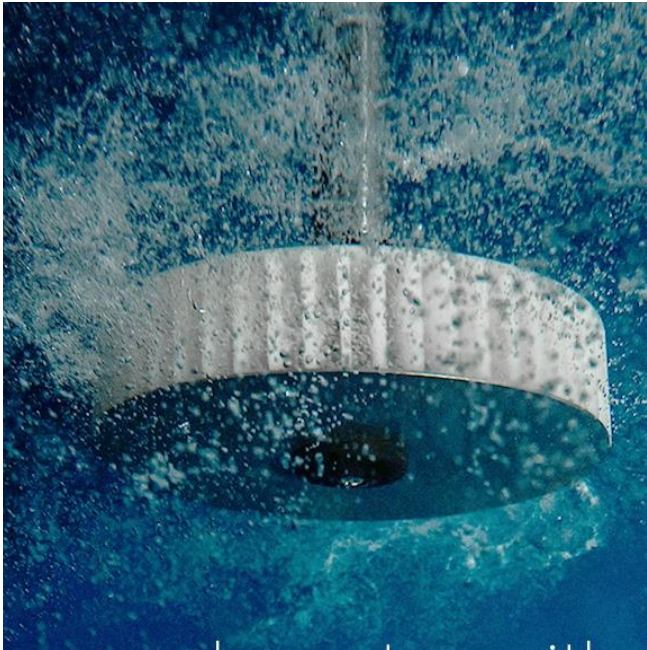


Ejector operation



Ejector operates like a submersible pump, due to the pressure of water gushing out, it sucks air into it and the mixture is released into the tank

Turbine aerators



- Turbine aerators popular in ponds, aqua culture etc. Its ETP use is increasing - high oxygenation capacity.
- Has a motor-driven turbine impeller rotating at high speed, integrated with air line or installed above a pipe or a sparging ring.
- Air bubbles discharged from the pipes are dispersed by the rotation of the turbine.
- Depending on depth of aeration basin, more than one impeller may be used in the same axis.
- The unit ensures mixing and break down/ disperse air bubbles (consume more power).

Turbine aeration

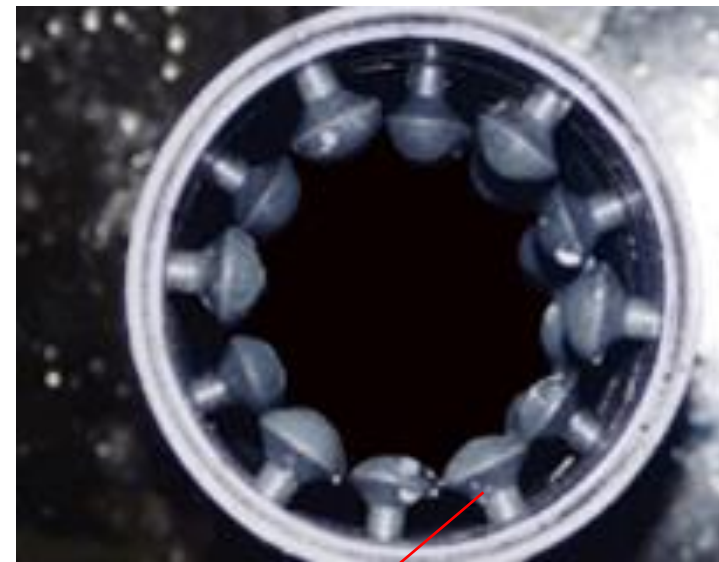
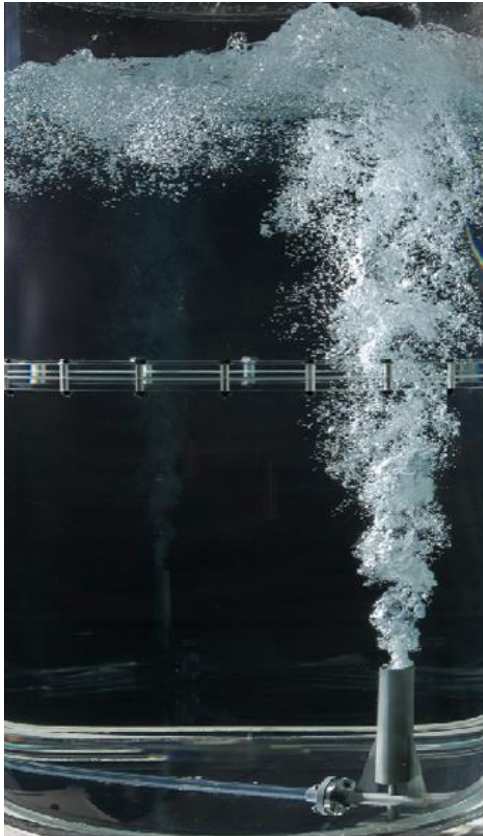


Deflected air bubblers



- Ensure collision of air introduced into a tube with multiple deflectors to create fine bubbles.
- Example is Japanese made OHR aerator: air is introduced to a polypropylene or steel tube, equipped with mushroom like projections within.
- Air along with water hits these projections create smaller bubbles. moves through a zig-zag motion.
- Advantage is long life, absence of clogging and easiness of maintenance.
- Yet, aeration is not as efficient as diffused air and hence slightly higher power consumption.

Deflected air bubblers - OHR aerator



Mushroom like
projections within
the tube

Ejector operation



Due to the special design of the system, OHR allows the air bubbles to break finer, creating a fine-medium bubble.



DIFFUSED AERATION SYSTEMS

Image credit: environmental Dynamic int.

Diffused aeration systems



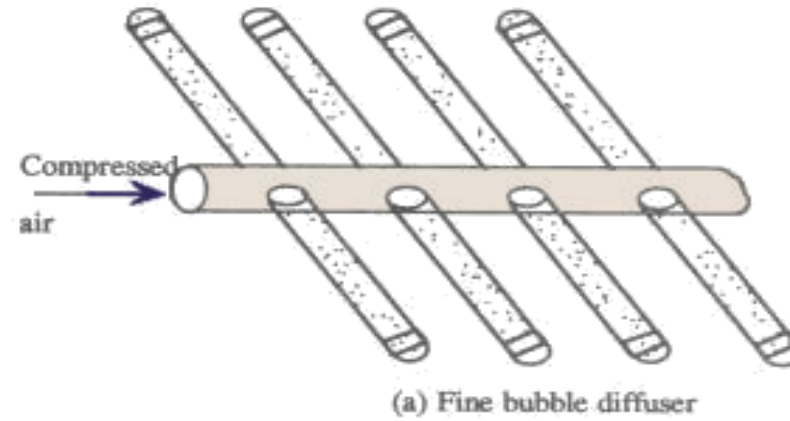
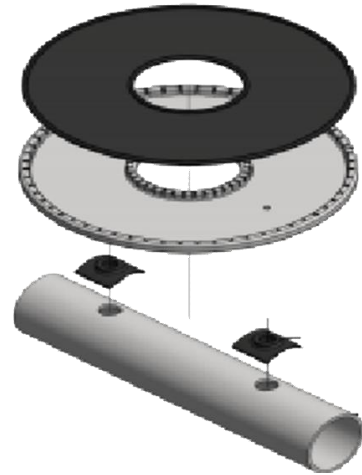
- Diffused aeration systems are divided into fine bubble, medium and coarse bubble diffusers.
- Fine bubble diffusers (EPDM rubber, ceramic or steel) fine pores provide tiny bubbles, high oxygen transfer
- Most common fine bubble diffuser is made of EPDM rubber, covering either a pipe or a disc made of plastic.
- Non-clogging due to fine pores in the rubber diffusers: open when inflated and closes when air withdrawn.
- This closing of pores prevent the sludge getting into the diffuser tubes & air lines which would clog the air line.

Diffused aeration systems

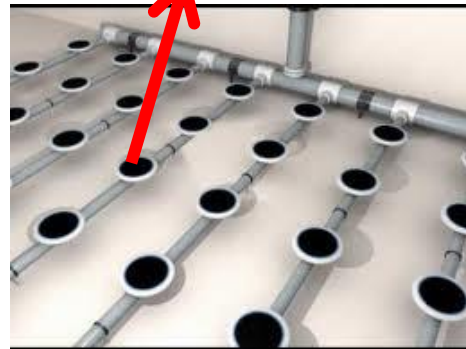


- Medium bubble diffusers are perforated pipes or tubes wrapped with plastic or woven fabric.
- Coarse or large bubble diffusers can be orifice devices.
- Coarse bubble diffusers, less efficient, is sometimes preferred : dust particles in air not a problem, lower cost and low maintenance
- The diffusers are placed along air manifolds, close to the bottom of the aeration tanks.
- Fine & medium types are installed in a grid of pipes (fixed or flexible) dropped down to bottom of tank.

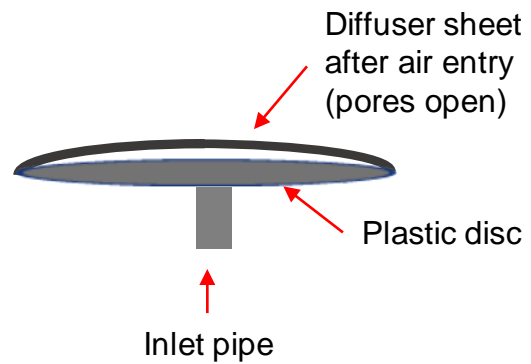
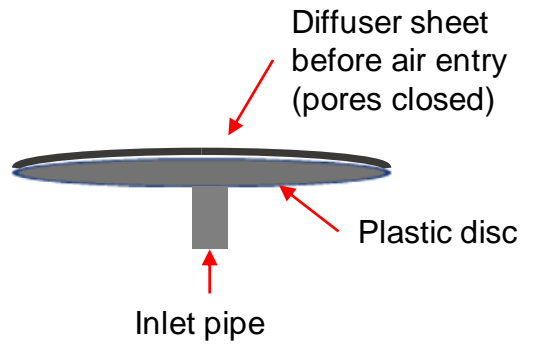
Fine Bubble Diffused Aeration Systems



Bubble bottom diffusers



Non-clogging action of diffusers



Disc Diffusers for diffused aeration (ABS make)



Efficiency of submerged aerators



- Submerged aerators work on principle of contact air bubbles get while rising to the top.
- Coarse bubble aerators mostly in equalization tank.
- Fine bubble only gentle agitation at surface.
- When a diffuser sheet get broken, identified by high turbulence (like coarse bubble) at that location.
- Cleaning of diffuser sheeths using acetic acid/dilute HCl once in six months improve performance.
- EPDM diffuser sheets will become brittle after some time (due to hardness in water). Life : 2-4 years.

Conclusion



- Aerator is the heart of ETP. Selection based on site conditions, size & effluent type
- Surface aerators, less efficient but sturdier, still preferred by some.
- Submerged aeration need deeper tanks.
- Diffused aeration used by about 80% of ETPs. Decreasing efficiency, replacement are concerns.
- Turbine type aerators and aspirators gain popularity of late.
- OHR kind of aerators are getting popular due to long life, sturdiness.

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