Sagar Mozumder
Lecturer, ESDM, DIU

Physical Treatment Processes

Advantages and disadvantages

Physical methods
Advantages :

- The most effective adsorbent, great, capacity, produce a high-quality treated effluent
- No sludge production, little or no consumption of chemicals.

Disadvantages :

- Economically unfeasible, formation of by-products, technical constraints

PHYSICAL TREATMENT PROCESS

- Treatment methods in which the application of physical forces predominates are known as physical unit operations.
- Because most of these methods evolved directly from man's first observations of nature, they were the first to be used for wastewater treatment.
- Screening, mixing, flocculation, sedimentation, flotation, filtration, and gas transfer are typical unit operations.

Screening

The first unit operation generally encountered in wastewater treatment plants is screening.

A screen is a device with openings , generally of uniform size, that is used to retain solids found in the wastewater to be treated.

Role of screening:

The principal role of screening is to remove coarse materials from the flow stream that could

- Damage the subsequent process equipments

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- Reduce overall treatment process reliability and effectiveness
- Sometimes it contaminate waterways.
- Eliminate materials that may inhibit the beneficial reuse of biosolids.

Classification of Screen

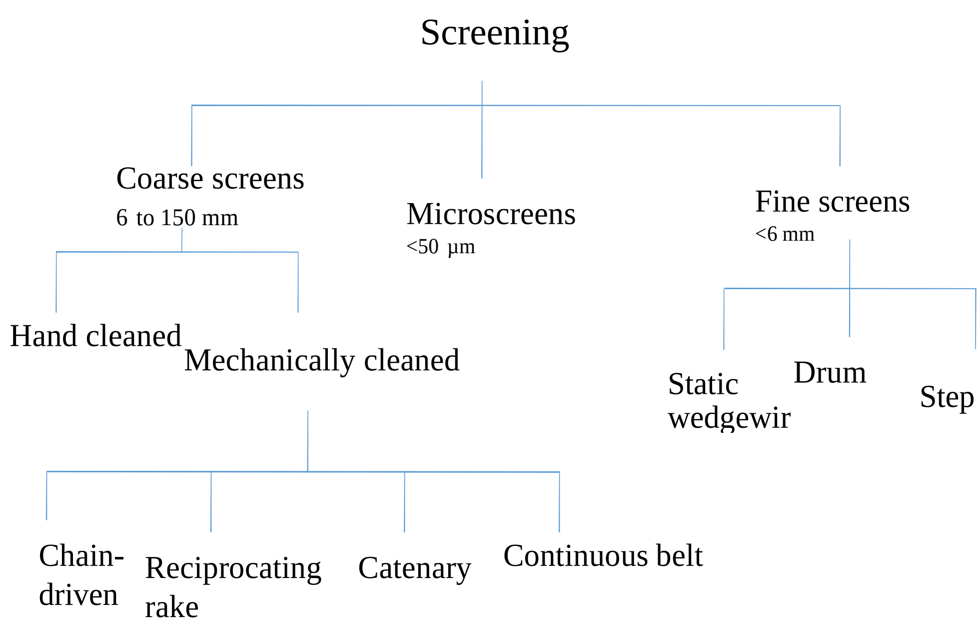
There are generally two types of screens are used in wastewater treatment

I.Coarse Screen: Coarse screens have clear openings ranging from 6 to 150 mm (0.25 to 6 in)

II.Fine Screen: Fine screens have clear openings less than 6mm. Microscreen have clear openings less than 50µm

Are used principally in removing fine solids from treated effluents.

Screening element may consists of parallel bars, rods, gratings, wire mesh perforated plate etc. In case of fine screen the element consists of perforated plates, wedgewire, wire cloths etc.



SEDIMENTATION PROCESS

Sedimentation is the process of allowing particles in suspension in water to settle out of the suspension under the effect of gravity. The particles that settle out from the suspension become sediment, and in water treatment is known as sludge.

- Gravity separation
- Employ for removal of SS from WW
- **3 basic classification**
  - **Discrete (Type I)**
  - **Flocculent (Type II)**
  - **Zone (Type III)**
- Common operation and found in almost all WWTP
- LESS COSTLY than many other treatment processes

Gravity separation is an industrial method ofseparating two components, either a suspension, or dry granular mixture where separating the components with gravity is sufficiently practical

Settling

Solid liquid separation process in which a suspension is separated into two phases

- Clarified supernatant leaving the top of the sedimentation tank (overflow).
- Concentrated sludge leaving the bottom of the sedimentation tank (underflow).

Purpose of Settling

- To remove coarse dispersed phase.
- To remove coagulated and flocculated impurities.
- To remove precipitated impurities after chemical treatment.
- To settle the sludge (biomass) after activated sludge process / tricking filters.

Principle of Settling

- Suspended solids present in water having specific gravity greater than that of water tend to settle down by gravity as soon as the turbulence is retarded by offering storage.
- Basin in which the flow is retarded is called settling tank.
- Theoretical average time for which the water is detained in the settling tank is called the detention period.

Types of Settling

Type I: Discrete particle settling - Particles settle individually without interaction with neighboring particles.

Type II: Flocculent Particles – Flocculation causes the particles to increase in mass and settle at a faster rate.

Type III: Hindered or Zone settling –The mass of particles tends to settle as a unit with individual particles remaining in fixed positions with respect to each other.

Discrete particles are those which do not change size, shape and mass during settling and which do not influence each other by being too close. Particle settling under this condition is called discrete settling. In case of closely packed , the water displaced by the particles may cause additional friction and the settling velocity is reduced. This is termed as hindered settling. Hindered settling becomes noticeable when the concentration of suspended solids is greater than 2000 gm/l. This situation of high concentration of suspended solids may happen in river water during high flooding and heavy rainfall. Sometimes form the settling characteristics represented by stoke's law. This may occur in settling of algae or freshly termed flock by the process of flocculation with coagulant. These particles tend to stick together and for, new bigger particles, which settle at a faster rate. This type of settling is called flocculent settling. Discrete, hindered and flocculent settling are shown in the following figure.

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Sagar Mozumder
Lecturer, ESDM, DIU

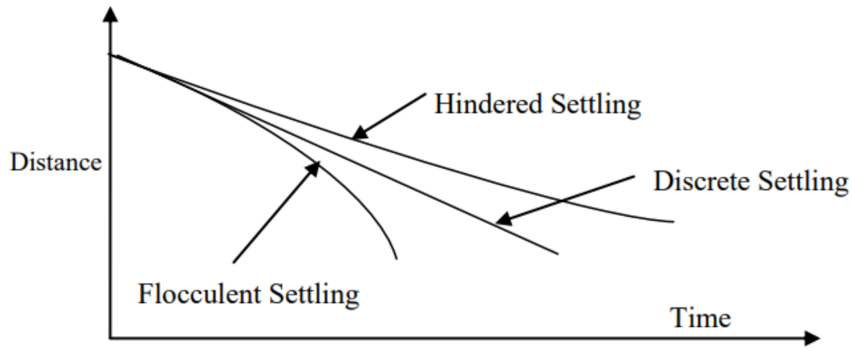
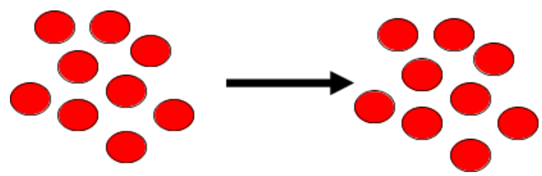


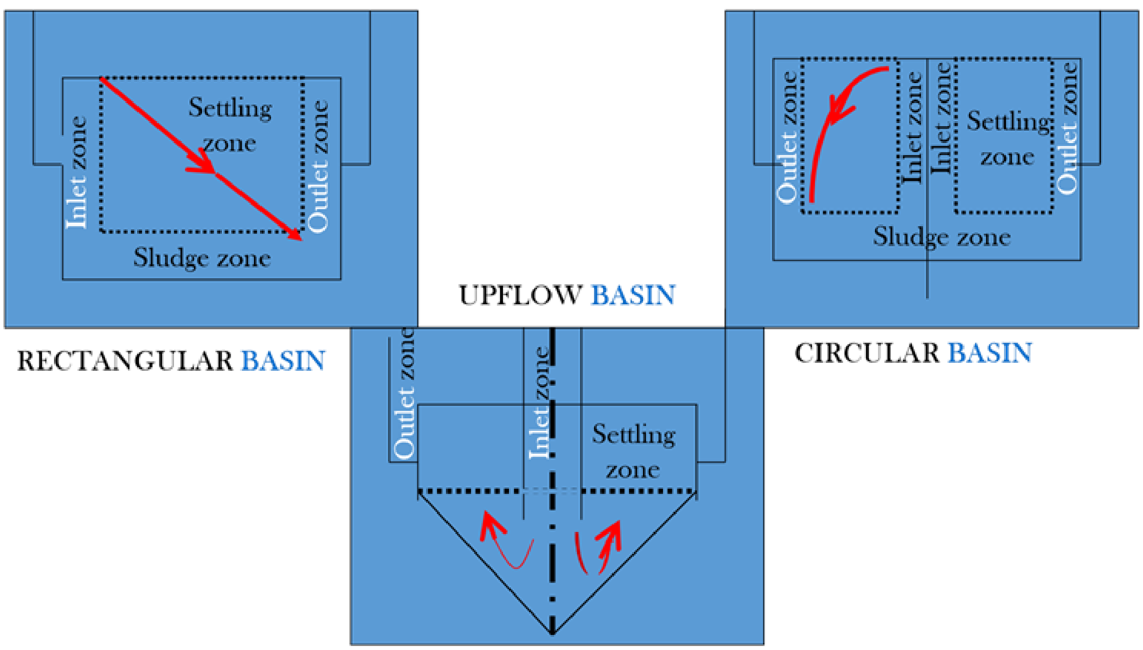
Fig.Settling of different types of particles in water.

TYPE 1 Sedimentation (discrete)

Particle MAINTAINCE its INDIVIDUALITY and does NOT CHANGE in size, shape and density during the settling process.



Idealized discrete particle settling in 3 DIFFERENT TYPE OF BASINS is illustrated below:



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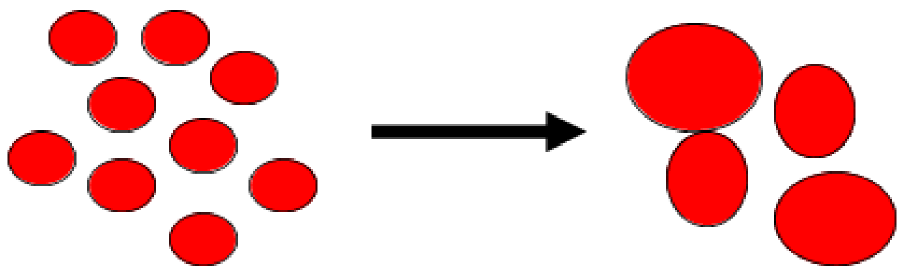
Lecturer, ESDM, DIU

TYPE 2 Sedimentation (flocculent)

Particle velocity of the particle is HIGH as it settles through the tank depth because of COALESCENE with OTHER PARTICLES.



Detention Time(hydarulic retention time, HRT) : length of time a particle or unit volume of ww remains in a reactor.

TYPE 3 Sedimentation (zone)

- The floc particles adhere together and the mass settle as a blanket, forming a distinct interface between the floc and supernatant.
- It is characterized by ACTIVATED SLUDGE & FLOCCULATED CHEMICAL/ SUSPENSION when the concentration of solid exceed $\pm$ 500mg/L
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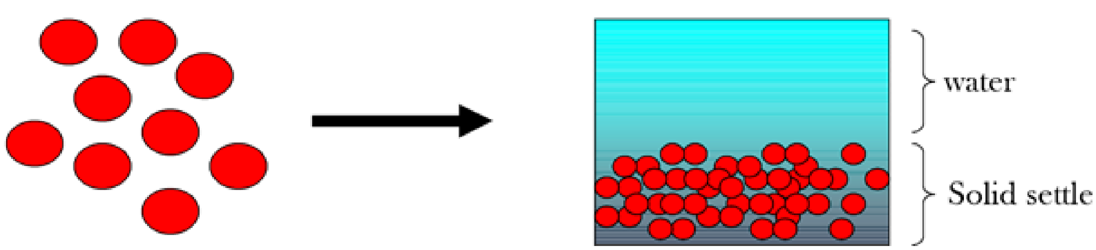

Settling Velocity

Settling velocity of spherical particles under laminar flow conditions is given by the simplified equation:

$$V_s = \frac{g}{18}(S-1)\frac{D^2}{\gamma}$$

Where V_s is the settling velocity, g = acceleration due to gravity, S = specific gravity of the particle, d = diameter of the particle, γ = kinematic viscosity of water.

The above equation is called Stoke's Law. Stoke's Law holds good only for particle size 0.1 cm in diameter and Reynold's Number 1 or less. For larger particles having diameter greater than 1 cm and Reynold's number above 2000, Newton's Law for fractional resistance or drag applies.

$$V_s = \sqrt{\frac{4g}{3C_D}(S-1)d}$$

Where C_D is the Newton's coefficient of drag. The Particles in between the above mentioned sizes or Reynold's number are transition settling.

Stoke's Law is valid for computation of settling velocity of discrete particles.

If a particle is suspended in water, it initially has two forces acting upon it:

(1) ***force of gravity***:

$$F_g=r_p g V_p$$

(2) the ***buoyant force*** quantified by Archimedes as:

$$F_b=rgV_p$$

If the density of the particle differs from that of the water, a net force is exerted and the particle is accelaratd in the direction of the force:

$$F_{net}=(r_p-r)gV_p$$

This net force becomes the driving force.

Once the motion has been initiated, a third force is created due to viscous friction. This force, called the ***drag force***, is quantified by:

$$F_d = C_D A_p r v^2 / 2$$

C_D= drag coefficient.

A_p = projected area of the particle.

Buoyant force: The buoyant force is the upward force exerted on an object wholly or partly immersed in a fluid. This upward force is also called Upthrust. Due to the buoyant force, a body submerged partially or fully in a fluid appears to lose its weight, i.e. appears to be lighter.

Drag force: In fluid dynamics, drag (sometimes called fluid resistance) is a force acting opposite to the relative motion of any object moving with respect to a surrounding fluid. This can exist between two fluid layers (or surfaces) or between a fluid and a solid surface. Unlike other resistive forces, such as dry friction, which are nearly independent of velocity, the drag force depends on velocity. Drag force is proportional to the velocity for low-speed flow and the squared velocity for high speed flow, where the distinction between low and high speed is measured by the Reynolds number. Drag forces always tend to decrease fluid velocity relative to the solid object in the fluid's path.