Fundamentals of Clarification Technology

Fundamentals

In fundamentals of clarification technology we will discussed about Coagulation, flocculation and sedimentation phenomena.

Description

Clarification removes suspended matter from water. Surface waters require clarification because they have moderate to high levels of suspended matter. Well waters do not require clarification because they have low levels of suspended matter.

The suspended matter in water includes two kinds of particles:

- Settle-able Particles (macro-particles, typically visible to the eye)
- Non-Settle-able Particles (micro-particles, normally visible through a microscope)

Settle-able particles are particles in water that settle out over time. The water itself is clear, indicating an absence of suspended matter (turbidity). If non-settle-able particles had been in the water, the water would not be clear. This "turbidity" would have indicated the presence of non-settle-able particles. Turbidity is an indirect measurement of the amount of suspended matter (settle-able particles and on-settle-able particles) in water. Clarification uses chemicals and sedimentation to remove suspended matter (settle-able particles and non-settle-able particles). Several steps are involved.

First, coagulation destabilizes the particle surface charge that keeps the particles in solution. Once destabilized, the particles no longer repel one another and come together as floc.
Second, floc agglomerate into larger particles and Polymers are used to enhance the flocculation process.

Third, sedimentation causes agglomerated floc to settle out. The settled floc is collected and concentrated for discharge to waste, called clarifier blowdown, or recycled to the coagulation step, called sludge recycle. Clarified water is collected and flows out of the clarifier.

Coagulation

The first step of the clarification process is coagulation. Particles in water have a naturally occurring negative charge. This causes them to repel each other and stay in suspension. When this charge is destabilized, the particles no longer repel one another, and can come together in closer proximity. **A chemical salt, called a coagulant, is mixed with the inlet water to destabilize the charge**. Common coagulants are aluminum sulfate (alum), ferric sulfate, ferric chloride and organic coagulant. The coagulants provide a positive charge, in the form of metallic cations, that destabilize the natural negative charge of the particles. The metallic cations combine with hydroxide in the water to form a metallic hydroxide that is an insoluble compound. The destabilized particles and metal hydroxide precipitates agglomerate into small, visible particles called floc. Color, organic matter and colloids, including colloidal silica, are removed by becoming bound up in the floc. The precise mechanism for removal-absorption, adsorption, co-precipitation, or a combination-is not fully understood.

The addition of too much coagulant can cause the suspended matter to be re-dispersed with the opposite charge. The amount of removal is dependent upon the coagulant dosage and the pH.

Alum (aluminum sulfate), ferric sulfate, ferric chloride and organic coagulants are acidic salts and decrease the pH of the influent water. Because of this, the pH of the water must be adjusted with caustic (sodium hydroxide) or another alkaline (high pH chemical).The adjustment is to a pH of 5.5 to 6.5 and is done to achieve the lowest residual of suspended matter. Lime is used as the coagulant when the treatment objective is hardness reduction. The dosage depends on the desired operating pH of the clarifier. For the greatest removal of hardness, the pH range is 9.5 – 10.5. Feed of coagulant alone does not produce satisfactory floc in waters having a low suspended matter concentration. In this instance, bentonite clay is added. Bentonite clay creates an artificial base of settleable macroparticles that seed the growth of floc.

Polymers are added to reduce the amount of coagulant required, broaden the working pH range and create denser, heavier floc that settles out more easily. Polymers are long-chain organic compounds of high molecular weight that bridge floc particles together or modify their surface charge.

In almost all cases, the water to be treated is disinfected with either gaseous chlorine or sodium hypochlorite. This oxidizes organic matter in the water that has taste and odor and certain metals, such as manganese and iron. When oxidized, these constituents are transformed into a form that can be removed during clarification. Their removal is important because they can cause fouling of process components.

Coagulation is carried out in a fast mix chamber. Fast mix is required because the coagulant and water must be thoroughly mixed to allow the suspended matter and coagulant to come into contact with each other. If it is not fast mixed, some suspended matter may not come into contact with coagulant, the surface charge will not be destabilized and flocculation will not occur. As flocculated water flows into the slow mix chamber, polymer is added.

Flocculation

In the next step of clarification, the small floc (microfloc) is allowed to grow into larger floc, called macrofloc or agglomerated floc. This process, called flocculation. Flocculation is accomplished by gently stirring the coagulated water to assure contact between microfloc particles and polymer. The polymer enhances agglomerated floc formation. As the agglomerated floc continues to grow, it becomes denser and heavier, allowing it to settle. Mixing too rapidly can create what is called floc shear. Shear is the breaking apart of existing floc particles. The agglomerated floc, or macrofloc, is sheared back into microfloc.

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Sedimentation

The final step of the clarification process is sedimentation. In this step, agglomerated floc settles out to form sludge and the sludge is transported to the sludge concentration chamber by the scraper. The sludge thickening pickets concentrate the sludge. The sludge is discharged to waste in a process called clarifier blowdown. Above the sludge, clarified water is collected in the outlet launder and flows forward for use or further treatment.