TRIFLOC

Waste water contains solids as:

1. Dissolved Solids
2. Colloidal Solids
3. Suspended solids

Dissolved solids:

- They are electrically charged and can interact with the water, so they are completely stable and will never settle out of the water.
- Chemicals in solution are not visible, either using the naked eye or using a microscope, and are less than 1 mµ in size. (1 mµ or mili-micron is equal to 0.000000039 inches.)

Colloidal Solids:

- They do not dissolve in water although they are electrically charged.
- Still, the particles are so small that they will not settle out of the water even after several years and they cannot be removed by filtration alone.
- Colloidal solids range between 1 and 500 mµ in size and can be seen only with a high-powered microscope.
- Examples include bacteria, fine clays, and silts.
- Colloidal solids often cause colored water, such as the "tea color" of swamp water.

Suspended Solids:

- They will settle out of water over time, though this may be so slow that it is impractical to merely allow the particles to settle out in a water treatment plant.
- The particles are more than 1,000 mµ in size and can be seen with a microscope or, sometimes, with the naked eye. Examples of suspended solids include sand and heavy silts.
- The chemistry of coagulation and flocculation is primarily based on electricity.
- Electricity is the behavior of negative and positively charged particles due to their attraction and repulsion.
- Like charges (two negatively charged particles or two positively charged particles) repel each other while opposite charges (a positively charged particle and a negatively charged particle) attract.
- Most particles dissolved in water have a negative charge, so they tend to repel each other.
- As a result, they stay dispersed and dissolved or colloidal in the water.

INTRODUCTION

- The purpose of most coagulant chemicals is to neutralize the negative charges on the turbidity particles to prevent those particles from repelling each other.
- The amount of coagulant which should be added to the water will depend on the zeta potential, a measurement of the magnitude of electrical charge surrounding the colloidal particles.
- You can think of the **zeta potential** as the amount of repulsive force which keeps the particles in the water.
- If the zeta potential is large, then more coagulants will be needed.
- Coagulants tend to be positively charged.
- Due to their positive charge, they are attracted to the negative particles in the water.
- The combination of positive and negative charges results in a neutral, or lack of charge.
- As a result, the particles no longer repel each other.
- The next force which will affect the particles is known as **Van der Waal's forces.**
- Van der Waal's forces refer to the tendency of particles in nature to attract each other weakly if they have no charge.
- Once the particles in water are not repelling each other, Van der Waal's forces make the particles drift toward each other and join together into a group.
- When enough particles have joined together, they become floc and will settle out of the water.

Coagulant chemicals come in two main types - primary coagulants and coagulant aids.

- Primary coagulants neutralize the electrical charges of particles in the water which causes the particles to clump together.

- Coagulant aids add density to slow-settling flocs and add toughness to the flocs so that they will not break up during the mixing and settling processes.
- Primary coagulants are always used in the coagulation - flocculation process.
- Coagulant aids, in contrast, are not always required and are generally used to reduce flocculation time.
- Chemically, coagulant chemicals are either metallic salts (such as alum) or polymers.
- Polymers are man-made organic compounds made up of a long chain of smaller molecules.
- Polymers can be either cationic (positively charged), anionic (negatively charged), or nonionic (neutrally charged.)

The table below shows many of the common coagulant chemicals and lists whether they are used as primary coagulants or as coagulant aids.

Different sources of water need different coagulants

Chemical Name	Chemical Formula	Primary Coagulant	Coagulant Aid
Aluminum Sulfate (Alum)	$Al_2(SO_4)_3 \cdot 14\ H_2O$	√	
Ferrous Sulfate	$FeSO_4 \cdot 7\ H_2O$	√	
Ferric Sulfate	$Fe_2\,(SO_4)_3 \cdot 9\ H_2O$	√	
Ferric Chloride	$FeCl_3 \cdot 6\ H_2O$	√	
Cationic Polymer	Various	√	√
Calcium Hydroxide (Lime)	$Ca(OH)_2$	√	√
Calcium Oxide (Quicklime)	CaO	√	√
Sodium Aluminate	$Na_2Al_2O_4$	√	√
Bentonite	Clay		√
Calcium Carbonate	$CaCO_3$		√
Sodium Silicate	Na_2SiO_3		√
Anionic Polymer	Various		√
Nonionic Polymer	Various		√
***Used as a primary coagulant only in water softening processes.**			

- In a well-run water treatment plant, adjustments are often necessary in order to maximize the coagulation / flocculation process.
- These adjustments are a reaction to changes in the raw water entering the plant.
- Coagulation will be affected by changes in the water's pH, alkalinity, temperature, time, velocity and zeta potential.
- The effectiveness of a coagulant is generally pH dependent.
- Water with a color will coagulate better at low pH (4.4-6) with alum.
- Alkalinity is needed to provide anions, such as (OH) for forming insoluble compounds to precipitate them out.
- It could be naturally present in the water or needed to be added as hydroxides, carbonates, or bicarbonates.
- Generally 1 part alum uses 0.5 parts alkalinity for proper coagulation.
- The higher is the temperature, the faster the reaction, and the more effective the coagulation.
- Winter temperature will slow down the reaction rate, which can be helped by an extended detention time.
- Mostly, it is naturally provided due to lower water demand in winter.
- Time is an important factor as well.
- Proper mixing and detention times are very important to coagulation.
- The higher velocity causes the shearing or breaking of floc particles and lower velocity will let them settle in the flocculation basins.
- Velocity around 1 ft /sec in the flocculation basins should be maintained.
- Zeta potential is the charge at the boundary of the colloidal turbidity particle and the surrounding water.
- The higher the charge the more is the repulsion between the turbidity particles, less the coagulation, and vice versa.
- Higher zeta potential requires the higher coagulant dose.
- An effective coagulation is aimed at reducing zeta potential charge to almost 0.

Coagulant

- The proper type and concentration of coagulant are essential to the coagulation process.
- The coagulant choice will depend on the conditions at the plant.
- The concentration of coagulant also depends on the water conditions, and a jar test can be used to determine the correct concentration to use at any given time.
- Coagulants are usually fed into the water using a gravimetric feeder or a metering pump.
- A gravimetric feeder feeds dry chemicals into the water by weight.
- A metering pump feeds a wet solution (a liquid) into the water by pumping a volume of solution with each stroke or rotation.

Improper coagulation related to coagulant may result from:

1. Using old chemicals
2. Using the wrong coagulant
3. Using the wrong concentration of coagulant.

This may result from setting the wrong feed rate on the gravimetric feeder or metering pump or from a malfunction of the equipment.

Alum, Ferrous sulfate, ferric salts cause Alzheimer's disease.

- The high concentration of aluminum is also of concern because of potential adverse health effects.
- Aluminum intake into the body has been linked with several possible neuro pathological diseases including presenile dementia and Alzheimer's disease (Crapper *et al*., 1973; Alfrey *et al*., 1976; Martyn *et al*., 1989; Flaten, 2001).

Hence the need for biodegradable polymers:

- Chitosan is a linear copolymer of D-glucosamine and N-acetyl-D-glucosamine produced by the deacetylation of chitin, a natural polymer of major importance (Roberts, 1992; Kurita, 2006).
- Chitin is the second most abundant biopolymer in the world, after cellulose.
- The main sources exploited are two marine crustaceans, shrimps and crabs.
- Chitosan has unique properties among biopolymers especially due to the presence of primary amino groups and it is a commercially interesting compound because of its high nitrogen content in comparison to cellulose. (Roberts, 1992).
- The main parameters influencing the characteristics and properties of chitosan is its molecular weight (MW), degree of deacetylation (DD), representing the molar fraction of deacetylated units, and crystallinity.
- These parameters are determined by the conditions set during preparation (Kurita, 2006; Rinaudo, 2006).
- Many Researchers have used chitosan as a coagulant and flocculent in water as well as wastewater treatment (Meyssami, 2005; Haw *et al*., 2006; Rizzo *et al*., 2008; Droppo, 2008; Renault, 2009).
- High content of amine group in chitosan provides cationic charge at acidic pH and can destabilize colloidal suspension to promote the growth of large coarse floc which can settle rapidly (Roussy, 2005).
- Also it has long chain polymer with positive charges at natural water pH, can effectively coagulate natural particulates and colloidal materials, which are negatively charged, by adsorption, charge neutralization, interparticle bridging as well as hydrophobic flocculation (Li, 2005)

TRIFLOC successfully flocculates the anionic suspended particles and reduce the COD and turbidity in industrial wastewaters.

NOVEL FEATURES OF TRIFLOC:

- Enhances filtration process.
- Separates many kinds of particles from water.
- Simplicity and cost-effectiveness.
- Biodegradable.

In optimum conditions like neutral pH, 3.5-7.5 minutes of rapid agitation at 300 rpm, slow agitation at 40 rpm for about 30-45 minutes, 45-90 minutes of settling time, **TRIFLOC** at a dose level of 1.5-2.5 mg / L can result in about 65-75% COD Reduction and 85-95% turbidity reduction.

For Better Results: Alum may be used @ 5 mg / L

TRIFLOC contains:

1. Herbal extracts
2. Biopolymer
3. Polyacrylamide
4. Ferric Chloride

Store in a cool & dry place away from sunlight.

Method of Analysis:

Jar Test
(**Adapted from TRIPATHY and DE 2006**)

- The jar test is used to identify the most adapted mix of chemical compounds and concentrations for coagulation-flocculation.
- It is a batch test consisting of using several identical jars containing the same volume and concentration of feed, which are charged simultaneously with six different doses of a potentially effective coagulant.
- The six jars can be stirred simultaneously at known speeds.
- The treated feed samples are mixed rapidly and then slowly and then allowed to settle.
- These three stages are an approximation of the sequences based on the large-scale plants of rapid mix, coagulation flocculation and settling basins.
- At the end of the settling period, test samples are drawn from the jars and turbidity of supernatant liquid is measured.
- A plot of turbidity against coagulant dose gives an indication of the optimum dosage (i.e. the minimum amount required to give acceptable clarification).
- The criteria thus obtained from a bench jar test are the quality of resultant floc and the clarity of the supernatant liquid after settling.
- The design of the full-scale plant process is then done based on the bench-scale selection of chemicals and their concentrations.

Unfortunately, the jar test suffers from a number of disadvantages, despite its widespread application.
It is a batch test, which can be very time-consuming and the results obtained from a series of jar tests might not correspond to the results obtained on a full-scale plant.

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