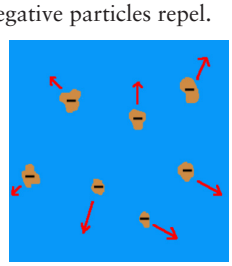
What Every Operator Needs to Know About Chemically Enhanced Primary Treatment

Dick Finger and Henryk Melcer

Knowledge	Principles	Practical Considerations
Primary sedimentation is a cost-effective process for removing contaminants and reducing secondary loading.	This process removes settleable solids by allowing them to settle out under quiescent conditions.	Factors affecting primary clarifier performance include • wastewater characteristics, • clarifier geometry, • clarifier flow rate/surface overflow rate/solids loading rate, • clarifier depth, • inlet and outlet conditions, • proportion of settleable solids in the influent, • settling rate of the settleable solids, and • wastewater temperature.
Chemically enhanced primary treatment (CEPT) can improve removal of settleable solids and biochemical oxygen demand (BOD).	CEPT uses chemical addition to modify wastewater characteristics and improve the performance of the primary clarification process.	Potential effects of CEPT include • increased settling rates of the existing settleable solids; • consolidation of the solids so they settle more rapidly; • incorporation of slowly settling settleable solids into the solids floc, thus improving removal; • incorporation of colloidal solids into the settleable solids, thus increasing solids/BOD removal; and • potentially adsorbing some dissolved solids into the settleable solids, thus further improving BOD removal.
The addition of chemicals involves two mechanisms that are part of the process of CEPT: coagulation and flocculation.	During coagulation, the coagulant chemical neutralizes the electrical charges of the fine particles in the water, so that the particles no longer repel each other and induce the particles. This enables the particles to come closer together and form small floc particles. During flocculation, a process of gentle mixing brings the fine particles and flocs formed by coagulation into contact with each other.	Steps in Coagulation Negative particles repel. 

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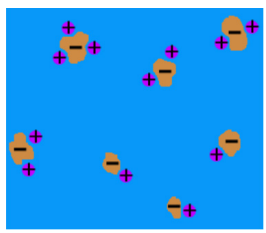
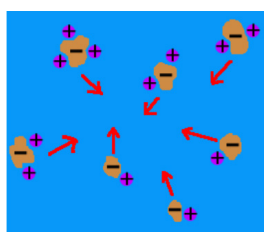
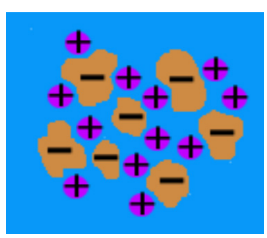
The addition of chemicals involves two mechanisms that are part of the process of CEPT: coagulation and flocculation. *(continued)*	The addition of a flocculant (usually polymer) during flocculation serves to gather together the small flocs through bridging mechanisms, increasing the size of the floc particles and strengthening them.	Positive coagulant neutralizes charge.  Neutral particles attract.  Particles join to form a floc. 
Several different chemicals can be used for CEPT.	Chemical-selection drivers include cost, corrosivity, effluent wastewater characteristics, availability and reliability of supply, and solids-disposal capacity.	The primary chemicals used for CEPT are aluminum salts, iron salts, and polymer.
Testing is needed to choose the right chemical and dose for CEPT.	Operators often use bench-scale testing (jar testing) to evaluate dosages and chemicals for CEPT.	Optimal chemical choice and chemical dosages can vary over time.
Typical CEPT chemicals and application rates	There are three primary aluminum salts. They are • alum, $Al_2(SO_4)_3 \cdot 14\ H_2O$ (pH 1.9 – 2.3); • sodium aluminate, $Na_2Al_2O_4$ (pH 12); and • polyaluminum chlorides (pH 0.5 – 4.4). Two iron salts are common: • ferric chloride, $FeCl_3 \cdot 6\ H_2O$ (pH < 2), and • ferric sulfate, $Fe_2(SO_4)_3 \cdot 9\ H_2O$ (pH < 1) Either anionic or cationic polymers can be used for CEPT.	Aluminum salts must be dosed to achieve 5 to 12 mg/L of aluminum. This means about 5 to 130 mg/L of alum would be dosed. Iron salts should be dosed to between 10 and 20 mg/L as iron. This is about 30 to 50 mg/L of ferric chloride. Polymer should be dosed at 0.25 to 2 mg/L as active polymer.

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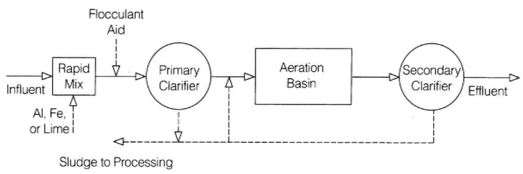
The equipment needed to implement CEPT falls into three categories: chemical dosing, mixing, and settling or flocculation.	For chemical handling and dosing, operators need chemical storage, chemical feeders, and chemical diffusers. Operators also need rapid mixing equipment. After thorough mixing, they need time and areas for the solids to settle and the ability to remove the accumulated solids.	This simple process schematic shows all aspects of CEPT.  The rapid mixing can be performed by mechanical mixer, energy gradient such as a Parshall flume, in-line mixers, or an air sparger. Ideally, the flocculation area will have a baffled tank, tank with low-speed mixer, tank with a turbine mixer, or aerated channel.
CEPT affects downstream solids pumping and handling.	CEPT will increase the mass of settled solids in the primary clarifier. Pumping and downstream facilities need to be sized for the additional load. Increased solids result from better capture and added chemical floc.	An increase in solids from alum addition can be in the range of 30% to 40%. An increase in solids from ferric chloride addition can be in the range of 45% to 55%.
CEPT can greatly increase the removal of wastewater pollutants.	CEPT is well-suited to improve removal of total suspended solids, BOD, and phosphorus.	Conventional primary treatment removes • 30% to 70% total suspended solids (TSS), • 35% to 40% BOD, and • 5% to 10% phosphorus. CEPT removes • 60% to 90% TSS, • 40% to 70% BOD, and • 70% to 90% phosphorus. These estimates come from *Wastewater Engineering: Treatment and Reuse, 4th Edition* by Metcalf & Eddy, published in 2003 by McGraw-Hill.
CEPT systems come with their own set of operations and maintenance (O&M) issues.	Operators should expect such O&M issues with any chemical equipment system. Typical life expectancy for CEPT systems is approximately 10 years.	Because CEPT systems use chemicals, they require additional training and safety equipment. Chemical costs can be significant. Polymer solutions deteriorate rapidly when diluted and must be used quickly. Optimal dosing rates change over time, thus requiring periodic testing to achieve cost-effective results. Alkalinity adjustment may be required at high flows in low-alkalinity wastewater. Increased solids production due to improved capture and chemical precipitates requires added solids-processing capacity.

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