# An Introduction to Chemically Enhanced Primary Treatment

## Introduction

Chemically Enhanced Primary Treatment (CEPT) is the process by which chemicals, typically metal salts and/or polymers in the form of organic polyelectrolytes, are added to primary sedimentation basins. The chemicals cause the suspended particles to clump together via the processes of coagulation and flocculation. The particle aggregates, or flocs, settle faster thereby enhancing treatment efficiency, measured as removal of solids, organic matter and nutrients from the wastewater. The chemicals utilized in CEPT are the same ones commonly added in potable water treatment (e. g. ferric chloride, aluminum sulfate), and there are practically no residual metals in the supernatant (Harleman and Murcott, 1992).

CEPT may be implemented using a dedicated "CEPT tank" (i. e. a settling tank specially designed for CEPT), or by retrofitting a conventional primary treatment facility, or stabilization ponds (Ødegaard et al., 1987; Hanaeus, 1991a,b,c). The later two incarnations of CEPT are relevant when upgrading overloaded or underdesigned existing systems (Harleman and Murcott, 1992).

CEPT has many important advantages over conventional treatment. It offers a cheaper, simpler and more efficient alternative to conventional treatment, as is discussed in the following sections. Most importantly, it is the least expensive wastewater treatment process in which the effluent can be effectively disinfected.

## Financial Benefits of CEPT

CEPT allows the sedimentation basins to operate at higher overflow rates, while still maintaining a high removal rates of total suspended solids (TSS) and biochemical oxygen demand (BOD). Hence the treatment infrastructure can be smaller, which reduces capital costs. Additionally, CEPT provides the opportunity for either reducing the size of subsequent treatment units, or increasing the capacity of existing conventional treatment plants, such as activated sludge basins. The addition of metal salts and/or a polymer will only

require tanks for the chemicals and injection equipment. Table 1 presents data comparing the costs of primary treatment, secondary biological treatment, and chemically enhanced primary treatment.

Table 1: Comparison of Treatment Costs (National Research Council, 1992)

| | Capital Costs ($\$/10^3 m^3.d^{-1}$) | O&M Costs ($\$/10^6 m^3$) | Total Costs ($\$/10^6 m^3$) |
|---|---|---|---|
| Conventional Primary Treatment | 3.1 — 4.2 | 0.8 — 0.9 | 1.7 — 2.1 |
| Conventional Primary + Biological Secondary Treatment | 9.1 — 9.8 | 1.2 — 1.6 | 3.5 — 4.3 |
| Chemically Enhanced Primary Treatment | 4.2 — 5.3 | 0.9 — 1.1 | 2.1 — 2.6 |

CEPT costs minimally more than primary treatment, and only about half as much as secondary treatment. Yet, the removal efficiencies show CEPTs superiority, as discussed in the next section.

# Efficiency of CEPT

Table 2 illustrates how CEPT enhances the removal of TSS and its associated BOD, through chemical coagulation and flocculation, followed by settling of the floc. The data, based on a survey of 100 wastewater treatment plants in the United States, show CEPTs superior efficiencies over conventional primary treatment. Moreover, when combined with the cost analysis presented in Table 1, it can be said that CEPT is highly competitive with biological secondary treatment.

CEPT is ideal for a coastal city since the removal of TSS is very high and the decrease in BOD is sufficient so as to not impact oxygen concentrations in the ocean. This is the case in two of the largest operating CEPT facilities in the world (San Diego and Hong Kong). Hong Kong's Stone Cutter's Island plant also benefits from increased performance due to seawater addition (Harleman et al., 1997).

CEPT is also appropriate for in-land wastewater facilities, and is utilized for phosphorus removal by a number of facilities discharging their effluent into the Great Lakes (Harleman and Murcott, 1992). Indeed, while biological secondary treatment removes TSS and BOD at a very high efficiency, it does not effectively remove phosphorus and produces nitrates (Harleman and Morrissey, 1992). If this effluent does not undergo nutrient removal before it is released into a body of water, eutrophication can occur. The algal blooms often accompanying this kind of nutrient loading deprive the water body of oxygen, which is equivalent releasing a high-BOD effluent into that body of water. CEPT effectively removes a high amount of phosphorus, which is usually the limiting nutrient in fresh water systems.

Finally, in developing countries, the primary objective of any sanitation system is disinfection, due to the high levels of morbidity incurred by water-borne illnesses. CEPT is the least expensive method of treatment in which the effluent can be appropriately disinfected (Harleman and Murcott, 2001b,a).

Table 2: Comparison of Removal Efficiencies (National Research Council, 1992)

| | TSS (%) | BOD (%) | TP (%) | TN[1] (%) | FOG[2] (%) |
|---|---|---|---|---|---|
| Conventional Primary Treatment | 55 | 35 | 20 | 15 | 51 |
| Conventional Primary + Biological Secondary Treatment | 91 | 85 | 30 | 31 | 98 |
| Chemically Enhanced Primary Treatment | 85 | 57 | 85 | 37 | 71 |

# Ease of Implementation

A conventional primary treatment process consists of bar screens, a grit chamber, and a settling tank (or primary clarifier) (see Figure 1). To upgrade a conventional primary treatment facility to a CEPT facility, all that is needed is the addition of a chemical coagulant (and optionally a flocculent) as shown in Figure 1. With CEPTs high surface overflow rate, the sedimentation basins will not need to be large when compared to conventional primary sedimentation basins (Harleman et al., 1997).

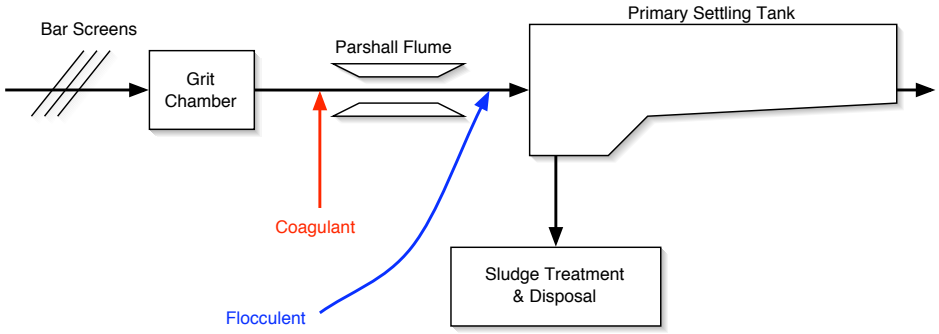


Figure 1: Schematic of Conventional Primary Treatment and CEPT

[1]Total Nitrogen
[2]Fats, Oils and Grease

# Conclusion

CEPT is an efficient, cost-effective and easily implemented wastewater treatment technology. The addition of chemical coagulants and/or polyelectrolytes allows for the increased removal of phosphorus, suspended solids and its associated biochemical oxygen demand. The increased removal efficiencies allow for the design of smaller basins and greater overflow rates.

CEPT has been used for over one hundred years, yet it is not as commonly found as would be expected upon analysis of its performance. The misconception is that CEPT dramatically increased sludge production. However, CEPT is used today with a minimal coagulant dosage (10 - 50 mg/L), and the chemicals themselves make only a slight contribution to the total sludge production. The greatest portion of the increase of sludge production is due to the increased solids removal in the settling tank. And that is precisely CEPT's goal.

CEPT treatment does not preclude secondary or tertiary treatment. It makes any subsequent treatment smaller and less costly due to the increased efficiency. CEPT is a relatively simple technology providing a low-cost and effective treatment, which is easily implemented over existing infrastructure (Harleman and Murcott, 1992, 2001b,a).

# References


J. Hanaeus. Chemical precipitation in ponds for wastewater treatment. *Vatten*, 47(2):108–116, 1991a.

J. Hanaeus. Sludge accumulation in ponds for wastewater treatment using alum precipitation. *Vatten*, 47(3):181–188, 1991b.

J. Hanaeus. *Wastewater Treatment by Chemical Precipitation in Ponds*. PhD thesis, Lulea University of Technology, 1991c.

D. R. F. Harleman, P. Harremöes, and Q. Yi. Hong Kong Harbor Cleanup: International panel reviews plans for treatment upgrade. *Water Environment & Technology*, pages 47–50, March 1997.

D. R. F. Harleman and S. P. Morrissey. Retrofitting conventional primary treatment plants for chemically enhanced primary treatment in the USA. In R. Klutie and H. Hahn, editors, *Chemical Water and Wastewater Treatment II*, 5th Gothenburg Symposium. Springer Verlag, Berlin, 1992.

D. R. F. Harleman and S. Murcott. CEPT: challenging the status quo. *Water 21*, pages 57–59, June 2001a.

D. R. F. Harleman and S. Murcott. An innovative approach to urban wastewater treatment in the developing world. *Water 21*, pages 44–48, June 2001b.

D. R. F. Harleman and S. E. Murcott. Upgrading and multi-stage development of municipal wastewater treatment plants: Applicability of chemically enhanced primary treatment. Technical report, World Bank, 1992.

National Research Council, editor. *Wastewater Management in Urban Coastal Areas*. National Academy Press, Washington D. C., 1992.

H. Ødegaard, P. Balmer, and J. Hanaeus. Chemical precipitation in highly loaded stabilization ponds in cold climates: Scandinavian experiences. *Water Science Technology*, 19(12): 71–77, 1987.