Outline of Treatment Process

Waste pretreatment at the Sauget P-Chem plant consists of screening of influent wastes on large steel bar racks, one of which is mechanically cleaned. Thereafter, floatables are removed from the surface of the inflow by a rope skimmer. Since the removal of oil is only partially complete at this point, additional skimming mechanisms are included throughout the plant process.

The headworks provide a limited opportunity for the blending of source waters, flow and concentration equalization, and neutralization. During wet weather, excessively high stormwater flows are diverted Into a 9 million gallon stormwater retention basin. Subsequently, this accumulation is added to the Sauget plant finished water.

Grit removal is achieved in a rectangular, aerated grit chamber. An inclined, continuous screw transports grit to a storage bin.

Since, despite blending in the headworks, the influent wastes are predominantly acid, additional neutralization is provided. Lime slurries are applied in three successive mixed neutralization compartments. Plant effluent water is monitored at the outlet so that finished water pH is maintained close to 8.3. From chemical solubility considerations, the addition of lime and the maintenance of this pH should result in the near-complete precipitation of metals, which form insoluble hydroxides. This would include copper, zinc and cadmium, the metals of principal concern in the present study.

**Influent Wastes**

**Solutia**

*Acids:* Sulfuric, Hydrochloric, Phosphoric, Formic
Ammonia, Aniline, Benzene, Xylene, Ethylene Glycol,
Methylethyl ketone, Methylisobutyl ketone,
Monochlorobenzene, Orthodichlorobenzene,
Orthonitrophenol, Paranitrophenol

**Cerro**

#2 Fuel Oil, Gasoline, Kerosene, Trichloroethylene

**Ethyl**

Gear, Crankcase Oil, Transmission Fluid, Benzene, Isobutylene

**Big River Zinc**

*Oxides:* Arsenic, Cadmium, Calcium, Manganese, Sodium
Zinc & Copper Sulfate, Sulfuric Acid, #2 Diesel Fuel, Gasoline, PCB
Potassium Permanganate, Soda Ash, Sodium Hydrosulfide, Strontium Carbonate

| | Municipal Wastewater | P-Chem Influent | P-Chem Effluent |
|---|---|---|---|
| Total Solids, mg/l | | | |
| Dissolved | 500 | - | |
| Suspended | 200 | 206 | 35 |
| BOD $_{5d,\ 20\ °C}$, mg O/l | 200 | 246 | 140 |
| COD, mg O/l | 500 | - | |
| TOC, mg C/l | 160 | - | |

| | Toxicity of Metals to Biological Waste Treatment | | P-Chem Effluent |
|---|---|---|---|
| | Carbonaceous | Nitrification | (5 year average) |
| Copper | 1.0 | 0.005 | 0.09 |
| Zinc | 0.8 | 0.08 | 0.43 |
| Nickel | 1.0 | 0.25 | 0.04 |
| Cyanide | 0.1 | 0.34 | - |
| Arsenic | 0.1 | - | - |
| Phenols | 200. | 4. | 1.7 |
| Cadmium | - | - | 0.01 |
| Chromium | - | - | 0.01 |
| Lead | - | - | 0.00 |
| Iron | - | - | 0.23 |

The removal of the metal precipitates is accomplished with the aid of a high molecular weight synthetic polymer coagulant. The polymer is dosed at between 1 to 3 ppm based on daily operational jar test results.

Rapid chemical mix occurs in the two flumes from the neutralization basin. On entering the north and south settling basins, flocculation is provided in three stages by redwood paddle flocculators. The energy input is tapered by reducing the number of paddles attached to each of the rotors. Since oil comes to the surface during the slow mix, oil is again skimmed from the surface of the flocculation compartment.

Each of the 0.9 mg flocculation-settling basins is designed for a flow of 13 mgd. At a flow of 4.1 mgd, the theoretical detention time is 11 hours in each basin. Sludge can be removed from sludge storage hoppers in the basins at a maximum rate of 400 gpm.

The settled wastewater exits the settling basins over serpentine v-notch weirs. Baffling is provided in front of the weirs to limit the escape of oil that accumulates on the surface. These floatables are raked to the front of the settling basin by the sludge raking mechanism. Rising solids, bubbles, the surfacing of oil, turbulence due to sludge raking and wind stirring may carry settled metal precipitates to the surface and over the effluent weir. In addition, since the influent waste may often contain cooling waters, temperatures are periodically high. This may lead to temperature-induced density currents in the settling tanks.

Composite samplers are used to obtain samples of plant effluent for copper, zinc and cadmium monitoring. In addition, monitoring is conducted for suspended solids, pH, and turbidity. Sludge samples are further tested for toxic compound leaching potential (TCLP). Membrane filtration of the composite samples indicated that the metals present were in the filterable or particulate form

Supplemental Analyses

As part of the present evaluation, samples were collected throughout the treatment process for dissolved oxygen. When oxygen depletion during treatment was confirmed by two separate daily samplings, additional analyses were conducted for the forms of nitrogen and alkalinity. This was to determine whether anoxic conditions in the bottom of the settling tanks were initiating anaerobic digestion of the sludge and the conversion of organic amines to ammonium ion and alkalinity.

Microscopic examination was also undertaken to both observe and quantify the number of organisms present at each stage of the treatment process. Organism populations were found to increase from influent to effluent. Despite their abundance, most of the organisms found in the effluent appeared to be undergoing autolysis. This was taken as an indication that they were strict anaerobes from the settled sludge that were stressed or dying from exposure to oxygen in the overlying water.

The P-Chem plant was designed for a flow of 26 mgd and has a 15 to 20 mgd rated output capacity. Each settling tank is designed for 13 mgd. Based on an annual average flow of 4 to 8 mgd, it appears that there is no hydraulic or process overload. Even though floc break-up may occur during rapid mix and flocculation, metals removals remain in the range of 80 to 90%.

Low flow conditions, on the other hand, result in the temporary removal of one of the two treatment trains from service. During these times, sludge stored in the idle settling tanks becomes anoxic and undergoes anaerobic decomposition. Sulfate reduction within the sludge blanket would be expected to produce sulfides that would further reduce metal solubility. If metals increase in the effluent from an idle tank when first returned to service, the increase may be related to hydraulic resuspension of the sludge or rising gas bubbles.

Because the growth of bacteria in the settling tank contributes to both suspended matter and turbidity measurements, both monitoring parameters indicate low solids removals that are poorly related to the higher metals removals.

Since the metal precipitates appear very dark in color, they can be visually distinguished from the whitish haze caused by bacterial growths. This characteristic may offer an avenue for operational monitoring. The color of the membrane used to filter plant effluent may be well related to total metals concentration. Zinc, at 0.43 mg Zn/l, and iron, at 0.23 mg Fe/l are the metals found in greatest abundance in the P-Chem plant effluent. Both may be present as precipitated sulfides.

Although enhanced coagulation, based on comprehensive jar test studies, offers the most promise for rapidly controlling excursions in the P-Chem plant effluent metals concentrations, effluent polishing is another avenue worthy of consideration. On a trial basis, tube or tray settlers may be placed around the effluent launders to observe improvements in settling efficiency and metals removals.

Although more costly and requiring more operational maintenance, microscreens placed in the effluent channels might provide consistent protection against metals excursions caused by upsets in the settling tank. Testing of microstrainers screens ranging from 15 to 60 µm would indicate the feasibility of microscreening.

Protein & Organic Acid Degradation

$$RCH\text{-}NH_2\text{-}COOH + 2\,H_2O \;\wedge\; NH_4^+ + HCO_3^-$$

Sulfate Reduction

$$CH_3COO^- + SO_4^{2-} \;\wedge\; 2\,HCO_3^- + HS^-$$