Sarnia • Lambton Environmental Association
Industries Working Together

Wastewater Treatment - Physical/Chemical

This monograph, one in a series of single issue documents dealing with Lambton County environment, has been prepared by the Sarnia-Lambton Environmental Association in co-operation with the School Boards of Lambton Kent.

Introduction

Fifty-six point sources discharge into the St. Clair River and its tributaries in Ontario and Michigan. These sources include thermal electric generating stations, industrial plants, petroleum refineries, pulp and paper producers, food processors and municipal wastewater treatment plants. The total discharges from these point sources is approximately 11,800,000 cubic metres of water per day*****. *RAP, Stage 1, page 9*

Most of this tremendous volume of water is used for once-through cooling processes. Thermal generating stations of electricity account for 80% of all cooling water use. Once-through cooling water generally requires no treatment before being returned to the river; however, wastewaters that have been associated with in-plant process operations, together with stormwater and ships' ballasts may require physical, chemical and/or biological treatment.

* 11,800,000 m^3/day
- approx. 3% of the St. Clair River's average daily flow
- approx. 200 times the average daily water flow through Lambton County's Drinking Water Plant.

Facts

The clarifier below, one of many designs, separates

Wastewater Sources	*Examples of Wastes Requiring Physical Treat-*
• municipal	-- domestic, storm runoff
• food processing	-- meat/vegetable trimmings
• petroleum refineries acids, bases	-- oil, grease, coagulents,
• petrochemical plants	-- acids, bases, suspended

Key Words

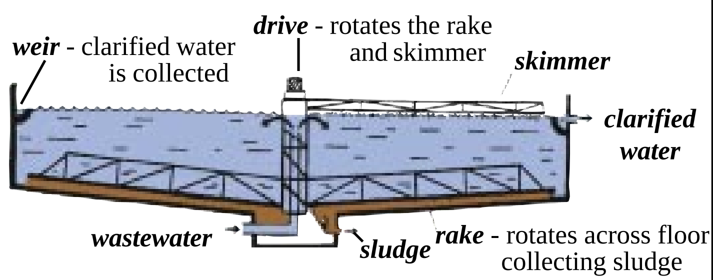
adsorption - is the grouping together of molecules on the surface of a solid or liquid; such "groupings" are the result of attractive forces between molecules

clarification - clarifiers are designed to efficiently remove undissolved substances from wastewater; removal is dependent upon density differences and is often enhanced by chemical means

point source - a discharge source that is distinct, identifiable and measurable such as a discharge pipe from an industrial plant or from a municipal wastewater treatment plant

Physical and Chemical Methods are Used to Separate Wastes from Water

Clarifiers Remove Undissolved Substances



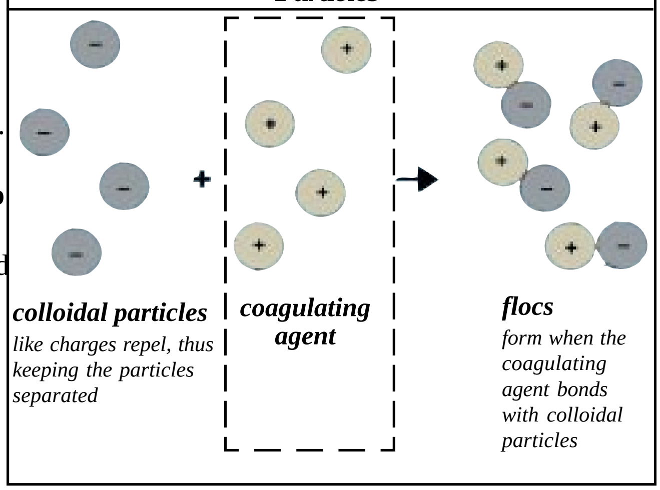
Clarification

Clarifiers are tank-like structures that may be either circular or rectangular in shape. **When wastewaters enter these treatment areas denser undissolved substances settle out,** others rise to the surface. A scraper (rake) moves across the bottom of the clarifier; settled matter (sludge) is moved to a collection area. A skimmer moves across the water's surface collecting floating material.

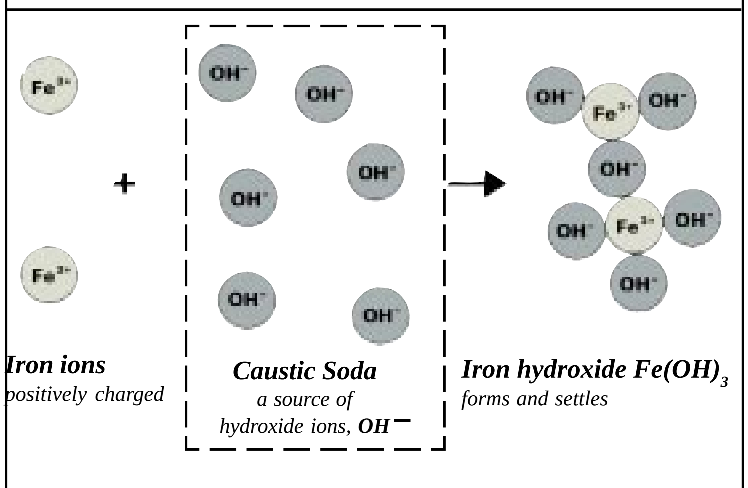
Coagulation

Wastes that are removed by this process are classed as suspended or colloidal. Colloids consist of small particles that are constantly moving; because of size and motion, gravity does not cause them to settle out. **Coagulating agents, eg. alum and ferric chloride, reduce the effects of electrical charges which keep the particles of waste separate from each other.** The particles then join together to form masses called flocs. These flocs then rise to the surface or settle to the bottom. Flocculating agents are frequently used to bond flocs together - this speeds the rate at which they rise to the surface or settle to the bottom.

Coagulating Agents Aid In Removal Of Small Particles



Precipitation Removes Heavy Metal Ions



Precipitation

Lime and caustic soda are common sources of hydroxide (OH^-) ions. OH^- ions combine with ions of some metals to form insoluble metal hydroxides (precipitation). **Precipitated metals settle out and thus are removed from the water;** adsorption, using activated carbon, improves this separation process.

Iron is one of many metals which is commonly removed in this way.

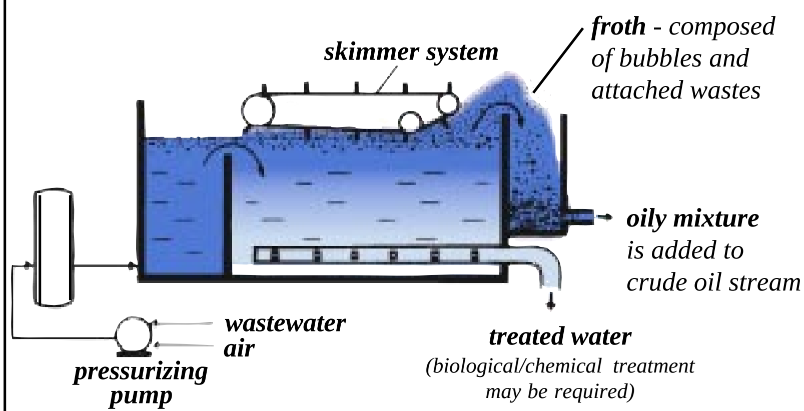
(see Monograph W5)

Physical and Chemical Methods are Used to Separate Wastes from Water

Air Flotation

This treatment usually follows oil-water separation. Wastewater is pressurized to 3-5 times normal atmospheric pressure in the presence of air to produce a saturated air-water solution. When this solution is released to normal pressure in the flotation unit, tiny air bubbles form throughout the liquid; the same effect is observed when a bottle of pop is opened. **As the air bubbles form they become attached to tiny oil droplets and to suspended particles; a froth of bubbles and attached wastes rises to the surface** and is skimmed off.

Flotation Removes Traces of Suspended Particles, Oil & Grease

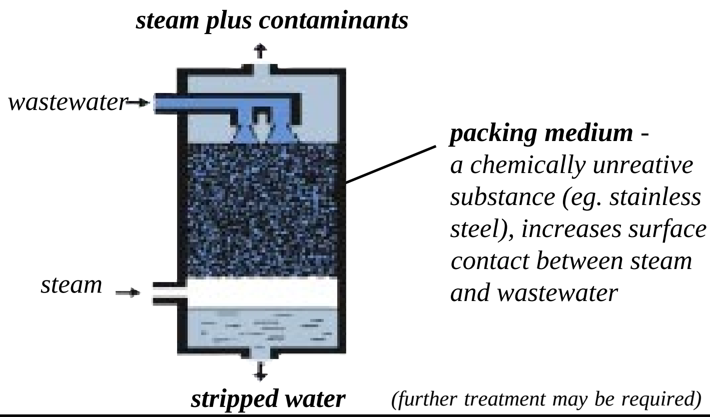


Stripping

As steam rises through the column it removes (strips) contaminants from wastewater that is moving in the opposite direction. Hydrogen sulphide and ammonia are two contaminants that are stripped from refinery wastes.

Methods that are used to recover contaminants from the flow of steam (as it exits from the stripper) include condensation/vacuum recovery systems, biox and incineration.

Steam Serves As A Stripping Agent

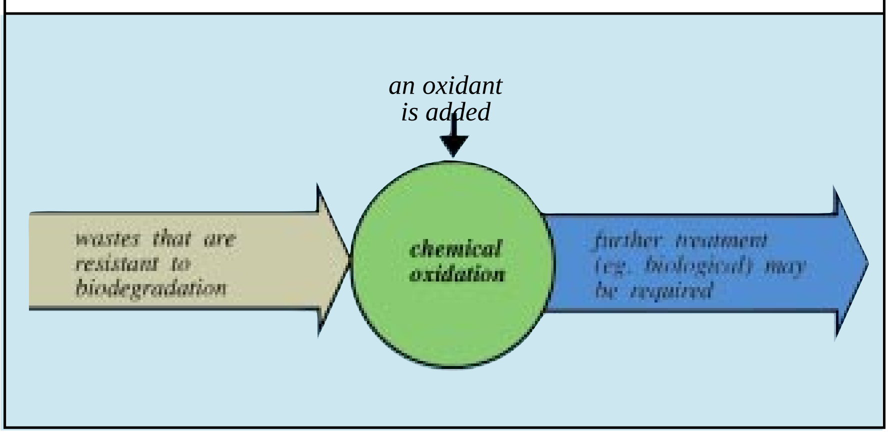


Oxidation

Common oxidizing agents, in addition to oxygen, are chlorine, ozone, hydrogen peroxide and potassium permanganate. These substances oxidize wastes to make them more biodegradable and/or more readily removed by adsorption.

Oxidation can be enhanced through control of pH and also through using catalysts.

Non-biodegradable Wastes Can Be Oxidized

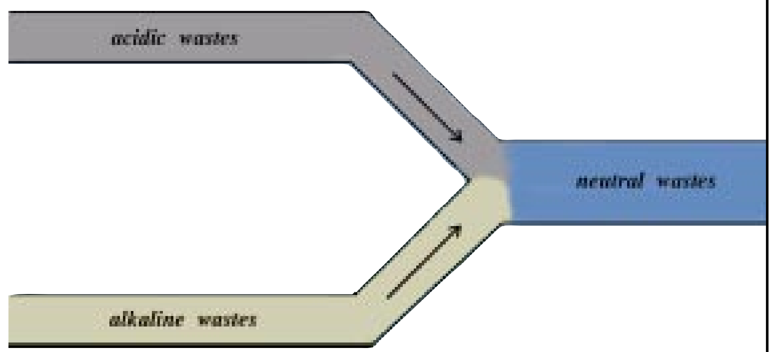


Physical and Chemical Methods are Used to Separate Wastes from Water

Neutralization

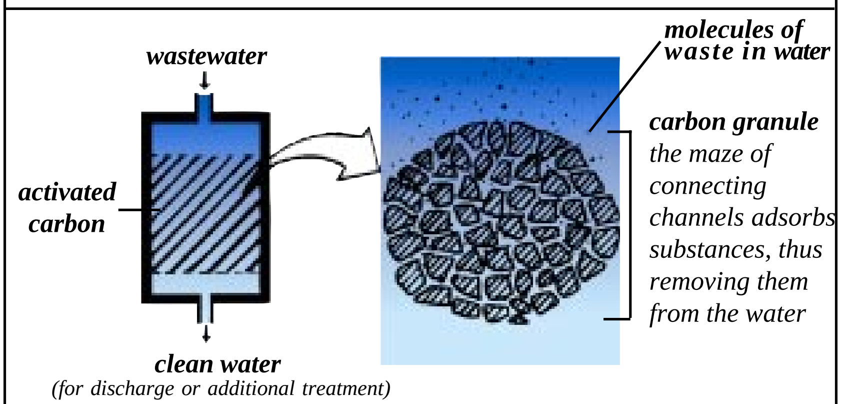
Blending acidic and basic wastes is a function of most equalization systems. This action (neutralization) is essential before wastes are directed to biological treatment processes where microorganisms feed on organic substances. Extreme changes in pH often kill microorganisms.

Blending of Wastes Reduces Use of Chemical Neutralizers



Adsorption

Carbon, highly porous, adsorbs many substances



Activated carbons are highly porous; they contain mazes of intercon-necting channels. **An imbalance of molecular forces in the walls attracts many substances; these are physically held (adsorbed) by the carbon surfaces.** After much use, the carbon may be re-generated and used again.

Effective adsorption of contaminants requires a large surface area. Typically, a handfull of activated carbon has a total surface area comparable to that of 10 football fields.

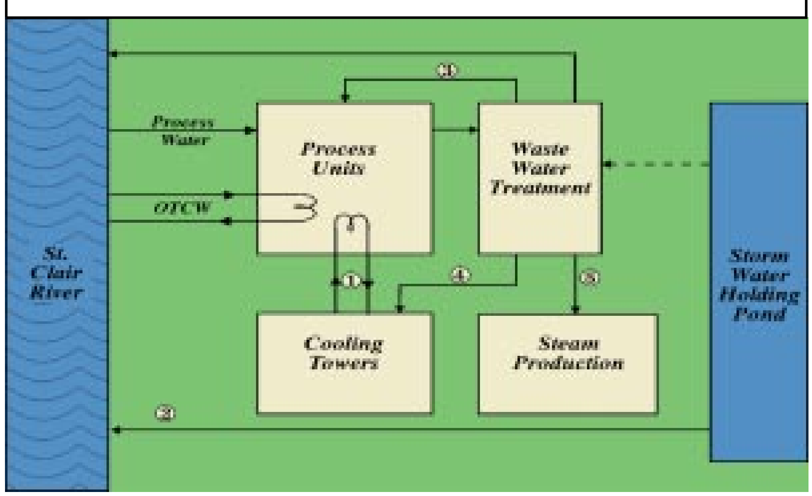
Wastewater Reduction

Reductions in wastewater production almost always result in decreased amounts of wastes that enter the river. Typical reductions include:

1. replacing once-through cooling water (OTCW) with water that has been recirculated through cooling towers
2. keeping clean stormwater separate from wastewater that requires treatment

3, 4, 5. reusing treated wastewater eg. in process units; in cooling towers; as feed water for boilers.

Possibilities for Reduction



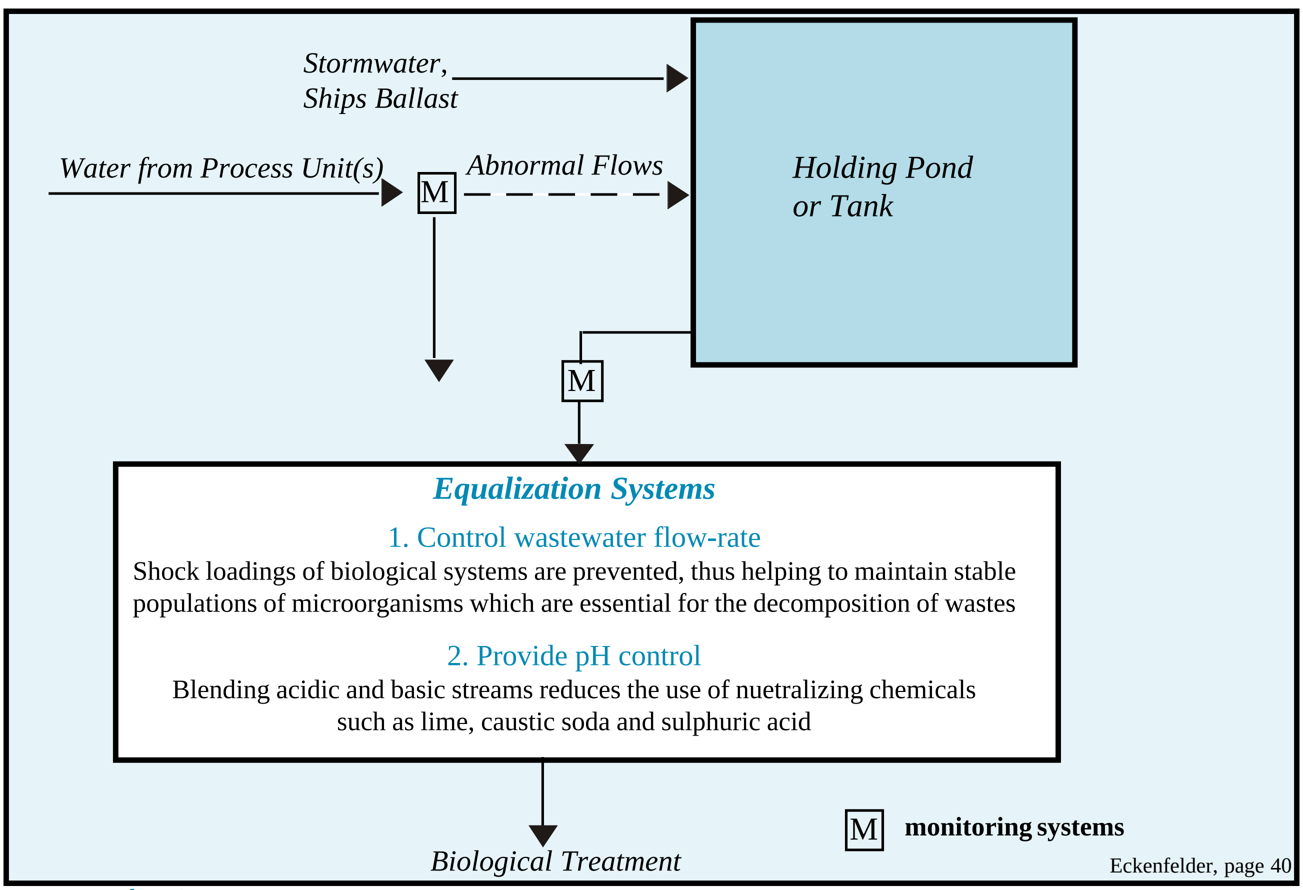
Biological Treatment of Wastes

Microorganisms in aquatic systems feed on dissolved/suspended organic matter; their digestive processes decompose organic wastes. Oxygen is consumed during these decomposition processes thus decreasing the supply of dissolved oxygen in the water. If the rate of decomposition is excessive, the resultant oxygen depletion produces stresses on aquatic organisms. Biological (secondary) treatment systems address problems associated with biochemical oxygen demand. **Break-down of wastes is transferred from natural waterways to lagoons and/or vessels where conditions can be controlled and therefore decomposition occurs efficiently.** Biological treatment is simply a concentrated, controlled, application of a natural process.

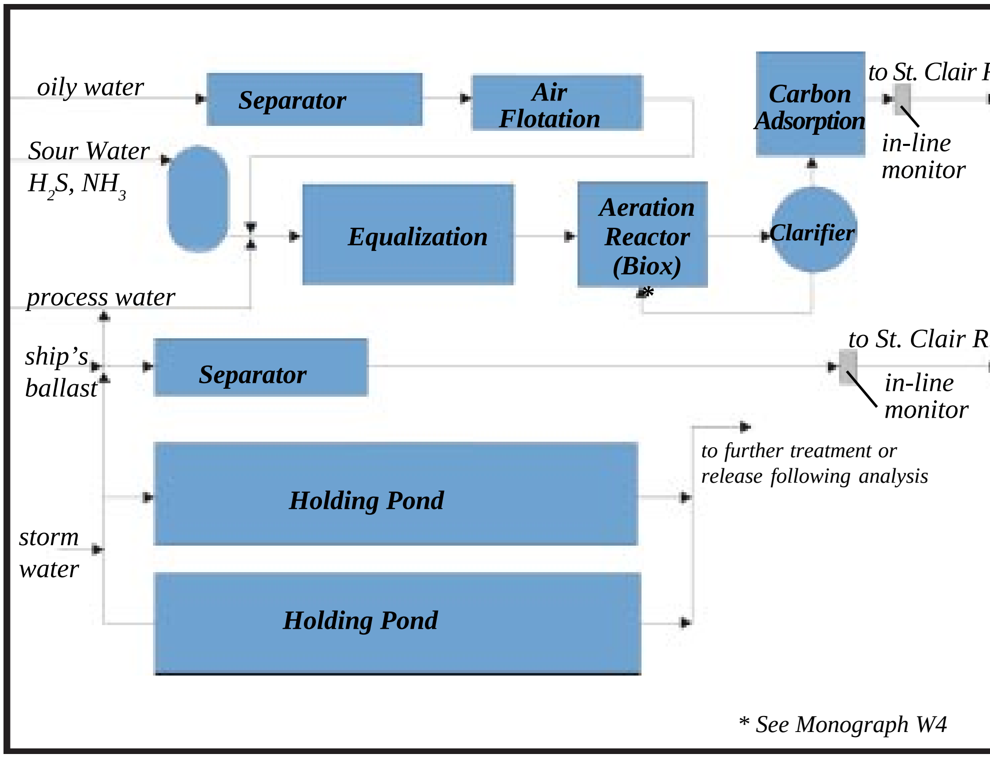
See Monograph W4

Equalization

Equalization systems contain large reservoirs together with piping and treatment processes. **These systems minimize fluctuations in wastewater flows and thus give stability, ensuring that wastewater treatment is carried out under the best possible conditions.**



Simplified Schematic For Treatment of Industrial Wastewater



If problems occur in any area of treatment, the wastewater is directed to a holding pond to permit corrective action.

When analyses show that waste treatment has been successfully completed, the treated water is released to the river.

Conclusion

Many forms of wastewater treatment are possible; choosing the best combination of pollution prevention and treatment techniques for each situation is challenging.

Resources

Eckenfelder, W. Wesley, 1989, Water Resources and Environmental Engineering

Lambton College of Applied Arts & Tech, 1992, Refinery Wastewater Effluent Treatment Training Manual

Manahan, Stanley E., 1991, Environmental Chemistry

Air & Waste Management Association, 1992, Air Pollution Engineering Manual

Ontario Ministry of Environment (MOE) / Michigan Dept. of Natural Resources, St. Clair River Remedial Action Plan (RAP) Stage I, 1991 and Stage II, 1994

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