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**Environmental Pollution**

**9<sup>th</sup> Lecture**

**Thermal pollution**

## Thermal pollution

Sometimes called "**thermal enrichment**", is the degradation of water quality by any process that changes ambient water temperature. Thermal pollution is the rise or drop in the temperature of a natural body of water caused by human influence. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers.

When water used as a coolant is returned to the natural environment at a higher temperature, the sudden change in temperature decreases oxygen supply and affects ecosystem composition. Fish and other organisms adapted to particular temperature range can be killed by an abrupt change in water temperature (either a rapid increase or decrease) known as "thermal shock". Elevated water temperatures decrease oxygen levels, which can kill fish and alter food chain composition, reduce species biodiversity.

## Sources and control of thermal pollution



Cooling tower at Gustav Knepper Power Station, Germany

### 1- Industrial wastewater

In the United States about 75 to 80 percent of thermal pollution is generated by power plants. The remainder is from industrial sources such as petroleum refineries, pulp and paper mills, chemical plants, steel mills and smelters.

Heated water from these sources may be controlled with:

- a- cooling ponds, man-made bodies of water designed for cooling by evaporation, convection, and radiation

b- cooling towers, which transfer waste heat to the atmosphere through evaporation and/or heat transfer

c- cogeneration, a process where waste heat is recycled for domestic and/or industrial heating purposes.

Converting facilities from once-through cooling to closed-loop systems can significantly decrease the thermal pollution emitted. These systems release water at a temperature more comparable to the natural environment.

## 2- Reservoirs

As water stratifies within man-made dams, the temperature at the bottom drops dramatically. Many dams are constructed to release this cold water from the bottom into the natural systems. This may be mitigated by designing the dam to release warmer surface waters instead of the colder water at the bottom of the reservoir.



A bioretention cell for treating urban runoff in California

## 3- Urban runoff

During warm weather, urban runoff can have significant thermal impacts on small streams. As storm water passes over hot rooftops, parking lots, roads and sidewalks it absorbs some of the heat, an effect of the urban heat island. Storm water management facilities that absorb runoff or direct it into groundwater, such as bioretention systems and infiltration basins, reduce these thermal effects by allowing the water more time to release excess heat before entering the aquatic environment. These related systems for managing runoff are components of an expanding urban design approach commonly called green infrastructure.

Retention basins (stormwater ponds) tend to be less effective at reducing runoff temperature, as the water may be heated by the sun before being discharged to a receiving stream.



Potrero Generating Station discharged heated water into San Francisco Bay. The plant was closed in 2011.

## Effects

### 1- Warm water effects

Elevated temperature typically decreases the level of dissolved oxygen and of water, as gases are less soluble in hotter liquids. This can harm aquatic animals such as fish, amphibians and other aquatic organisms. Thermal pollution may also increase the metabolic rate of aquatic animals, as enzyme activity, resulting in these organisms consuming more food in a shorter time than if their environment were not changed. Biodiversity can be decreased as a result.

High temperature limits oxygen dispersion into deeper waters, contributing to anaerobic conditions. This can lead to increased bacteria levels when there is ample food supply. Many aquatic species will fail to reproduce at elevated temperatures.

### Cold water effects

Releases of unnaturally cold water from reservoirs can dramatically change the fish and macroinvertebrate fauna of rivers, and reduce river productivity. In Australia, where many rivers have warmer temperature regimes, native fish species have been eliminated, and macroinvertebrate fauna have been drastically altered. Survival rates of fish have dropped up to 75% due to cold water releases.

### Thermal shock effects

When a power plant first opens or shuts down for repair or other causes, fish and other organisms adapted to particular temperature range can be killed by the abrupt change in water temperature, either an increase or decrease, known as "**thermal shock**".