Thermal Pollution

1 Introduction

Thermal pollution, sometimes called "thermal enrichment," is the degradation of water quality by any process that changes ambient water temperature.

Thermal pollution results from the addition of heat to surface waters (rivers, lakes, and oceans) in an amount that creates adverse conditions for the survival of aquatic life.

Basically, **thermal pollution** makes the water less suitable for domestic, recreational and industrial uses.

An example of **thermal pollution** is water used for cooling in a power plant that runs into a nearby river and harms the river's ecosystem.

Thermal energy (also called **heat** energy) is produced when a rise in temperature causes atoms and molecules to move faster and collide with each other.
The energy that comes from the temperature of the heated substance is called **thermal energy**.

Thus, **thermal pollution** is usually associated with increase of water temperature in a stream, lake, or ocean due to the discharge of heated water from industrial processes, such as the generation of electricity.

Increase in ambient water temperature also occur in streams where shading vegetation along the banks is removed or where sediments have made the water more turbid.

Both of these effects allow more energy from the sun to be absorbed by the water and thereby increase its temperature.

2 Various causes of thermal pollution

i. The major sources of thermal pollution are discharge of heated water or hot waste material into water bodies from

a) Nuclear Power plants

b) Industrial plants

c) Hydro-electric power

d) Coal Fired power plants

(a) Water as a Cooling Agent in Nuclear Power plants

The cooling water discharge from nuclear power plants (NPPs) is among the greatest local sources of thermal pollution due to the high levels of energy produced per plant.

The regional climate warming can potentially reinforce negative environmental effects from thermal pollution from point sources such as NPPs.

(b) Water as a Cooling Agent in Industrial plants

Production and Manufacturing plants are the biggest sources of thermal pollution.

These plants draw water from a nearby source to keep machines cool and then release back to the source with higher temperatures.

When heated water returns to the river or ocean, the water temperature rises sharply.

Industrial effluents: A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers.

Increase in temperature of the receiving water decreases the dissolved oxygen of water.
The foul-smelling gases increased in water resulting in death of marine organisms.

When oxygen levels are altered in the water, this can also degrade the quality and longevity of life in wildlife that lives underwater.
This process can also wipe away stream side vegetation, which constantly depends on constant levels of oxygen and temperature.

By altering these natural environments, industries are essentially helping decrease the quality of life for these marine-based life forms, which can ultimately destroy habitats if they are not controlled and careful about their practices.

(c) Water as a Cooling Agent in Hydro-electric power

Hydro power is a type of renewable energy, and once the power plant is constructed it produces little or no waste.

Globally, hydro power contributes more electricity than any other renewable energy type. Generation of hydroelectric power sometimes results in negative thermal loading in water systems. It creates less heat on water sources than NPPs.

(d) Water as a Cooling Agent in Coal Fired power plants

Coal is utilised as a fuel in coal fired power plants. Condenser coils are cooled with water from nearby lake or river. The heated effluents decrease the D.O of water.

What is Thermal Shock?

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 rise in water temperature known as 'thermal shock'.

Most aquatic organisms have developed enzyme systems that operate in only narrow ranges of temperature, and can be killed by sudden temperature changes that are beyond the tolerance limits of their metabolic systems.

ii. Soil erosion

Soil erosion is another major factor that causes thermal pollution. Consistent soil erosion causes water bodies to rise, making them more exposed to sunlight.

The high temperature could prove fatal for aquatic biomes as it may give rise to anaerobic conditions.

iii. Deforestation

Trees and plants prevent sunlight from falling directly on lakes, ponds or rivers.

When deforestation takes place, these water bodies are directly exposed to sunlight, thus absorbing more heat and raising its temperature.

Deforestation is also the main cause of the higher concentrations of greenhouse gases, i.e. global warming in the atmosphere.

iv. Run off from Paved Surfaces

Urban runoff discharged to surface waters from paved surfaces like roads and parking lots can make the water warmer.

During summer seasons, the pavement gets quite hot, which creates warm runoffs that get into the sewer systems and water bodies.

v. Natural Causes

Natural causes like volcanoes, geothermal vents and hot springs under the oceans and seas can trigger warm lava to raise the temperature of water bodies.
Lightening can also introduce a massive amount of heat into the oceans.

This means that the overall temperature of the water source will rise, having significant impacts on the environment.

vi. Retention Ponds

Retention ponds can be another source of thermal shock because the water bodies that are relatively small and shallow can absorb quite a bit of heat energy from the sun.

When that water is pumped directly into a river, lake, or bay, it causes a significant temperature increase.
It is similar to pouring a hot pitcher of water into a bathtub full of water that causes the water to jump a few degrees Fahrenheit.

vii. Domestic Sewage

Domestic sewage is often discharged into rivers, lakes, canals or streams without treating the waste.
The temperature of municipal water sewage is normally high than receiving water.

With the increase in temperature of the receiving water, the dissolved oxygen (DO) decreases, and the demand for oxygen increases, causing anaerobic conditions.

3 Effects of Thermal Pollution

Among recognized scientists and scholars, there are generally two schools of thought when it comes to the effects of thermal pollution.

The effects of thermal pollution are diverse, but in short, thermal pollution damages water ecosystems and reduces animal populations.

Plant species, algae, bacteria, and multi-celled animals all respond differently to significant temperature changes.

Wastewater would not be able to be properly maintained; we would have no industries that could produce the goods we need, and so on.

The effects of thermal pollution on ecosystems, however, greatly outweigh the benefits that industries have by participating in the act.

i. Decrease in DO (Dissolved Oxygen) Levels

The warm temperature reduces the levels of DO (Dissolved Oxygen) in water. The warm water holds relatively less oxygen than cold water. The decrease in DO can create suffocation for plants and animals such as fish, amphibians and cope pods, which may give rise to anaerobic conditions.

Warmer water allows algae to flourish on the surface of the water, and over the long term, growing algae can decrease oxygen levels in the water.

ii. Increase in Toxins

With the constant flow of high-temperature discharge from industries, there is a huge increase in toxins that are being regurgitated into the natural body of water.

These toxins may contain chemicals or radiation that may have a harsh impact on the local ecology and make them susceptible to various diseases.

iii. Loss of Biodiversity

A dent in the biological activity in the water may cause a significant loss of biodiversity.

Changes in the environment may cause certain species of organisms to shift their base to some other place while there could be a significant number of species that may shift in because of warmer waters.

Organisms that can adapt easily may have an advantage over organisms that are not used to the warmer temperatures.

iv. Ecological Impact

A sudden thermal shock can result in mass killings of fish, insects, plants or amphibians.

Hotter water may prove favorable for some species, while it could be lethal for other species.

Small water temperature increases the level of activity, while higher temperature decreases the level of activity.

Many aquatic species are sensitive to small temperature changes such as one degree Celsius that can cause significant changes in organism metabolism and other adverse cellular biology effects.

v. Affects Reproductive Systems

A significant halt in the reproduction of marine wildlife (although reproduction can still occur between fish – but the likelihood of defects in newborns is significantly higher) can happen due to increasing temperatures as reproduction can happen within a certain range of temperature.

Excessive temperature can cause the release of immature eggs or can prevent the normal development of certain eggs.

vi. Increases Metabolic Rate

Thermal pollution increases the metabolic rate of organisms as increasing enzyme activity occurs that causes organisms to consume more food than what is normally required if their environment were not changed. It disrupts the stability of the food chain and alters the balance of species com-

position.

vii. Migration

The warm water can also cause particular species of organisms to migrate to a suitable environment that would cater to its requirements for survival.

This can result in a loss for those species that depend on them for their daily food as their food chain is interrupted.

4 How to control Thermal pollution?

Solutions of thermal pollution is required for its detrimental effects on the aquatic ecosystem in the future.

A number of methods have been suggested and developed to convert the thermal effluents from power plants into useful heat resources for maximizing the benefits.

The solutions to thermal discharge into water bodies are as follows:

i. Cooling Ponds

Cooling ponds or reservoirs are the simplest methods of controlling thermal discharges.

In cooling ponds, heated effluents on the surface of water maximize the dissipation of heat to the atmosphere and minimize the area and volume of water.

This is the simplest and cheapest method that cools the water to a considerably low temperature.

However, the method alone is less desirable as well as inefficient in terms of air-water contact.

ii. Cooling Towers

After using water from water sources for cooling purposes, it is subsequently returned to the water body after passing through the condenser, which is termed as the cooling process.

Therefore, cooling towers are designed to control the temperature of water to make the cooling process more effective.

Cooling towers are mainly used to dissipate the recovered waste heat to eliminate the problems of thermal pollution.

iii. Artificial Lake

Artificial lakes are man-made water bodies that offer a possible alternative.

The heated effluents may be discharged into the lake at one end, and the water may be withdrawn from the other end for cooling purposes. The heat is eventually dissipated through evaporation.

However, these lakes have to be rejuvenated continuously.

iv. Water Recycling

Industrially treated water can be recycled for domestic use or industrial heating that the problem of thermal pollution can be mitigated.

v. Other Applications

The thermal discharge (rejected heat) of power plants can be used in other purposes like:

• Industrial and space heating.

• Biological applications such as soil warming.

• Fish culture, livestock shelters and heating greenhouses.

• Most of these potential physical applications are applicable in colder regions or locations.

• Above all else, the most important thing to consider is that the effects of thermal pollution greatly outweigh the human need for it to be done.

Plants and industries have been able to find successful ways around thermal pollution, but many of them are not practicing it because it's simply easier to work from the traditional model.

If we want to promote the thriving environment that surrounds marine biology, then the attitude around thermal pollution needs to take a drastic turn.

• By being aware of the causes and effects, you can have a significant impact on how these plants choose to operate, and you can opt to make the change.