Algal Growth Control in Solar Pond

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Abstract

Solar pond clarity is important for maximum solar power collection. The main culprit in reducing pond clarity is algae and slime. Dust, leaves and other factors are minor contributors to turbidity. The most suitable method for maintaining pond clarity is the addition of copper sulphate at a rate of 0.5 mg/ liter(0.5 g/m^3).

1. Theoretical Consideration

Solar pond stores solar energy in the lower depth of the pond. Thus, in order to collect maximum solar energy, it is important that the sun ray reaches the bottom of the pond. The turbidity of a still water mass increases slowly with time particularly if the water mass contains chemicals or nutrients that are necessary for growth of living organisms or plants and there is sunshine. Algae and plankton carry out photosynthesis in lakes rivers or sea. If there

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were excess in nutrient particularly nitrogen and phosphorus, eutrophication occurs in the waterways and lakes. In the case of solar pond such occurrence as eutrophication is unlikely but some algal growth do occur. Figure 1 shows various layers that occur in a stratified lake. During the warm summer months the sun heats the upper layers of the water causing circulation to a depth known as thermocline the zone of well-aerated warm water above the thermocline is called the epilimnion. The cold noncirculating poorly aerated water below the thermocline is in the hypolimnion. The water in the epilimnion and hypolimnion does not mix so that the lake is stratified. Most algal productivity occurrs in the epilimnion. The algal cells that drop below the thermocline into the hypolimnion are degraded by the heterotrophic microflora. This respiratory activity further depletes the oxygen level in the hypolimnion. In nutrient rich lakes the hypolimnion is usually totally deficient in oxygen by midsummer.

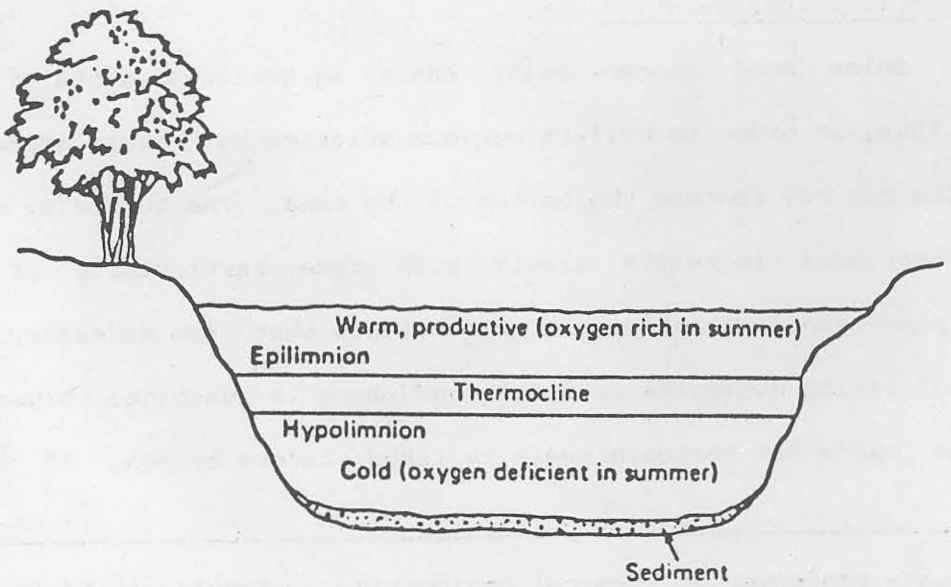

Figure 1 Thermal stratification of a deep lake

2. Growth of Algae

The growth of algae is dependent on the fixation of light energy by the chlorophylls to yield cell mass and oxygen according to the reaction :

$$CO_2 + H_2O \xrightarrow[\text{Chlorophylls}]{\text{light}} \text{biomass } (CH_2O)_n + O_2$$

The growth of algae can be measured through the determination of biomass, or oxygen evolution or carbon-14 uptake or the concentration of DNA and ATP.

2.1 Nutrition Algae has the same nutrient requirement as for plants. The elements required in high concentration are carbon, phosphorus, nitrogen, hydrogen, and oxygen. Carbon must be mainly in the form of CO_2; phosphorus as phosphate; nitrogen as ammonium or nitrate; and hydrogen and oxygen are provided in the water. These elements are termed macronutrients. When inorganic nitrogen in the water becomes limiting, the nitrogen-fixing blue-green algae often proliferate.

In addition the algae require micronutrients, such as magnesium, sulfur, chlorine, iron, and many metals, in low concentrations. These elements are usually present in water in abundant quantities for algal growth.

Many algae can not synthesize some essential metabolites which are called growth factors. These metabolites are supplied by excretion or degradation products from other organisms.

2.2 Light The intensity of light affects both the species of algae in the water and the rate of photosynthesis. Different algal species response to different levels of light intensity for growth to occur.

2.3 Temperature Algae can grow over a wide range of temperature from ice cold water to hot springs temperature. For each temperature range there is a group of algae.

2.4 Limiting Factors Algal growth is controlled by the concentration of nutrients. The growth yield is directly proportional to the concentration of nutrients which are present in minimal quantities, rather than those nutrients which are abundant. The increased concentration of nitrogen and phophorus in eutrophic waters are the major sources of excessive algal biomass.

3. Control of Algal Growth

The photosynthesis : respiration ratio is a very useful tool in the determination of the health of a body of water. As the depth of water increases, the respiration rate is greater than the rate of photosynthesis which produces algae. The sources of respiration are respiration of the algae; grazing on the algae by fish and zooplankton ; and biodegradation of algae and organic substrates by microorganisms. If the ratio is 1 respiration by heterotrophic consumers balances the primary productivity. In nutrient-enriched entrophic waters, photosynthesis outstrips the consumption. The ratio is, therefore, greater than 1. Thus, in order to control algal growth this ratio must be kept near 1 and the nutrient concentrations must be kept low.

Controlling of entrophication in waterways or lakes or ponds can be done through ecological management, or waste treatment or destratification, or chemical algicides, or biological algicide. Since our interest is in the control of algal growth in solar pond. The first three methods are not applicable. This is because the saline strata must be maintained and must not be disturbed. The only two methods available are the use of chemical and biological algicides.

3.1 Biological Algicides This method is applicable to lakes and ponds. Algae are highly susceptible to predation by bacteria when they are short of food or are limited by low light intensity or cold temperature. Inoculation of bacterial predators or viruses to actively growing algae has not been successful in lowering the algal population. Algal viruses are genus specific.

3.2 Chemical Algicides Application of copper sulphate is the most common means of preventing excessive algal growth in ponds. Copper sulphate should be added before substantial algal growth has occurred such as early in the spring.

Copper sulphate is relatively nontoxic to humans or fish at the concentrations required to kill alage. Concentrations of 0.1-0.5 mg/liter of water in the photic zone are usually applied. Table 1 below illustrates that no single group of algae is responsible for tastes and odours and each group required a different concentration of copper sulphate for control. Chlorination can prevent growth of

Table 1. Concentration of copper sulphate necessary for algal control in natural waters

Group of Algal	Organism	Problem	Amount of Copper Sulfate Required (mg/liter)
Algae			
Diatoms	Asterionella, Synedra, Tabellaria	Odor: aromatic to fishy	0.1-0.5
	Fragillaria, Navicula	Turbidity	0.1-0.3
	Melosira	Turbidity	0.2
Greens	Eudorina, Pandorina	Odor: fishy	2-10
	Volvox	Odor: fishy	0.25
	Chara, Cladophora	Turbidity, scum	0.1-0.5
	Coelastrum, Spirogyra	Turbidity, scum	0.1-0.3
Blue-greens	Anabaena, Aphanizomenon	Odor: moldy, grassy, vile	0.1-0.5
	Clathrocystis, Coelosphaerium	Odor: grassy, vile	0.1-0.3
	Oscillatoria	Turbidity	0.2-0.5
Golden or yellow-browns	Cryptomonas	Odor: aromatic	0.2-0.5
	Dinobryon	Odor: aromatic to fishy	0.2
	Mallomonas	Odor: aromatic	0.2-0.5
	Synura	Taste: cucumber	0.1-0.3
	Uroglenopsis	Odor: fishy;taste: oily	0.1-0.2
Dinoflagellates	Ceratium	Odor: fishy, vile	0.2-0.3
	Glenodinium	Odor: fishy	0.2-0.5
	Peridinium	Odor: fishy	0.5-2.0

diatoms, green and blue-green algaes, and dinoflagellates.

4. Algal Control With Respect to Solar Pond

The addition of chemical algicides may interfere with measurement of salt concentration in the solar pond through the use of conductivity probe. However, the concentrations used are too low to have any significant effect and the effect is background effect which can be compensated through initial calibration of the conductivity measuring instrument. Other distinct advantages of chemical algicide are the fact that it does not disturb the saline strata of the solar pond and the low cost of copper sulphate.

From table 1, the maximum copper sulphate concentraion which can control most algal growth is 0.5 mg/liter except for Eudorina and Pandorina (green algae) (2-10 mg/liter), and Peridinium (Dinoflagellates) (0.5-2.0 mg/liter). Thus, for solar pond the addition of 0.5 mg/liter copper sulphate should keep algal growth under control. If some growth still occurs more copper sulphate should be added up to 10 mg/liter.

Since algae can grow over a wide range of temperature, the high temperature that prevails in the solar pond cannot prohibit algal growth in the solar pond.

For a better understanding of algal growth in the solar pond, a study should be made in order to identify the algal species which exist in the solar pond.

5. Summary

Algal growth in an aquatic environment is related to the amount of nutrients that are present in the water, light intensity, and temperature. The limiting growth factor is the nutrient concentrations. The most appropriate method for algal growth control in the solar pond is the addition of copper sulphate at a concetration of 0.5 mg/liter (to the maximum of 10 mg/liter). There is a need to calibrate measuring instrument that measure conductivity in the solar pond in order to compensate for the presence of copper sulphate in the solar pond. Identification of the algal species present in the solar pond will enhance understanding of algal population and algal control in the solar pond.

6. References

1. Mitchell, R. (1974), Introduction to Environmental Microbiology, Prentice Hall, pp 189-211.

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