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# Comparative Study of Rice Straw and Ragi Straw for the Inhibition of Algal Bloom in Fresh Water

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## Abstract

*In recent years, there has been an apparent increase in the occurrence of harmful algal blooms in fresh waters. In this study, it has been attempted to compare the efficiency of rice straw and ragi straw at various concentrations to inhibit algal bloom in fresh water. Algae was collected from a nearby pond, ACCET, Karaikudi, India. Rice straw was collected from rice fields, Thanjavur, India. Ragi straw was collected from Perambalur district. The experiments were carried out in five trays of same dimensions were used among which one was kept control. 2g/l of rice straw was found to inhibit the algal growth at maximum rate. This is due to the release of large amounts of chemicals during the decomposition of the straws. The amount of chemicals released during the process may be differing in various concentrations. pH value was also measured during the experiment. The decreased pH values in the treatment were due to the release of organic acids from the decomposition of rice straw and ragi straw. A possible reason behind increase in COD and change in turbidity was discussed.*

**Keywords:** Algal blooms, chlorophyll ‘a’, inhibiting substances, rice straw, ragi straw.

## Introduction

Increasing population growth and industrialization over the past decades has led to an increasing load of pollutants into our water bodies. Major pollutants include suspended material which causes sediment accumulation at the lake bottom, organic material which leads to depletion of dissolved oxygen because of microbial degradation and nutrients (nitrogen-N and phosphorus-P) which lead to eutrophication (excessive growth of algae).

Eutrophication is the process of nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes, amongst which increased production of algae and aquatic macrophytes, deterioration of water quality and other symptomatic changes are found to be undesirable and interfere with water uses.

Eutrophication can be human-caused or natural. Untreated sewage effluent and agricultural run-off carrying fertilizers are examples of human-caused eutrophication. However, it also occurs naturally in situations where nutrients accumulate (e.g. depositional environments), or where they flow into systems on an ephemeral basis. Eutrophication generally promotes excessive plant growth and decay, favouring simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality. Phosphorus is a necessary nutrient for plants to live, and is the limiting factor for plant growth in many freshwater ecosystems. The addition of phosphorus increases algal growth. These algae assimilate the other necessary nutrients needed for plants and animals. When algae die they sink to the bottom where they are decomposed and the nutrients contained in organic matter are converted into an inorganic form by bacteria. The decomposition process uses oxygen and deprives the deeper waters of oxygen which can kill fish and other organisms. Also the necessary nutrients are all at the bottom of the aquatic ecosystem and if they are not brought up closer to the surface, where there is more available light allowing for photosynthesis for aquatic plants, a serious strain is placed on algae populations. Enhanced growth of aquatic vegetation or phytoplankton and algal blooms disrupts normal functioning of the ecosystem, causing a variety of problems such as a lack of oxygen needed for fish and shellfish to survive. The water becomes cloudy, typically coloured a shade of green, yellow, brown, or red. Eutrophication also decreases the value of rivers, lakes, and estuaries for recreation, fishing, hunting, and aesthetic enjoyment. Health problems can occur where eutrophic conditions interfere with drinking water treatment. Eutrophication was recognized as a pollution problem in European and North American lakes and reservoirs in the mid-20th century. Since then, it has become more widespread. Surveys showed that 54% of lakes in Asia are eutrophic; in Europe, 53%; in, 48%; in South America, 41%; and in Africa, 28%.

**Algal blooms:** The term algae refers to microscopically small, unicellular organisms, some of which colonies and thus reach sizes visible to the naked eye as minute green particles. These organisms are usually finely dispersed throughout the water and may cause considerable turbidity if they attain high densities.

Algae cause a number of problems in water. They impede flow in drainage systems; block pumps and sluices; interfere with navigation, fishing and other forms of recreation; cause taint and odour problems in potable waters; block filters and in some instances, create a health hazard to humans, livestock and wildlife.

The algal blooming produce disagreeable odour or tastes in water, affect dissolved oxygen concentration, impede water flow and drainage or seriously hinder recreational use of the water body[1,2]. Some species also produce "off-flavour" compounds or create filamentous blooms that may block filters used in drinking water supply systems.

The occurrence of harmful algal blooms is a problematic issue in many aquatic environments[3,4] and they pose serious risks for human and animal health, aquatic ecosystem sustainability and economic viability[5-10]. Algal growth during summer seasons in farm ponds can cause a number of problems and the control of algae with mechanical or chemical means can be costly and ineffective. Most of the algal blooms lead to an oxygen reduction within pond.

Many kinds of chemical agent or synthetic compound, including copper, chlorine, aluminium, calcium, are currently used to control phytoplankton and aquatic weeds in lakes, reservoirs and ponds. However chemical algaecides such as copper sulphate exhibited toxic effects on fish. They also can induce secondary pollution, by releasing phytotoxins that increase potential health risks in drinking water supplies.

A variety of methods have already been developed and applied to cope with the problems related to algal blooms , including UV-radiation[11], Nutrient diversion, artificial destratification, hypolimnetic aeration/ withdrawal, sediment oxidation/ removal, ultrasonic and bio manipulation[12].

The most direct form of control involves the application of algaecides, but this is expensive and potentially damaging to the environment. Even where chemical treatments have no immediate damaging effects on lakes there is the risk of accumulation of harmful concentrations in bottom sediments. Even though such methods are often effective, many of them are very expensive and sometimes give rise to secondary pollution, or act for a short function time.

A number of other materials have also been found to be anti-algal including brown-rotted wood[13,14] and some leaf litters, in particular oak leaves (Quercus robur)[15].

An alternative approach for the direct elimination of nuisance algae involves the application of biological control agents such as Viruses, bacteria, fungi, actinimycetes and protozoa.

Solar-powered LDC predictably prevents toxic algae blooms without having to either control nutrient availability or rely upon grid-based energy sources[16]. In recent years, decomposing barley straw in ponds, canals, or reservoirs have been studied and shown to be a promising and effective method for algal control.

Barley straw (Hordeum vulgare) has been identified as an effective method for reducing algal growth in a variety of aquatic systems within the United Kingdom[17,18]. The use of barley straw to control algae is a cost effective, user-friendly and environmentally sounds[19].

So, in this paper a novel method of controlling algae by using rice straw and ragi straw has been investigated to clarify how they can produce significant reductions in algal activity in the water.

As per the previous study concerned, the experiment aimed to identify and quantify 2,6-Dimethoxy-4-(2-propenyl)phenol and octanoic acid from decomposing barley straw in water because of the postulated importance of these two compounds in inhibiting algal growth[15,13,17]

Keeping all factors in mind, the objective of the study has been formulated as follows: i. To study the growth inhibition of algae by the decomposing rice straw and ragi straw. ii. To analyse the various parameters such as growth rate, chlorophyll 'a' content, pH, dissolved oxygen, COD, turbidity during the decomposition process of rice straw and ragi.

## Material and Methods

**Collection of materials:** Algae were collected from a nearby pond, alagappa chettiar college of Engineering and Technology, (ACCET), Karaikudi. Rice straw was collected from rice fields, Thanjavur. Ragi straw was collected from Perambalur district.

**Experimental setup:** The experiments were carried out in five trays of same dimensions were used (figure 1). The collected algae (50g each) was inoculated to each tank containing 20L of water and Bold's Basic medium was added to each tank for supplementing nutrients and trace elements in the tap water. One of the trays was kept as control. The remaining trays were used as treatment trays. Various concentrations of inhibition substances (figure 2 and figure 3) used in the experiment are given in table 1.

**Table-1**
**Various concentrations of inhibition substances used in the experiment**

| Experimental item | Concentration of Inhibition Substances Added |
|---|---|
| Tray 1(control) | Nil |
| Treatment 1 | 2g/l of rice straw |
| Treatment 2 | 4g/l of rice straw |
| Treatment 3 | 2g/l of ragi straw |
| Treatment 4 | 4g/l of ragi straw |

**Figure-1**
**Experimental Set up**

rice straw ragi straw

**Figure-2**
**Inhibition Substances**


**Figure-3**
**Experimental Setup after adding inhibition substances**

**Inoculation of straws:** The straws were air dried, cut into equal pieces, weighed, and loosely packed in nylon net. This nylon net was dropped or immersed in each tray and kept under supervision. Two separate plastic trays were set up for examining the chemical compounds released from rice and ragi straw respectively.

**Analysis of the various parameters:** The various parameters analysed were pH, dissolved oxygen (DO), turbidity, chemical oxygen demand (COD), chlorophyll 'a', identification of organisms.

## Results and Discussion

**Identification of algal species:** The organisms present in the sample was identified using microscopic analysis given in figure 4.

The raw algal sample contained mixed populations of species in which some are highly dominated. Most of the dominated species were cyanobacteria and diatoms particularly, *Navicula.* The inhibition substances showed a positive effect on all the algal species present in the samples.

**Estimation of chlorophyll 'a':** The inhibition of algal growth was determined by quantifying chlorophyll 'a' concentration with varying different concentrations of rice straw and Ragi straw were studied and tabulated in table 2.

The chlorophyll 'a' concentrations in the "control" and four "Treatment" trays were compared during the twelve weeks of the experiment. Thereafter, algae in the "control" tray grew much more rapidly than those in the four "Treatment" trays. The lowest value of chlorophyll 'a' was obtained by the tenth week. During that period, the chlorophyll 'a' concentration in the treatment 1 tray was 29.32mg/m$^3$ as compared to 44.63 mg/m$^3$ in the "control" tray. From the table 1, it can be observed that rice straw inhibit growth of algae than Ragi straw. When the two different loading rates of two different inhibiting substances, 2g/l of rice straw was found to inhibit the algal growth at maximum rate.

During the twelve weeks of the experiment, the decrease in chlorophyll 'a' concentration was witnessed. Compared to the control, the colour of treatment trays turns from green to slight brown during the third week of the experiment. During the tenth week of the experiment the colour of treatment trays were turned from slight brown to deep brown which indicates the complete reduction of chlorophyll 'a' from algae. The deep brown colour thus formed was due to the release of chemical compounds from the decomposition of rice straw and ragi straw. Then during the twelfth week of the experiment, the treatment trays were found with small green patches here and there which indicate the decomposition of inhibiting substances starts to cease.

From the observed data, the mean average values of chlorophyll 'a' concentration which shows that the rice straw of 2g/l loading rate gives the maximum inhibition rate of 32.48mg/m$^3$ when compared to the control 44.35 mg/m$^3$. This is due to the release of large amounts of chemicals during the decomposition of the straws. The amount of chemicals released during the process may be differing in various concentrations.

**Estimation of Turbidity levels:** From the table 3, it can be observed that the turbidity values are ranged from 38.7 NTU to 41.2 NTU in control tray and ranged from 33.5 NTU to 38.9 NTU in the treatment trays. Average of turbidity values were 34.91, 35.65, 34.64 and 35.29 NTU respectively in all treatment trays. As expected, higher the concentration of rice straw or ragi straw, the higher the value of turbidity obtained because of the formation of the residues. In control tray, average turbidity value was higher than the rest of treatment trays. This clearly indicated that residual algae present in the control tray contributed a lot in turbidity. But in treatment trays, because of formation of intermediate substance curb algal residue. That may be the reason for obtaining lower turbidity value.

**Estimation of Dissolved Oxygen:** Dissolved oxygen was measured in control and experimental setup is shown in table 4.

From table 4, it can be seen that dissolved oxygen was increased in the treatment trays than the control tray. It is known that algae impart oxygen during photosynthesis. Despite having lower concentrations of algae in treatment trays, higher value of dissolved oxygen was observed. The algal cells were slowly reduced in all treatment trays due to the release of chemicals from straws. These chemicals might have capable of aerating water since all trays were kept open in atmosphere.

The values of pH during the period of the experiment were measured. pH values were increased in control tray, whereas the pH values were decreased in treatment trays. The decreased pH values in the treatment were due to the release of organic acids from the decomposition of rice straw and ragi straw.

**Effect of inhibiting substances on chemical oxygen demand (COD):** COD measures the amount of organics in the sample. Samples were collected from each tray and the COD is determined and shown in table 5.

From the figure 5, it can be observed the COD values in the treatment as well as the control trays were increased gradually, whereas the COD values in the control tray was higher than that of all treatment trays. This may have been due to the substantial growth of the algae in the control tray. Algal cells were probably the largest component of the organics in the control whereas products from decomposed straws could be the major fraction of organics measured by COD in the treatment trays in which there were less amounts of algal cells. The increase in COD levels for the treatment trays was due to the release of organics from the breakdown of the straw. As mentioned above, the increase in COD for the control was probably due to the presence of a large quantity of algal cells.

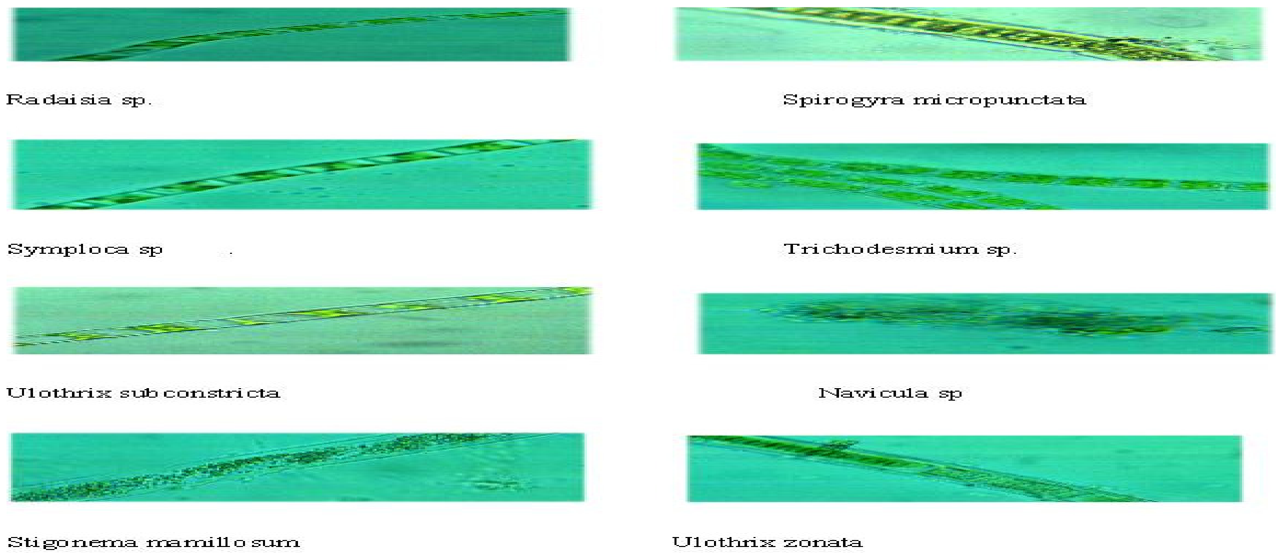


**Figure-4**
**Various species found in inoculums**

**Table-2**
**Estimation of Chlorophyll 'a'**

| No of weeks | Control | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 |
|---|---|---|---|---|---|
| 1. | 46.73 | 36.26 | 41.23 | 45.22 | 46.53 |
| 2. | 46.38 | 35.32 | 41.09 | 44.02 | 46.12 |
| 3. | 46.03 | 34.62 | 39.92 | 42.56 | 44.12 |
| 4. | 46.69 | 33.76 | 37.04 | 40.02 | 41.09 |
| 5. | 46.52 | 32.76 | 35.32 | 39.56 | 39.96 |
| 6. | 46.09 | 31.52 | 33.03 | 36.52 | 37.62 |
| 7. | 46.05 | 31.51 | 32.93 | 35.62 | 35.93 |
| 8. | 45.51 | 30.92 | 31.53 | 34.72 | 34.96 |
| 9. | 45.52 | 30.56 | 31.09 | 33.93 | 34.54 |
| 10. | 44.63 | 29.32 | 32.43 | 33.52 | 35.68 |
| 11. | 44.52 | 39.52 | 32.98 | 33.03 | 35.93 |
| 12. | 43.63 | 33.76 | 33.56 | 33.62 | 36.72 |
| Avg mean (mg/$m^3$) | 44.35 | 32.48 | 35.18 | 37.7 | 39.10 |

**Table-3**
**Estimation of Turbidity levels**

| No of weeks | Control | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 |
|---|---|---|---|---|---|
| 1. | 38.7 | 36.3 | 38.9 | 35.8 | 38.7 |
| 2. | 38.9 | 35.9 | 36.8 | 35.4 | 38.5 |
| 3. | 38.8 | 34.5 | 34.3 | 34.8 | 36.2 |
| 4. | 40.6 | 33.5 | 34.3 | 33.6 | 34 |
| 5. | 40.5 | 34.6 | 33.5 | 33.4 | 33.8 |
| 6. | 40.5 | 34.8 | 35.6 | 34.2 | 33.6 |
| 7. | 40.6 | 35.1 | 35.8 | 34.8 | 34.5 |
| 8. | 41.2 | 34.6 | 35.6 | 34.1 | 34.3 |
| 9. | 40.9 | 34.2 | 36.1 | 34.6 | 34.6 |
| 10. | 40.3 | 35.6 | 36 | 35.1 | 34.6 |
| 11. | 40.2 | 35.2 | 35.3 | 35 | 34.9 |
| 12. | 40.6 | 35.1 | 35.6 | 34.9 | 35.8 |

**Table-4**
**Illustration of Dissolved Oxygen levels**

| Weeks | Control | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 |
|---|---|---|---|---|---|
| 1 | 10.8 | 10.6 | 10.3 | 10.2 | 10.7 |
| 2 | 11.6 | 11.5 | 10.4 | 10.5 | 11.6 |
| 3 | 9.5 | 9.4 | 9.0 | 8.6 | 8.8 |
| 4 | 9.4 | 9.3 | 9.8 | 9.1 | 9.5 |
| 5 | 9.4 | 9.5 | 9.6 | 9.7 | 9.8 |
| 6 | 9.7 | 9.6 | 9.6 | 9.9 | 9.8 |
| 7 | 9.6 | 9.8 | 10.1 | 10.3 | 10.4 |
| 8 | 9.5 | 10.4 | 10.6 | 10.3 | 10.2 |
| 9 | 9.3 | 10.8 | 10.6 | 10.2 | 10.3 |
| 10 | 9.5 | 10.8 | 10.7 | 10.3 | 10.4 |
| 11 | 9.3 | 10.7 | 10.5 | 10.5 | 10.6 |
| 12 | 9.3 | 10.6 | 10.7 | 10.7 | 10.5 |

**Table-5**
**Illustration of COD levels**

| **No of weeks** | **Control** | **Treatment 1** | **Treatment 2** | **Treatment 3** | **Treatment 4** |
|---|---|---|---|---|---|
| 1. | 160 | 140 | 140 | 120 | 140 |
| 2. | 280 | 160 | 180 | 180 | 240 |
| 3. | 320 | 180 | 200 | 180 | 240 |
| 4. | 340 | 190 | 200 | 200 | 260 |
| 5. | 340 | 200 | 210 | 230 | 260 |
| 6. | 360 | 210 | 210 | 240 | 280 |
| 7. | 380 | 220 | 230 | 240 | 280 |
| 8. | 390 | 240 | 250 | 260 | 300 |
| 9. | 420 | 240 | 260 | 280 | 310 |
| 10. | 420 | 260 | 280 | 280 | 260 |
| 11. | 460 | 240 | 240 | 180 | 240 |
| 12. | 480 | 220 | 240 | 160 | 220 |

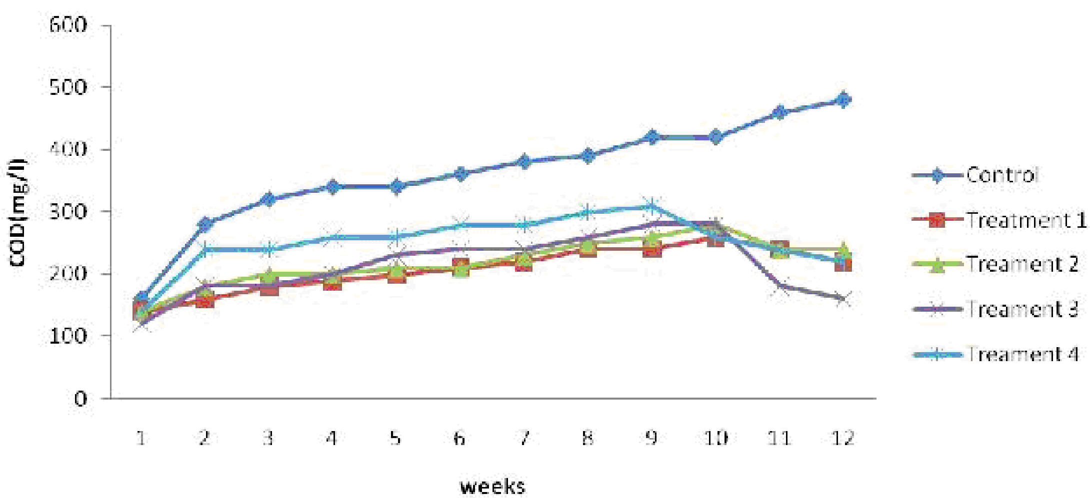


**Figure-5**
**Variations of COD concentration among the experiment**

## Conclusion

It could be concluded from this study that the growth of algae was inhibited by rice straw and ragi straw. This activity was due to the synergistic effects of various compounds in the straw materials. Decomposing rice straw of 2 g/L was effective (among the experiment conducted) in inhibiting the growth of Algae in water. By the tenth week, the chlorophyll 'a' concentration in the "Treatment" tanks was approximately 29.32mg/m$^3$ compared to 46.73 mg/m$^3$ in the control tank. Decomposing rice straw and ragi straws were also increased the amount of organics in the water. This is because the anti algal agents released by the straw are more effective in preventing algal growth than in killing algae already present. The chemicals produced during this process are naturally occurring decomposition of any plant material in water.

This project produced new and valuable information about the effect of decomposing rice and ragi straw on algal growth and several water quality parameters. Several chemical compounds from decomposed rice and ragi straws could be further studied for their inhibitory effects.

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