CHRIS ON KOI

CONTROL OF ALGAE WITH BARLEY STRAW

INTRODUCTION

The following is the text of an information sheet produced by the *Centre for Aquatic Plant Management in England* who discovered and developed the use of barley straw as a method of algal control.

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 odor - 1 - problems in potable waters, block filters and, in some instances, create a health hazard to humans, livestock and wildlife. These problems seem to be increasing, probably because nutrient levels in water are rising as a result of human activity and natural processes. At the same time there is a growing worldwide demand for improvement in water quality. Thus, the need to control algae is increasing for environmental, recreational and public health reasons.

Because of their small size and rapid growth rates, algae are difficult to control by methods used for other aquatic plants. Cutting and other forms of mechanical control can help to reduce problems with filamentous algae but are of very limited use. Many algae are susceptible to appropriate herbicides but this approach is unpopular in some waters on environmental and public health grounds. Furthermore, herbicides which control algae also kill higher plants so that, although the water is cleared temporarily of all plants, once the herbicide has gone from the water, the re-growth of algae is not restricted by competition from the higher plants and the problem can get worse in subsequent years.

A new method of controlling algae has been developed by the Centre for Aquatic Plant Management which overcomes many of these problems. This involves the application of barley straw to water and has been tested in a wide range of situations and in many countries throughout the world and has proved to be very successful in most situations with no known undesirable side-effects. It offers a cheap and environmentally acceptable way of controlling algae in water bodies ranging from garden ponds to large reservoirs, streams, rivers and lakes.

Despite the simplicity of the idea, experience has shown that there are a number of basic rules which must be followed to ensure that the straw works successfully. The purpose of this leaflet is to provide practical advice on the optimum ways of using straw.

HOW STRAW WORKS

In order to use straw effectively, it is necessary to understand something of how the process works. When barley straw is put into water, it starts to rot and during this process a chemical is released which inhibits the growth of algae. Rotting is a microbial process and is temperature dependent, being faster in summer than in winter. As a rough guide, it may take 6-8 weeks for straw to become active when water temperatures are below 10oC but only 1-2 weeks when the water is above 20oC. During this period, algal growth will continue unchecked. Once the straw has started to release the chemical it will remain active until it has almost completely decomposed. The duration of this period varies with the temperature and the form in which the straw is applied and this will be discussed in more detail later. However, as a generalisation, straw is likely to remain active for approximately six months, after which its activity gradually decreases.

Although the exact mechanism by which straw controls algae has not been fully proven we believe that the process may occur as follows. When straw rots, chemicals in the cell walls decompose at different rates. Lignins are very persistent and are likely to remain and be released into the water as the other components decay. If there is plenty of oxygen available in the water, lignins can be oxidised to humic acids and other humic substances. These humic substances occur naturally in many waters and it has been shown that, when sunlight shines onto water which contains dissolved oxygen, in the presence of humic substances, hydrogen peroxide is formed. Low levels of peroxide are known to inhibit the growth of algae and experiments have shown that sustained low concentrations of hydrogen peroxide can have a very similar effect on algae to that of straw. Peroxides are very reactive molecules and will only last in water for a short time. However, when humic substances are present, peroxides will be continuously generated whenever there is sufficient sunlight. The slow decomposition of the straw ensures that humic substances are always present to catalyse this reaction.

There are various factors which affect the performance of straw and which support this hypothesis. It is important to take these factors into account to ensure successful treatment of algal problems with straw.

1. **Type of Straw** - Barley straw works more effectively and for longer periods than wheat or other straws and should always be used in preference to other straws. If barley is unavailable, other straws, including wheat, linseed, oil seed rape, lavender stalks and maize can be used as a substitute. The information in this leaflet describes the use of barley straw. If other straws are used, it is likely that the quantities applied and frequency of application may have to be increased.

   We have tested a range of barley straw varieties, including some grown organically; all these were active at the same level. Hay and green plant materials should not be used because they can release nutrients which may increase algal growth. Also they rot very rapidly and may cause deoxygenation of the water.

2. **The anti-algal chemical -** The chemical released by the straw does not kill algal cells already present but it prevents the growth of new algal cells. Thus algae which die will not be replaced when the straw is present and so the algal problem is controlled.
3. **Speed of effect -** Once the straw has become active, the time taken for control to become effective varies with the type of alga. Small, unicellular species which make the water appear green and turbid, usually disappear within 6-8 weeks of straw application. The larger filamentous algae, often known as blanket weeds, can survive for longer periods and may not be controlled adequately in the first season if the straw is added too late in the growing

season when algal growth is dense. It is, therefore, preferable to add the straw very early in the spring before algal growth starts.

4. **Production of the anti-algal activity -** Activity is only produced if the straw is rotting under well oxygenated conditions. Usually, there is adequate dissolved oxygen in water to ensure that the chemical is produced by the straw. However, if the straw is applied in large compact masses such as bales, or to very sheltered and isolated areas of water, there will be insufficient water movement through the straw, which will progressively become anaerobic (without oxygen). Under these conditions, only the surface layers of the straw will produce the chemical and so the majority of the straw will have no useful effect.
5. **Absorption and inactivation of the chemical -** The chemical is very quickly absorbed by algae and is inactivated by mud. Therefore, in waters which have high algal populations and are turbid with suspended mud, it is necessary to add more straw than in clear waters.
6. **Selective effect on algae-** The chemical does not appear to have any effect on higher plants. In our experiments, we have seen that the suppression of dense algal growth has allowed flowering plants (macrophytes) to recolonise waters which were previously dominated by algae. In several shallow lakes where straw was used, algae were replaced by higher plants which suppressed the subsequent growth of algae, so eliminating the need for further straw treatments.
7. **Effects on invertebrate animals and fish -** There are no reports of harmful effects on invertebrates or fish except in a few instances where excessive amounts of straw were applied to small ponds and the water became deoxygenated. These excessive doses were at least 100 times the doses recommended in this leaflet. In most instances, invertebrate populations increase substantially around the straw so providing a useful food source for fish. There is anecdotal evidence that, in fish farms and fisheries, straw treatments may be associated with improved gill function and fish health and vigour.

HOW MUCH STRAW TO APPLY?

In ponds, lakes and other still water bodies. We have found that the most important measurement in calculating the quantity of straw required is the surface area of the water. Surprisingly, the volume of the water does not appear to affect the performance of the straw as might be expected. This may be because the majority of algal growth takes place in the surface layers of the water and so it is not necessary to measure the depth of the water or volume of the lake when calculating the quantity of straw required.

In still waters such as lakes, ponds and reservoirs, the minimum quantity of straw needed to control algae is about 10g straw m-2 of water surface. However, when a water body with a history of severe algal problems is first treated, a higher dose is preferable (25 g m-2) and quantities up to 100 g m-2 have been used. Once the algal problem has been controlled, and further additions of straw are being made to prevent a recurrence of the problem, the dose can be reduced.

In turbid or muddy waters, it will always be necessary to add more straw than in clear, mud-free waters. It is clear from numerous trials in different types of water body that the quantity of straw needed can vary considerably and it is better to apply too much initially and then to reduce the quantity gradually each time straw is added until the dose has been reduced to 10g m-2 or until algal growth starts to increase again when the dose should be increased to a previously effective level.

There is a theoretical level at which straw could cause problems by deoxygenating the water. This is caused by the microorganisms which colonise the straw and absorb oxygen from the water and by chemical oxygen demand of the rotting process. However, straw decomposes slowly and the oxygen demand of these microorganisms is unlikely to cause any problems unless excessive amounts of straw (more than 100g m-2) are applied. Deoxygenation can occur as the result of natural processes especially in prolonged hot weather when the solubility of oxygen in water is reduced and biological oxygen demand increased. This deoxygenation is often caused by algal blooms and so the presence of straw, which prevents the formation of these blooms, can reduce the risk of deoxygenation. However, straw should not be applied during prolonged periods of hot weather to waters containing dense algal blooms as the combined oxygen demand from the algal bloom and the straw could temporarily increase the risk of deoxygenation.

In flowing waters such as streams and rivers. We do not yet have sufficient information on the properties of straw to express a quantity of straw required in relation to the surface area or volume of water flowing down the stream. However, straw has been used effectively in these situations by placing quantities of straw at intervals along either bank of the river. The distance between straw masses has usually been between 30-50m and the size of each straw mass was chosen, for convenience, as about one bale (20kg).

The risk of causing deoxygenation in flowing waters is very small as the continuous supply of fresh oxygenated water will prevent any local deoxygenation around the straw.

HOW TO APPLY STRAW

The best way of applying straw varies with the size and type of water body. Suggestions as to the most appropriate methods for different types of water body are given below.

Fast flowing rivers and streams. Straw can be applied in the form of bales because the flow of water will keep oxygen levels high enough to prevent the straw from becoming anaerobic. Only small bales (approximately 20kg) should be used. Bales can break up under the forces produced by fast flowing water and they should normally be wrapped with netting or chicken wire and securely anchored to the bank or posts driven into the river bed. Another way of applying straw which has worked effectively in flowing water is to place the straw in gabions. These are wire mesh boxes (usually filled with stone for bank protection) but they work equally effectively as cages for straw. They have the additional advantage that they can be refilled as the straw rots away. Nets and loose woven sacks (e.g. Onion sacks) filled with straw can also be used. In all instances, it is essential to ensure that the straw container is well anchored to the bank or to stakes in the bottom which will hold it in place during periods of high flow.

Slow flowing rivers. Straw should be applied in a loose form, either in gabions or as straw sausages. This increases the diffusion of oxygen to the site of decomposition and speeds up the process in this type of environment.

Ponds, lakes and reservoirs. In still or very slow flowing water, bales should not normally be used as they are too tightly packed and do not allow adequate water movement through the straw. It is preferable to apply the straw in a loose form retained in some form of netting or cage.

SMALL PONDS

In small garden ponds where only a few grams of straw are needed, the straw can be put into a net bag, nylon stocking or simply tied into a bundle with string. This can be attached to an anchor made of a stone or brick and dropped into the pond. However, as the straw becomes waterlogged, the net will gradually sink to the bottom. In this position, it will not work as effectively as it does near the surface and it is advisable to include some form of float in the net. Floats can be made of corks, polystyrene or small plastic bottles with well-fitting screw tops. Once the straw has rotted, the net, complete with float and anchor can be removed and used again.

Some garden centres supply small packets of straw for use in ponds. They will work best if anchored and attached to a float as described above.

In larger ponds, lakes and reservoirs, where larger quantities of straw are needed, bales should be broken up on the bank and the loose straw wrapped in some form of netting or wire. One of the simpler ways of wrapping large quantities of loose straw is to use one of the various forms of tubular netting normally sold for wrapping Christmas trees, constructing onion sacks and for other agricultural purposes.

When used in conjunction with a tree wrapping machine they can be used to construct straw sausages which can be made up to about 20m long and contain some 50kg of straw. The length and size of each sausage is determined by the size and shape of the water body (described later). It is advisable to incorporate some floats within the netting to keep the straw near the surface when it becomes waterlogged. When first constructed, these sausages float well and can be towed behind a boat to the required position and anchored by rope to concrete blocks or sacks of gravel. It is preferable to anchor these straw sausages at only one end so that they can swing round to offer minimum resistance to wind or currents. Straw sausages can interfere with angling and boat traffic and their positioning needs to be carefully considered so as to have the minimum adverse effect on water users. Floats or buoys can be attached as markers to warn boat traffic or anglers of the position of the straw.

WHERE TO APPLY STRAW

It is always preferable to apply several small quantities of straw to a water body rather than one large one. This improves the distribution of the active factors throughout the water body. Straw works best if it is held near to the surface where water movement is greatest. This keeps the straw well oxygenated and helps to distribute the anti-algal chemical. In addition this ensures that the chemical is produced close to where the majority of the algae are growing and away from the bottom mud which will inactivate the chemical. The following aspects should be considered when deciding where to place the straw within a water body.

Small ponds - In small ponds where only a single net of straw is required, this should be placed in the centre of the pond. However, if there is an incoming flow of water, either as a stream or fountain, the straw net should be placed where there is a continuous flow of water over and through the straw. This will help to keep the straw oxygenated and spread the chemical throughout the pond.

Lakes and Reservoirs- In any body of still water, it can be assumed that the anti-algal chemical will diffuse outwards in all directions from each net of straw gradually being absorbed by algae and inactivated by mud until the concentration becomes too low to be effective. Beyond this distance, algal growth will continue unchecked and these algae will gradually drift back into the treated areas giving the impression that the straw is not working. In order to ensure that there are no areas within the water body unaffected by the straw, it is necessary to calculate how much straw is needed, how many nets should be employed and how far apart each net should be. Nets or sausages of straw should then be placed so that each net is roughly equidistant from its neighbours and from the bank. The steps involved in this calculation are explained overleaf with an example:

In rivers and streams - From the point of view of getting maximum benefit from straw, it would be preferable to place the straw as a barrier across the flow of water. However, this is seldom possible because the force of the water would tend to wash the straw away and the straw would impede water movement and boat traffic. Therefore, bales, straw nets or gabions should either be placed opposite each other in pairs or alternately along both banks. In fast flowing streams where there is little mud to absorb the chemical, the space between straw nets can be as much as 100 m (50 m if placed alternately) but in slow-flowing muddy watercourses, this space should be reduced to no more than 30 m. In very narrow streams, it may be necessary to place the straw close to the bank so as not to impede flow but in larger watercourses the straw should be as far out from the bank as possible. This makes it less subject to vandalism and damage from livestock and ensures that there is a good flow of water around and through the straw.

Always ensure that the straw is well secured to the bank or to stakes in the bottom so that it does not get washed away during floods. It is usually necessary to consult the local water authority before applying straw to flowing water because they have the responsibility of ensuring that there is no danger to water supplies or other riparian users caused by partial obstruction to the flow.

Marine situations - There has been very little research with straw in seawater and any treatments in these conditions should be regarded as experimental. Results from a very limited number of trials in salt water lagoons and artificial pools suggest that straw can work in salt as well as fresh water. However, it is very unlikely that it would have any effect on the large marine algae normally found on rocky shores or on kelp beds in the seas because of the problems of short persistence time and exposure. It is also unlikely that sufficient straw could be placed and held for long periods in the open sea.

Table 1. Method for estimating amount of straw required.

Decision Step

Calculated example

1. Estimate the surface area of the lake 1.5ha (15,000 m2)
2. Decide on the dose rate of straw required. This will range from 10g/m2 (1 lb per 500 sq feet)in a clear lake with little algae or mud to 50 g/m2 (5 lb per 500 sq feet) in a heavily infested lake with muddy water 25 g/m2 (2.5 lb per 500 sq feet)

   (Note - My rough conversions may be in error. It doesn't seem like all that much straw to me.)

3. Multiply the area of the lake (in m2) by the quantity of straw required per m2 to obtain the total quantity required 15,000 x 25 = 375,000 g 375,000ö1000 = 375kg
4. To obtain the number of bales to be purchased, divide the total weight of straw by the weight of bales (small rectangular bales normally weigh about 20kg). Weights should be checked on other sizes and shapes of bales. 375ö20 = 19 bales
5. Decide on the weight of straw to be placed in each net. (Bear in mind that the smaller the quantity in each net, the more nets there are and so the better the distribution of the chemical. Against this, the time and labour to construct the nets and the interference that they may cause to the lake functions will limit the numbers). Nets should normally contain between 1kg (in small lakes) to 40kg (in very large lakes). 25 kg
6. Calculate the number of nets which will have to be constructed. Divide the total quantity of straw required (3) by the weight in each net (5). 375 ö25 = 15 nets
7. Calculate the area of water which will be treated by each net at the dose rate decided in 2 (above). 25kgö25g/m2 = 1,000 m2
8. Calculate the radius of a circle with an area of the size calculated in 6 (above) using r2. r2 = 1,000 r = 1,000ö3.142 r = 17.85m
9. The diameter of a circle of 1,000 m2 is .r x 2 diameter = 35.7 m
10. Decide on the most appropriate placement of the nets of straw in the lake so that each one is approximately 35m from its neighbour and 17m from the bank. Usually a regular square grid pattern with centres at 35 m

The spacing of nets does not need to be exact. Practical considerations may influence the number of nets and their local placement. For example, it may be necessary to leave a wider corridor between some sets of nets to allow for adequate boat passage or angling purposes. Where possible any enlarged gaps between straw nets should be compensated for by decreasing the gaps between adjacent nets. If there are any inflowing streams, it is advisable to increase the number of nets near the inlet so that water flows through the straw and distributes the chemical into the lake. It is possible to compensate for this local concentration of straw nets near the inlet by reducing the numbers of nets near any outlet as the chemical released from these may be washed out of the lake.

In an irregularly shaped water body, the preferred place for some of the nets is opposite any promontories or points where the nets will be exposed to maximum wind and wave action. The remainder should be spaced between these, using the method of calculating the gaps shown above.

WHEN TO APPLY STRAW

Although straw can be applied at any time of year, it is much more effective if applied before algal growth takes place. This is because the anti-algal agents released by the straw are more effective in preventing algal growth than in killing algae already present. Therefore, straw is best applied in the autumn, winter or very early spring when the water temperature is low. The straw will usually become active within one month and will continue to inhibit algal growth for about 6 months. However, rapid algal growth can take place once the straw has rotted away and so further applications should be made each 6 months.

It is important to note that the rate at which straw rots varies considerably and regular observations should be kept on the straw so that fresh straw can be added before the end of the 6 month period if necessary. It is not always possible to predict that an algal problem will occur and so it is sometimes necessary to treat an algal problem which has already developed. Some algae, mainly the small unicellular species and the cyanobacteria (blue-green algae), can be controlled by adding straw to existing blooms.

The time taken for the algae to be controlled depends on a number of factors, of which water temperature is probably the most important. At water temperatures above 20oC straw has been effective in controlling algal blooms within 4-5 weeks, sometimes even faster. Avoid applying straw during prolonged periods of hot weather as the combined effect of the dying algae and the rotting straw may increase the risk of deoxygenation. At lower temperatures, the process is slower and it may take 8 - 10 weeks to control the algae but the risk of deoxygenation is then minimal.

When filamentous algae are the main problem, straw applied to dense floating mats will have very little useful effect unless combined with other treatments which will be described later. After the initial straw treatment, further additions will be required to prevent the return of the algae. Although a period of 6 months is suggested as the likely interval between straw applications, more frequent treatments may be necessary. It is inadvisable to wait until all the straw has rotted before making a second application as there will then be an interval when no chemical is being produced and rapid algal growth can take place. For the same reason, the old straw should not be removed for at least one month after the addition of the new straw. This allows time for the new straw to become active.

THE USE OF STRAW IN COMBINATION WITH OTHER CONTROL METHODS

Filamentous algae are not easily controlled by straw once they have formed floating mats. However, they can be controlled by other methods. In some situations, filamentous algae can be raked out. However, many fragments will remain in the water and rapid regrowth is likely. To prevent this straw should be added about one month before the alga is raked out.

In other situations, herbicides (diquat or terbutryn) have been used in combination with straw. The herbicides control the algae but their effects may not persist for long once the herbicide has decayed or been otherwise dissipated from the water. By adding straw at the same time, or soon after the herbicide has been applied and maintaining a straw treatment regime as outlined above, the straw helps to prevent the return of the algae.

OTHER EFFECTS OF STRAW

During the numerous field trials in which straw has been applied in a number of forms and in a range of water bodies, various effects in additional to the control of algae have been noted. While these have not been investigated in any detail, they have occurred sufficiently frequently to be worth noting as possible consequences of using straw.

1. Effects on other aquatic plants. No direct effect of straw on aquatic vascular plants has been found in either laboratory or field experiments. However, in several trials where straw has successfully controlled algae, there has been a noticeable increase in the growth of submerged vascular plants. It is likely that this is a result of the loss of competition from the algae which has allowed the vascular plants to recolonise water in which previously they were unable to compete with the algae. In some instances, the recovery of the vascular plants has been so marked that they, in turn, caused problems to water users and also required some form of management. However, they are generally easier to control and less troublesome than the algae and so are more acceptable in most waters. In some instances the recovery of the vascular plants has been so strong that they replaced the algal growth as the dominant plant form so that subsequent treatment with straw was no longer needed.
2. Effects on invertebrates It has been observed frequently that loose masses of well oxygenated straw provide a good habitat for some of the aquatic invertebrate animals such as the Water Shrimp (Gammarus spp.). These invertebrates, mostly detritus eaters, breed and grow rapidly in the safe environment created by the straw and their numbers can increase by several orders of magnitude within a few months. As the straw gradually rots away and the numbers of invertebrates increases, individuals leave the safety of the straw and become prey to fish and waterfowl. Invertebrate animals are generally beneficial to water bodies as they help to decompose organic matter in the bottom; some of them graze on algae and aquatic plants and they form an important part of the food chain.
3. Effects on fish and waterfowl There have been a number of observations of improved growth, vigour and health of fish in waters treated by straw. One reason for this is likely to be the increased food supply in the form of invertebrate animals. Fish may also find it easier to find food in water which is not densely colonised by unicellular or filamentous algae. However, another possible explanation is that, by controlling the algae, the straw allows better light penetration to occur to deeper levels in the water so that photosynthesis can occur in a greater volume of the water body and so provide an improved environment for the fish. It has also been noted by the Game Conservancy that young ducklings require a diet which consists mainly of invertebrate animals. They found that adding straw to gravel pits significantly increased the survival of young ducklings. In a number of water bodies, ducks and other waterfowl have been observed to nest and roost on floating masses of straw. This has been particularly beneficial to these birds in waters subject to high levels of human

interference and terrestrial predators as the floating straw masses are usually inaccessible from the bank.

There have been a number of anecdotal reports that incidents of some fish diseases and parasites appear to have been reduced in fisheries and fish farms in which straw has been used.

4. Effects of straw in flowing waters When straw has been applied in flowing waters, either in the form of bales or in gabions, it has been noted that water is deflected around the straw and the accelerated flow caused silt and fine gravel to be washed away from the vicinity of the straw. In a small stream which had a very uniform depth, pairs of gabions containing straw were placed opposite each other and angled downstream so as to create a rapid flow between them. This caused the gravelly bed of the stream to wash out and so scour holes were formed. These were immediately colonised by trout which were the dominant fish species. The overall effect created by three pairs of gabions placed at approximately 100 m intervals was to create a pool and riffle environment which is usually considered to be preferable to a uniform channel for fish and aquatic life generally. In small streams, it is likely that careful placement of straw bales or gabions could be used to manipulate the location of silt deposits ensuring that an open channel is maintained and that silt beds are allowed to develop only in acceptable locations.

SUMMARY

1. When algal problems occur in water bodies ranging from garden ponds to large reservoirs, lakes and rivers, barley straw offers an environmentally acceptable and cost-effective form of control.
2. It should be applied twice each year, preferably in early spring before algal growth starts and in autumn.
3. Particularly in static waters, the straw should be in a loose form through which water can pass easily and should be held in nets, cages or bags.
4. The minimum effective quantity of barley straw in still or very slow flowing water is about 2.5 g m-2 but higher doses of up to 50 g m-2 should be used in densely infested waters and muddy waters.
5. In rivers, masses of straw (bales or nets) should be spaced along the sides at intervals not more than 100m apart.
6. Straw should be supported by floats so that it does not sink to more than one metre below the surface, even when waterlogged.
7. If the straw starts to smell then it is not working and should be removed. This is caused by too much straw in too little water.

(Note - Some more info on Straw)" I am a co-owner of a ranch/subdivision with 7 stream fed trout ponds. We had problems with filamentous algae for several years and presently are using wheat straw to keep it under control. Use of straw for algae control has been discussed in this group in the past and quite a bit of research has been done on the subject in Britain.

Barley straw is preferred but in our area it is difficult to find and wheat straw is easy to find. I've even heard that alfalfa hay will work. We stake a couple bales of straw at the inlet to the ponds, attempting to hold them in place and nearly submerged. In our cold water environment we use the same bales all summer but the British papers recommend changing them at least three times during a season.

We are finding the bales to be better than previous non chemical methods and is almost zero cost. We used Aqua V, at over $700 every treatment, for several years with no apparent improvement. The bales won't clear the water instantly but we saw significant reduction in algae the first year and the bales weren't placed properly. We have avoided copper treatment due to the sensitivity of our trout to it and the fact the fish are being eaten by our residents. "

Chris Neaves