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Control of Clay Turbidity in Ponds

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What is turbidity?

Turbidity is a very general term that describes the "cloudiness" or "muddiness" of water. Turbidity can be caused by many substances, including microscopic algae (phytoplankton), bacteria, dissolved organic substances that stain water, suspended clay particles, and colloidal solids. Although turbidity can be a problem in many different types of water, turbidity caused by suspended clay tends to occur most often in soft, poorly-buffered (low alkalinity) waters.

Some of the substances that cause turbidity are more desirable in fish culture or recreational farm ponds than others. In moderate amounts, phytoplankton is a desirable form of turbidity because it provides food for microscopic animals (zooplankton) and filter-feeding fish, and improves water quality by producing dissolved oxygen and removing potentially toxic compounds such as ammonia. On the other hand, turbidity caused by clay particles is generally undesirable because it keeps light from penetrating the water, and light is required for algal growth. At very high concentrations, clay particles can also clog fish gills or smother fish eggs. Turbidity also may be objectionable to pond owners from an aesthetic standpoint.

Some sources of clay turbidity are runoff from clear-cut or overgrazed watersheds, road or building construction, the activities of cattle watering in farm ponds, pond bank erosion from wave action, excessive aeration, or the feeding activities of certain bottom-dwelling fish such as common carp or buffalo. This fact sheet will discuss the control of undesirable forms of turbidity, specifically that caused by suspended clay particles.

The effect of clay turbidity on dissolved oxygen

The dissolved oxygen in sportfish or farm ponds normally fluctuates widely during the summer. During the day, plant photosynthesis increases the oxygen concentration; during the night, plant and fish respiration reduces the oxygen concentration in the water. Clay turbidity reduces the magnitude of daily fluctuations in dissolved oxygen concentration, so that it gets neither very high nor very low. However, muddy water tends to have a lower average concentration of dissolved oxygen than water with a green phytoplankton bloom. Clay turbidity can sometimes develop quite suddenly, as when heavy storm runoff enters the pond or high winds churn the water and cause bottom soils to be resuspended. In such cases, oxygen may decline to critically low levels and make it necessary to aerate the pond.

The effect of turbidity on off-flavor in fish

Not much algae can grow in muddy water because clay particles limit the penetration of light into water. Blue-green algae are adapted to the dimly lit waters of moderately turbid ponds. Unfortunately, some of these algae can cause off-flavor in fish, which could be reason enough to clear water of clay turbidity. Interestingly, extremely muddy ponds have few, if any, algae in the water and often less problem with off-flavor than moderately muddy ponds.

The chemistry of colloidal clay suspensions

The chemistry of colloidal clay suspensions is not completely understood, primarily because fairly complex physical and chemical processes are involved. Clay particles are extremely small; some are even smaller than bacteria. Therefore, they will not settle readily, even in still water. The small size of these particles means that they have an extremely high surface area relative to the volume of the particle. A clay particle can be envisioned as a flat plate cov-

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ered with a negative electrical charge that attracts the positive ions in water. Positive ions that are immediately adjacent to the clay particle are said to be "adsorbed," while others that are farther away are less strongly attracted. In water, negatively charged clay particles are surrounded by clouds of positively charged ions. When these particles, surrounded by their ion clouds, come close to each other they are repulsed, much the same way similar poles of two magnets will repel each other (Fig. 1). The cumulative effect of the repulsion of a huge number of small particles prevents their aggregation into larger, heavier particles that would settle more readily. Taken together then, the extremely small size of clay particles and the surface electrical charge explain how particles remain in suspension.

Flocculation and coagulation

Flocculation is a way of controlling clay turbidity by adding substances to water that facilitate the formation of bridges between particles (Fig. 2), allowing them to combine into groups of small particles called "flocs" (Fig. 3). Metal salts make good flocculants, depending on pH. These hydrolyzed metal compounds destabilize colloids by shrinking the layer of positively charged ions surrounding clay particles, which increases the attraction of one particle to another (coagulation). Hydrolyzed metals also can be adsorbed onto the surfaces of clay particles and create bridges to other particles (flocculation). As these particles begin to settle, they ensnare other particles, become progressively heavier, and settle much more readily from suspension.

In general, the effectiveness of coagulants increases with the charge on the metal ion. The sodium (Na^+) in sodium chloride ($NaCl$) is not a very effective coagulant. The calcium (Ca^{2+}) in gypsum ($CaSO_4$) is more effective because it carries a +2 charge. The aluminum (Al^{3+}) in alum and the ferric-iron (Fe^{3+}) in ferric sulfate are more effective yet because

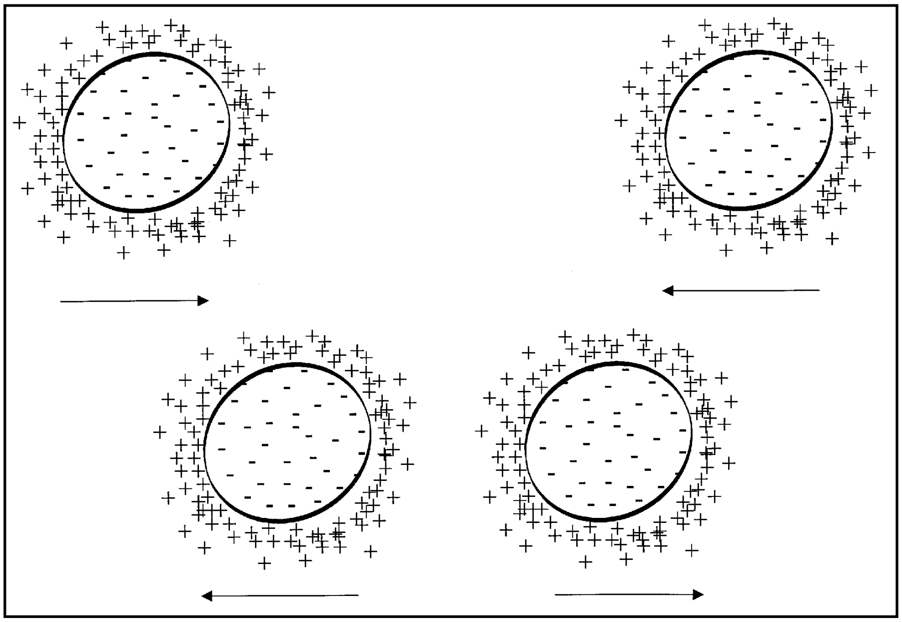

Figure 1. Small clay particles remain in suspension because they have the same surface charge and repel each other when they get too close.

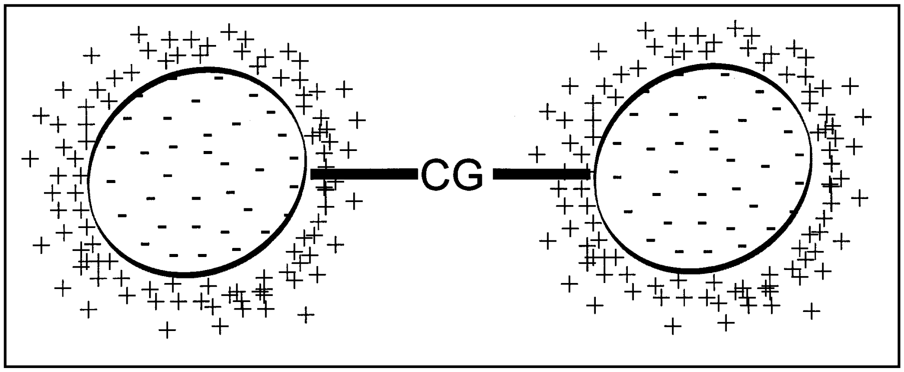

Figure 2. Coagulants (CG) such as alum form bridges between particles.

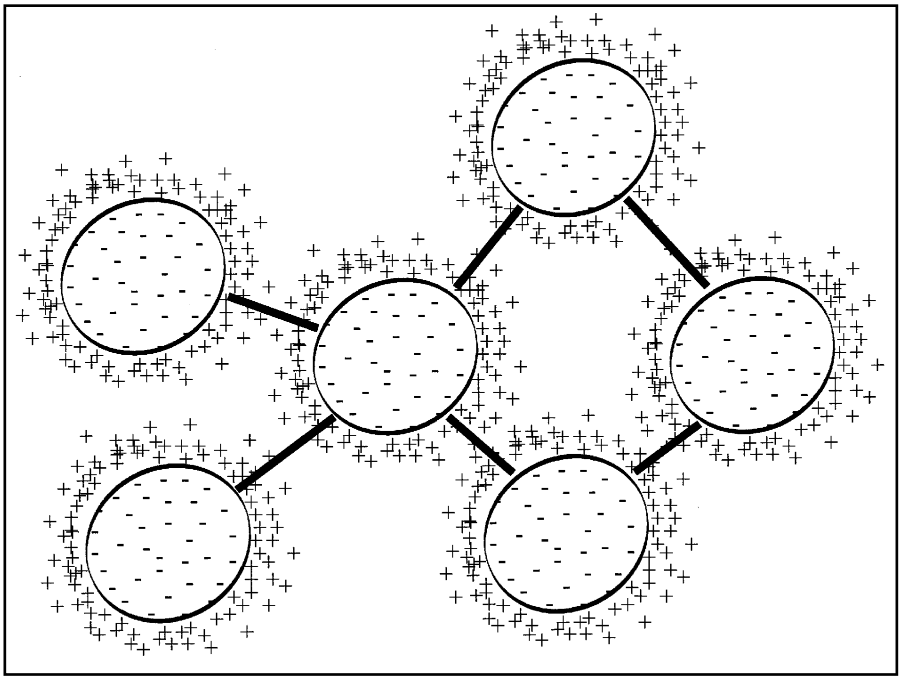

Figure 3. Adding coagulants to turbid water causes particles to aggregate into "flocs," which settle out more readily than individual particles.

they carry a +3 charge. Some companies now manufacture various synthetic "polyelectrolytes," which are large, long-chained molecules with even more charge than the metal salt coagulants listed here.

Alum

One of the most effective coagulants is alum, or aluminum sulfate, which has been used to clarify muddy waters since the time of the early Egyptians (2000 B.C.). Although alum is not always available from farm supply businesses, many companies selling industrial chemicals will carry it. A dose of 15 to 25 mg/L (150 to 250 pounds per acre) should be sufficient to remove the turbidity from most waters (Fig. 4). Use the lower concentration for moderately turbid (less than 12-inch visibility) waters and the higher concentration for highly turbid (less than 6-inch visibility) waters. Alum makes water more acidic. In ponds with low alkalinity (less than 20 mg/L as $CaCO_3$) it can reduce water pH to levels that may affect fish growth and survival. In low alkalinity ponds, add $^1/_2$ part hydrated lime for every part of alum applied in order to maintain proper pH.

Apply alum in calm weather because excessive turbulence will slow the settling of the flocs. The key to success with alum is to thoroughly and quickly mix the coagulant with the water. This can be accomplished by releasing a mixture of 10 parts water to 1 part alum into the prop wash of a boat as it is driven back and forth around the pond. Or, a slurry of alum and water can be spread over the pond surface. In ponds equipped with aerators, releasing a slurry of alum and water in front of the aerator will distribute it quickly. Wear a particle (dust) mask when mixing the dry chemical with water. If the dose is sufficient, water should be noticeably clearer within hours, although the full effect may not be apparent for several days.

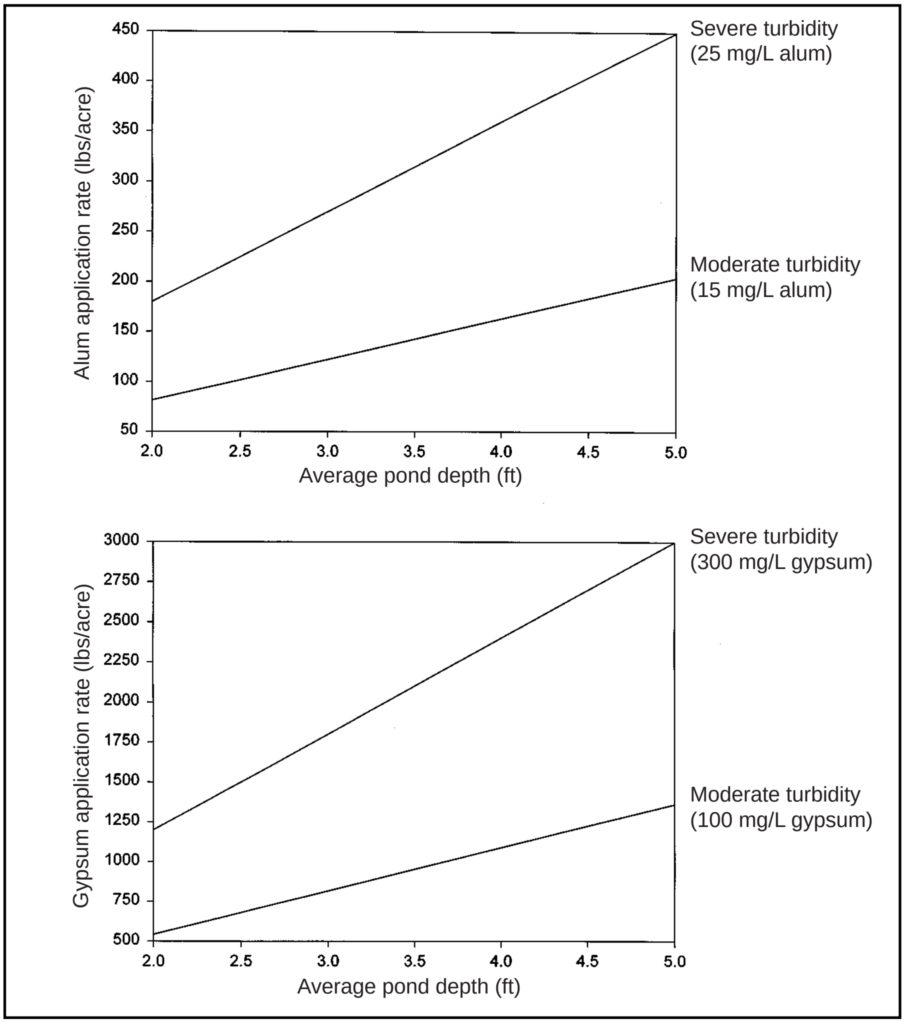

Figure 4. Guidelines for alum and gypsum application rates are a function of pond depth and the severity of the turbidity problem.

Other coagulants

Although not nearly as effective as alum, gypsum also can be used to control turbidity but without the loss of alkalinity. Gypsum must be added to achieve a concentration of 100 to 300 mg/L for effective turbidity control. For most ponds, gypsum application rates will range from about 1,000 to 2,000 pounds per acre (Fig. 4). In hard-water ponds (calcium hardness greater than 50 mg/L), the water is nearly saturated with calcium and gypsum may be ineffective. In that situation, alum will be the only effective coagulant.

All the coagulants mentioned can remove phosphorus from water. As phosphorus is an essential plant nutrient, it may be necessary to fertilize the pond after treating it for turbidity. On occasion, phytoplankton and clay can mutually coagulate, so fertilizing to start a phytoplankton bloom may also clear water of suspended clay particles.

Organic matter such as chopped hay or cottonseed meal can reduce clay turbidity in farm ponds. However, large amounts of material must be added to the pond, which may deplete the dissolved oxygen as the organic matter decomposes. It may also be difficult and costly to transport and uniformly distribute large amounts of organic matter.

The bucket test

Although the application rates recommended here for coagulants are applicable for most situations, there are many factors that can affect the effectiveness of the treatment process. These include the amount and kind of turbidity, chemical characteristics of the coagulant, mineral composition of the water, pH, temperature, and the amount of mixing during and after application. So, it is best to take an experimental approach to turbidity control. This can be done with a bucket test.

Obtain a small sample of a selected coagulant (alum or gypsum). Collect four 5-gallon buckets of turbid pond water. Carefully weigh four separate, small quantities of alum: 0.2, 0.3, 0.4 and 0.5 g. Add each weighed amount of coagulant to one bucket of water and stir vigorously for 1 to 2 minutes. Then, stir briefly every 5 minutes for up to 30 minutes. Observe the clarity of the water. Select the minimum dose of coagulant that clears the water. For example, suppose the water cleared in buckets 3 and 4, but did not clear in buckets 1 and 2. The dose of alum added to bucket 3 (0.4 g) would be the proper one.

Next, estimate average pond depth by measuring depth with a weighted line at 10 to 20 locations around the pond. Average depth also can be estimated by multiplying the maximum depth by 0.4. Select the application rate in Table 1 by first reading across the line for the minimum alum dose (0.4 g in the example) and then reading down the table to the average pond depth. The table entry where the two lines cross is the coagulant application rate in pounds per acre. To determine the total amount of coagulant required, multiply the application rate from Table 1 by the number of surface acres of the pond.

If gypsum is the coagulant selected, the bucket test and Table 1 can be modified slightly to determine application rates. Simply multiply the amount of coagulant added to each bucket by 10, adding 2, 3, 4 or 5 g gypsum to each bucket. Multiply the rates in Table 1 by 10 to determine the gypsum application rate. For example, if the minimum gypsum dose that cleared water was added to bucket 3 (4 g gypsum), and average pond depth is 3 feet, then the gypsum application rate is 1,810 pounds per acre.

Prevention is the best control method

Coagulants should be applied after the cause of the turbidity problem is corrected. Watershed protection and soil conservation practices should receive the highest priority for attention. If a watershed is to be clear-cut, leave buffer strips (stream-side management zones) about 50 to 100 feet wide along each side of feeder streams. These strips can trap a large quantity of sediment running off cleared slopes. If pond layout permits, divert turbid feeder streams around the pond or direct them through a sedimentation basin upstream from the pond. If a watershed is in pasture, balance livestock stocking rates with the availability of forage to minimize overgrazing. Within the pond, maintain grass cover along levees and pond margins. Deepen pond edges to minimize scouring of shallow edges by wave action. Windward levees in ponds with a long fetch (maximum length) oriented to the prevailing wind are subject to erosion by waves. Protect windward banks with riprap consisting of large boulders placed at the shoreline or log booms (logs linked with chain) placed along the base of the levee. Shallow sediments of old ponds may be periodically resuspended by wind-driven waves. Renovate old ponds after about 10 to 15 years by removing sediments that have accumulated. Spread and compact the excavated material on the pond levee. Finally, if practical, limit livestock access to a small section of the pond, preferably at the shallow end.

References

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Table 1. Alum application rates (pounds per acre) determined by a bucket test.

		Average pond depth (feet)						
Bucket	**Alum addition to 5-gallon bucket (g)**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
1	0.2	60	75	91	106	121	136	151
2	0.3	91	113	136	159	181	204	226
3	0.4	121	151	181	211	242	272	302
4	0.5	151	189	226	267	302	340	377

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