

CLEARING MUDDY PONDS

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INTRODUCTION

A frequent complaint of pond owners, especially after filling newly constructed ponds, is a muddy, dirty, or turbid appearance. Many owners wish for clear sparkling waters but are instead greeted by muddy ponds containing water that resembles chocolate milk. Turbid water, or turbidity, is caused by suspended organic and inorganic particles in a body of water that reduce clarity. In a muddy pond, it is primarily suspended clay particles that produce the turbidity.

It is important to understand the problems that turbidity produced by suspended clay particles could potentially cause in a pond's ecosystem. Clay turbidity in ponds reduces the ability of light to penetrate the water to depth, which results in reduced amounts of phytoplankton, and subsequently, reduced natural oxygen production and food for fish. Not only could muddy or turbid water cause stunted growth in fish, but overall aesthetics of the pond can be reduced. Another concern of muddy ponds is that suspended solids can lead to undesirable flavors, often referred to as "off-flavors," in fish harvested from the pond. Muddiness of ponds can also promote the growth



Figure 1. Newly constructed pond illustrating construction in clay soils. Photo displays how clay particles easily become suspended as the pond begins to fill, creating turbid or muddy water.

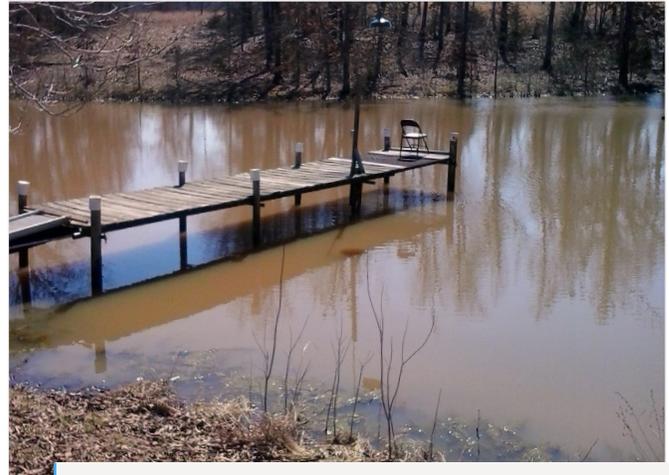


Figure 2. This photo displays turbid water, which can cause the fish within the pond to have an undesired flavor.

of bacteria and blue-green algae, which can lead to health problems for aquatic organisms, humans, and animals that may swim in or drink from the pond.

Most pond owners desire completely clear ponds that look "aesthetically pleasing," but due to lack of nutrients and associated food, this can also cause detrimental effects for fish populations if the pond owner is concerned about maintaining a good fishery. Completely clear water means there is no food in the water column for small fish to eat.

CAUSES OF MUDDY WATER

Ponds can appear muddy for various reasons. The most common causes for muddy ponds are new pond construction in clay soils, rainfall/runoff, erosion from wave action and other sources, and animals. One may wonder how these factors can cause a pond to become muddy, or turbid. To retain water, ponds must be constructed in, or lined with, clay-rich soil. Clay soils contain tiny, negatively charged clay particles that can suspend in the water, ultimately causing the appearance of muddy water. Runoff from a rain event can also bring clay particles into the pond from the surrounding environment.

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Figure 3. Livestock wading in ponds; lack of vegetation around a pond, resulting in runoff; and large quantities of bottom-dwelling fish, such as catfish, can stir or contribute clay particles to ponds, causing the water to become turbid.

Turbidity can result from high winds, abrupt changes in air temperature, and excessive rainfall disturbing clay particles, causing them to become suspended in the water. Wildlife, such as ducks, beavers, muskrats, and wading birds; livestock wading in or drinking from the pond; invasive species such as common carp, nutria, and feral hogs; and aeration systems can also cause suspension of clay particles. In some cases, fish species intentionally stocked into the pond, such as grass carp or catfish, can stir the bottom sediment, causing turbidity.

DETERMINING THE CAUSE OF THE PROBLEM

Before treating a pond, one must first determine the underlying cause of the issue—whether it is due to a problem stated above or it is related to a chemistry issue—and eliminate it. This is a crucial and often overlooked step. If the cause of the suspended clay is not first eliminated, the turbidity can soon return after a clearing treatment, resulting in wasted money and effort.

Testing turbidity/suspended particles

To test turbidity or issues with suspended particles, begin by taking a water sample in a clear jar. Place the water sample on a countertop and do not touch or move the jar for 24 hours. If the sediment settles to the bottom and the water now appears to be clear, this indicates that the pond has a problem caused by a physical issue identified above, such as fish, wildlife, an aerator, or rainfall/runoff stirring particles in the water. If this is the case, identify and remove the physical issue to clear the water. If the



Figure 4. Clear jug containing pond water used to test turbidity. While some sedimentation can be seen at the bottom of the jug, the photo still displays cloudy water, indicating that the chemistry of the water needs to be tested.

sediment does not settle, it is likely there is a problem that needs to be addressed through the chemistry of the water, and more tests need to be performed.

Testing the water chemistry

Once it has been determined the muddiness is not a result of a physical issue such as those above, it is now time to test if the issue can be addressed by water chemistry. Alkalinity, pH, and hardness tests should now be performed. These tests are important to determine which of several possible chemicals is most likely to clear a pond based on chemistry. There are two options for these tests. The first option is to pay a professional to take a sample of the water and determine the pH, alkalinity, and hardness of the pond water. The second option is for pond owners to do it themselves by purchasing a water chemistry kit available at many pool, pet, and farm stores, as well as online to determine the pH, alkalinity, and hardness of the pond water. Quick test strips are not recommended as they provide too large of a range to be accurate for the needs of a pond clearing test, and interpretation of results is quite subjective based on each individual's interpretation of the colors.

Unless pond owners have knowledge of water chemistry testing, are able to accurately interpret the results, and are willing to purchase more accurate testing kits and equipment than can be found at most pet and pool stores, it may be best to hire a professional to sample the pond. Hiring a professional is often less expensive than individually purchasing all of the testing supplies and chemicals and will yield more accurate results. The Texas A&M Aquatic Diagnostic Laboratory (ADL) performs basic water chemistry testing as well as pond chemical clearing tests to identify the chemical(s) most likely to clear the pond based on the water chemistry present. In addition, these tests will determine how much chemical is required to achieve a sufficient clearing result. More information on the ADL, the tests it performs, and directions on how to take and submit a sample can be found at <https://fisheries.tamu.edu/aquatic-diagnostics-lab/>.

TYPES OF CHEMICALS THAT CAN BE USED TO CLEAR PONDS

The results of the water chemistry tests indicate which chemical(s) is most likely to be successful at clearing the pond based on the chemistry present. There are four basic chemicals in addition to synthetic polymers that can be used to clear ponds with fish in them. These include agricultural lime (calcium carbonate), gypsum (calcium sulfate), alum (aluminum sulfate), Epsom salt (magnesium sulfate), and synthetic polymers available under various trade names. Some chemicals that can be used to clear ponds cannot be used in ponds containing fish because they can cause rapid changes in water chemistry that can kill fish. For ponds without fish, there are six basic chemicals plus synthetic polymers that are applicable for use. In addition to the four chemicals and synthetic polymers listed above, hydrated or slaked lime (calcium hydroxide) and quick or burnt lime (calcium oxide) may also be options for ponds that do not yet contain fish.

Based upon water chemistry, chemicals will need to be combined in some cases to keep the aquatic environment safe for fish and wildlife within the pond. For example, when using alum—which acidifies water—in low alkalinity waters such as those in much of East Texas, hydrated or agricultural lime must be applied at the same time to prevent rapid pH change and potential harm to fish. If alkalinity is greater than 50 parts per million (ppm) when using alum, the use of hydrated or agricultural lime may not be necessary.

Limestone or agricultural lime

Calcium carbonate, or agricultural lime, is commonly used to clear ponds when both hardness and alkalinity are low (<50 ppm) and are relatively close to a ratio of 1 part alkalinity to 1 part hardness. Calcium carbonate is considered to be a weak flocculating agent and is successful for long-term clearing in less than 20 percent of applications in which water chemistry is unknown. The effectiveness of calcium carbonate is increased dramatically when used in the correct situation when hardness and alkalinity are low but in relatively equal proportions. It works by increasing the hardness and alkalinity of pond water as well as stabilizing the pH. Calcium ions (Ca^{2+}) from the lime have a positive ionic charge so they can bind to negatively charged clay particles suspended in the water, causing them to clump and sink out of the water column. This is a process called flocculation. Due to weaker binding affinity, calcium carbonate often requires more than a ton of material per acre-foot of water, which can be difficult to apply.

Oftentimes, calcium carbonate is used in conjunction with other clearing chemicals that may acidify the water to help maintain a neutral pH and maintain alkalinity. There

are many benefits to the fishery and pond food chain of adding agricultural lime to ponds with low alkalinity or pH, aside from clearing effects. Therefore, if ponds have low alkalinity or pH, it can be beneficial to apply calcium carbonate to the pond to see if any clearing effect occurs before adding a different clearing treatment. If some clearing occurs, calcium carbonate alone may be the solution. If not, the pond will receive other benefits from agricultural lime and will now have sufficient alkalinity and buffering to apply another clearing chemical such as aluminum sulfate or magnesium sulfate.

Gypsum

Much like agricultural lime, gypsum (calcium sulfate) is considered a weak agent. Calcium sulfate is most successful when ponds have sufficient alkalinity (>50 ppm) but low hardness (<37.5 ppm), or when the hardness to alkalinity ratio is 0.75:1 or lower. The goal with calcium sulfate is to add enough calcium ions to increase hardness relative to alkalinity and bring the hardness close to a 1:1 ratio with alkalinity and hardness both greater than 50 ppm each. Like calcium carbonate, positively charged calcium ions (Ca^{2+}) from the gypsum bind to negatively charged clay particles suspended in the water, causing them to flocculate. The sulfate from calcium sulfate acidifies the water but is balanced by the already higher alkalinity to hardness ratio of the water.

Calcium sulfate tends to be successful in approximately 65 percent of applications when used in water with the right chemistry—sufficient alkalinity but low hardness. Due to weaker binding affinity, calcium sulfate often requires more than a ton of material per acre-foot of water, which can be difficult to apply. If the pond water has sufficient hardness (> 50 ppm), gypsum is not likely to be effective and should not be used.

Alum

Aluminum sulfate, commonly referred to as alum, is one of the most effective and oldest treatments for flocculating clay particles in a pond. It is also referred to as one of the “big guns” in clearing muddy water because it works in many different water chemistries and works where other treatments such as gypsum and agricultural lime do not. A drawback of alum is that it can rapidly lower both the pH and alkalinity of the



Figure 5. Aluminum sulfate, one of the “big guns” of clearing turbidity, is displayed in the image above. Due to its ability to rapidly lower the pH of pond water, it should only be used on ponds with an alkalinity higher than 50 ppm.

pond, potentially harming or even killing fish, so it should only be used in ponds with sufficient alkalinity of greater than 50 ppm. It can be used in ponds with an alkalinity of less than 50 ppm, but the pond must first be limed with agricultural lime to increase alkalinity above 50 ppm. An alternative is to apply alum along with hydrated or slaked lime (calcium hydroxide) at the same time at a ratio of 0.43 pounds of hydrated lime per pound of alum to prevent rapid pH change. It is good practice to apply a ratio of 0.43 pounds of hydrated lime per pound of alum even in ponds with alkalinity greater than 50 ppm to ensure stable pH and improve safety for fish present in the pond.

The positively charged aluminum ion (Al^{3+}) binds negatively charged clay particles to flocculate them, similar to the calcium ion (Ca^{2+}), but because it has a greater positive charge, it has a greater binding affinity for negatively charged clay particles and achieves a greater flocculation effect. Because it has a greater flocculation effect, a much smaller quantity of material is required to achieve a clearing effect compared to agricultural lime or gypsum. It is important to note that when using alum as a treatment in pond water, it needs to be quickly and thoroughly mixed. It should not be divided into several treatment periods, and it is best to apply alum during calm weather. If the wind is blowing too much, it could cause turbulence in the water and slow the settling of the suspended particles.

When using alum, it is best to make a slurry (mixture of water and alum, and hydrated lime if necessary) and distribute the slurry directly onto the pond's surface. The broader the area of application that can be done quickly, the better the results will be. A boat is often used for application over the surface area of ponds larger than 1 acre by pouring the slurry into the prop wash of the boat motor. In smaller ponds, a boat can be backed into the water, so the lower unit of the motor is submerged but the boat is left on the trailer hooked to the vehicle. The motor is then started and put into gear, and the slurry is poured directly into the prop wash to be circulated around the pond. Make sure to avoid inhalation of aluminum sulfate by wearing a dust mask when mixing the alum powder with water. After applying the chemical to the pond, the water should appear clearer within a few hours. The full effect of the treatment may take up to several days after the treatment was added.

Epsom salt

Epsom salt (magnesium sulfate) is another clearing treatment that works where other treatments such as gypsum and agricultural lime do not. A drawback of magnesium sulfate is that it can rapidly lower both the pH and alkalinity of the pond, similar to alum, potentially harming or even killing fish, so it should be used only in ponds with sufficient alkalinity of greater than 50 ppm. The positively charged magnesium ion (Mg^{2+}) binds

negatively charged clay particles to flocculate them, similar to the calcium ion (Ca^{2+}) in agricultural limestone and gypsum. The magnesium ion has a slightly greater binding affinity for negatively charged clay particles and achieves a greater flocculation effect than the calcium ion but is not as strong as the aluminum ion from alum. Because it has a slightly better flocculation effect than calcium, a smaller quantity of material is needed to achieve a clearing effect compared to agricultural lime or gypsum.

A drawback of magnesium sulfate is it is difficult to find in bulk quantities necessary to clear large ponds at a reasonable cost. Therefore, it is normally only used in specialized circumstances where other compounds may not be suitable. Another drawback of magnesium sulfate is that, like alum, it acidifies the water. This means that low alkalinity (<50 ppm) ponds must be limed with agricultural lime before applying magnesium sulfate. It is good practice to apply a ratio of 0.3 pounds of hydrated lime per pound of magnesium sulfate even in ponds with alkalinity greater than 50 ppm, to ensure stable pH and improve safety for fish present in the pond.

Synthetic polymers

Many synthetic polymers are marketed for clearing muddy ponds, such as polyacrylamide (PAM). However, it often takes a large amount of synthetic polymers to clear a pond, and due to the high cost, it may not be economically feasible for many pond owners. While these synthetic polymers often have about an 80 percent success rate of clearing ponds, their ability to keep the ponds clear is, in many cases, short-lived. Most ponds that are successfully cleared by these compounds become clouded again within 2 years. The reason synthetic polymers are not always effective long-term is unclear, but it has been demonstrated that synthetic polymers such as PAM are degraded by ultraviolet (UV) rays, and prolonged UV exposure from sunlight may eventually break down these polymers. In addition, many species of bacteria found in ponds biodegrade PAM by using the amide group of the polymer as a nitrogen source or the carbon chain as a carbon source.

Hydrated or slaked lime and quick or burnt lime

If there are no fish present in the pond, then other pond clearing treatments may be utilized. These chemicals should not be used in ponds that contain fish because they produce rapid pH and alkalinity changes and have a high probability of killing fish. If no fish are present, calcium hydroxide (hydrated/slaked lime) or calcium oxide (quick/burnt lime) may be considered. These compounds work similarly to agricultural limestone and gypsum by using the calcium ion to flocculate clay particles. As such, they have relatively weak clearing effects, similar to agricultural limestone and gypsum, but they are capable

Table 1. When to appropriately use chemicals.

Chemical	pH	Alkalinity	Hardness	Alkalinity: Hardness	Used When Fish Present	Effectiveness
Limestone/Ag. Lime (calcium carbonate)	<7.5	<50 ppm	<50 ppm	~1:1	yes	weak
Gypsum (calcium sulfate)		>50 ppm	<37.5 ppm	1:0.75 or lower	yes	weak
Alum (aluminum sulfate)	>7	>50 ppm		~1:1	yes, with adequate alkalinity	strong
Epsom Salt (magnesium sulfate)	>7	>50 ppm		~1:1	yes, with adequate alkalinity	moderate/strong
Synthetic polymers		varies based on compound			yes	moderate
Hydrated or Slaked Lime (calcium hydroxide)	>7				no	weak/moderate
Quick or Burnt Lime (calcium oxide)	>7				no	weak/moderate

of causing much more rapid changes in pH. These chemicals raise pH rather than decreasing it, so they are suitable for use in acidic to very weak alkaline waters. People often choose to use these compounds when fish are not present due to their low cost and wide availability.

Bucket or jar test

After pH, alkalinity, and hardness of the water have been determined and the most effective chemicals selected from the section above, owners can then perform a bucket or jar test to 1) determine if the chemical they selected will in fact be effective at clearing their pond; and 2) determine the quantity of chemical necessary to clear their pond. It is often advisable to do a bucket or jar test using at least two compounds from above, one with weak to moderate and one with moderate to strong activity, as long as both compounds are suitable for use with the pond's current water chemistry. The reason for using two compounds is to determine the cost effectiveness of the treatment as well as the efficacy of the chemical before spending a large amount of money on a clearing treatment. For example, a compound with weak activity such as gypsum might clear the water and be a lower cost per quantity unit, yet the larger amount of material (and trucking costs, which are often the largest expenses) needed to clear the pond may be more expensive in total than a compound such as alum that is more expensive per unit quantity but has stronger activity and requires far less material.

Begin by accurately measuring 1 gallon of pond water into each of several clear or see-through jars or buckets. Accurate measurement of the water is necessary, or the results may not be reflected in the pond water when the scale of the bucket test is multiplied up to the pond size. A minimum of five, 1-gallon containers will be needed for each chemical being tested, such as alum. Some chemicals, such as gypsum or agricultural

lime, may require several more containers or require the test to be divided into two different testing periods if enough containers are not available. Be careful not to disturb the pond sediment when collecting the water, as this can affect the results and cause the application of more chemical than necessary to clear the pond. Set aside 1 gallon of water in a container to act as the control. Carefully measure the appropriate amount of the chemical (see Tables 2 and 3 and table captions) being tested, mix it into a slurry following the directions in the table captions, and pour the correct, measured amounts into each of the remaining 1-gallon buckets of pond water. Label the buckets if necessary to keep track of the treatment quantities added. Stir each bucket vigorously for 1 to 2 minutes. Stir each bucket again after 30 minutes. Then leave the buckets undisturbed for 12 hours.

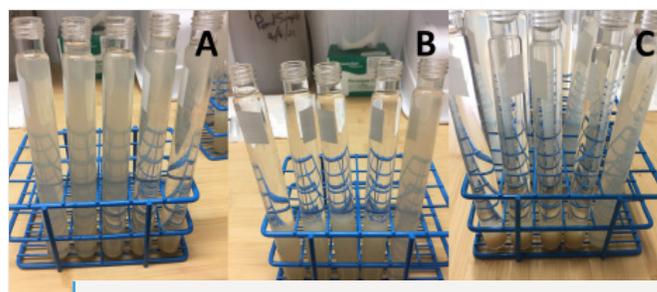


Figure 6. Miniaturized clearing test used by the Texas A&M Aquatic Diagnostic Laboratory to determine the quantity of gypsum to clear a pond. A) Samples of pond water prior to treatment. B) Pond water 5 minutes after adding five different rates of gypsum to the samples with decreasing concentrations of gypsum moving from left to right. The clay can already be seen precipitating in the flocculent in the four samples to the left, while the sample on the far right with the lowest dose of gypsum is not exhibiting a clearing effect. C) Displays the pond water 2 hours after adding the gypsum. A strong clearing effect can be seen with a significant precipitate located at the bottom of the tube in the four higher doses on the left, while the tube on the right containing the lowest dose of gypsum has yet to clear.

Table 2. Determining the proper amount of alum (aluminum sulfate) to use to clear muddy water during a bucket or jar test using 1 gallon of water for each application rate. Mix 1 level tablespoon (using a standard measuring spoon) of alum in 1 gallon of clean tap or well water and stir until alum forms a slurry (uniform mixture of water and chemical—all of the chemical may not be dissolved but should be in suspension through the stirring motion). This table lists how the number of tablespoons of slurry added to a 1-gallon pond water sample translates to pounds of chemical needed to clear a pond if the water sample clears in 12 hours.

Tablespoons of slurry added to 1-gallon pond water samples	Rate of alum to apply to pond if sample clears in 12 hours (lbs/acre-ft)	For ponds with alkalinity <50 ppm, add hydrated lime at the rate of (lbs/acre-ft)	For ponds with alkalinity >50 ppm, add hydrated lime at the rate of (lbs/acre-ft)
1	30	13	0
2	60	26	0
3	90	39	13
4	120	52	17

After 12 hours undisturbed, observe the changes in the water clarity within the test buckets. To determine which dosage to use, look at the clarity of the water and use the minimum dose required to make the water clear. For example, if buckets one and two are still completely or partially cloudy, but buckets three and four are both clear, the dose in bucket three would be used. If the tests were conducted in colored buckets because clear jars

or buckets were not available, at this point, a clear glass can be used to gently remove a sample of water from the top of the bucket to assess clarity. It is common to see between ¼ and 2 inches of loose sediment at the bottom of the bucket or jar. This is the clay and organic particles that have been flocculated by the clearing treatment. Be careful not to disturb this layer when examining the samples, or the sediment may accidentally become suspended in the water sample again. If this happens, allow the samples to sit undisturbed for another 12 hours and reevaluate.



Figure 7. Water clarity of pond prior to treatment with aluminum sulfate.



Figure 8. Water clarity from the pond in Figure 7, approximately 3 hours after treatment with alum. The water has already cleared enough to see catfish swimming in shallow water along the bank.

Table 3. Determining the amount of gypsum (calcium sulfate), agricultural limestone (calcium carbonate), or Epsom salt (magnesium sulfate) to use to clear muddy water during a bucket or jar test using 1 gallon of water for each application rate. Mix 2 level tablespoons (using a standard measuring spoon) of gypsum, agricultural limestone, or magnesium sulfate in 1 gallon of clean tap or well water. Stir until the gypsum, agricultural limestone, or magnesium sulfate forms a slurry (uniform mixture of water and chemical—all chemicals may not be dissolved but should be in suspension through the stirring motion). The table below lists how the number of tablespoons of slurry added to a 1-gallon pond water sample translates to pounds of chemical needed to clear a pond if the water sample clears in 12 hours.

Tablespoons of slurry should be added to 1-gallon pond water samples	Rate of chemical to apply to pond if sample clears in 12 hours (lbs/acre-ft)
1	80
2	160
3	240
4	320
5	400
6	480
7	560
8	640
9	720
10	800
11	880
12	960



Figure 9. Water clarity from the pond in Figures 7 and 8, approximately 8 hours after treatment with alum. Schools of sunfish are easily visible in the newly cleared water.

PREVENTION OF MUDDY PONDS

A common “fix” for muddy ponds is the application of chemical coagulants such as alum, limestone, gypsum, Epsom salt, etc. Chemical coagulants should only be applied after the cause of the turbidity has been identified and corrected. There are several simple actions that pond owners can take to limit turbidity in their ponds. Pond owners should maintain tall grass (>6 inches) or other heavy vegetation cover around the pond border and levees. They should minimize the scouring of shallow edges by deepening them. Owners can also protect windward banks by placing rip rap or large boulders along the shoreline to block some of the wave action. Geotextile fabric can be placed along exposed banks to limit wave action suspending clay particles. Sediments that have accumulated over time in older ponds should be removed to prevent winds from stirring up shallow sediments. Owners should give livestock access to only a small portion of the shallow end of a pond for watering and fence off the remainder of the pond. Lastly, avoid stocking the pond with bottom-dwelling or rooting fish

such as carp, koi, buffalo, and catfish that may stir up pond sediments.

Keep in mind that any clearing treatment is likely to be short-lived in bodies of water with substantial catfish, koi, carp, or any other benthic fish populations; aerators (especially on-bottom or upwelling aerators); livestock drinking from/entering the pond; or with areas of bare land or erosion around the pond or upstream in the watershed. These factors will eventually re-suspend clay particles flocculated from clearing treatments or add new clay particles to the pond. Causes of turbidity must first be identified and eliminated before any clearing treatment should be applied. Clearing effects may last 1 day or 2 years, but the water will likely become turbid again if any of the aforementioned factors are present.

One way to maintain the clarity of a pond for a longer period of time is to line it with a pond liner. This provides a physical barrier between the water and the clay sediment of the pond bottom to prevent suspension of clay particles. Also, new ponds frequently experience high clay turbidity rates for the first couple of years and many, although not all, clear on their own as the pond ecosystem becomes established. Some ponds simply may never become fully clear no matter what clearing treatments are applied, due to a variety of soil and environmental factors.

SUGGESTED READINGS

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