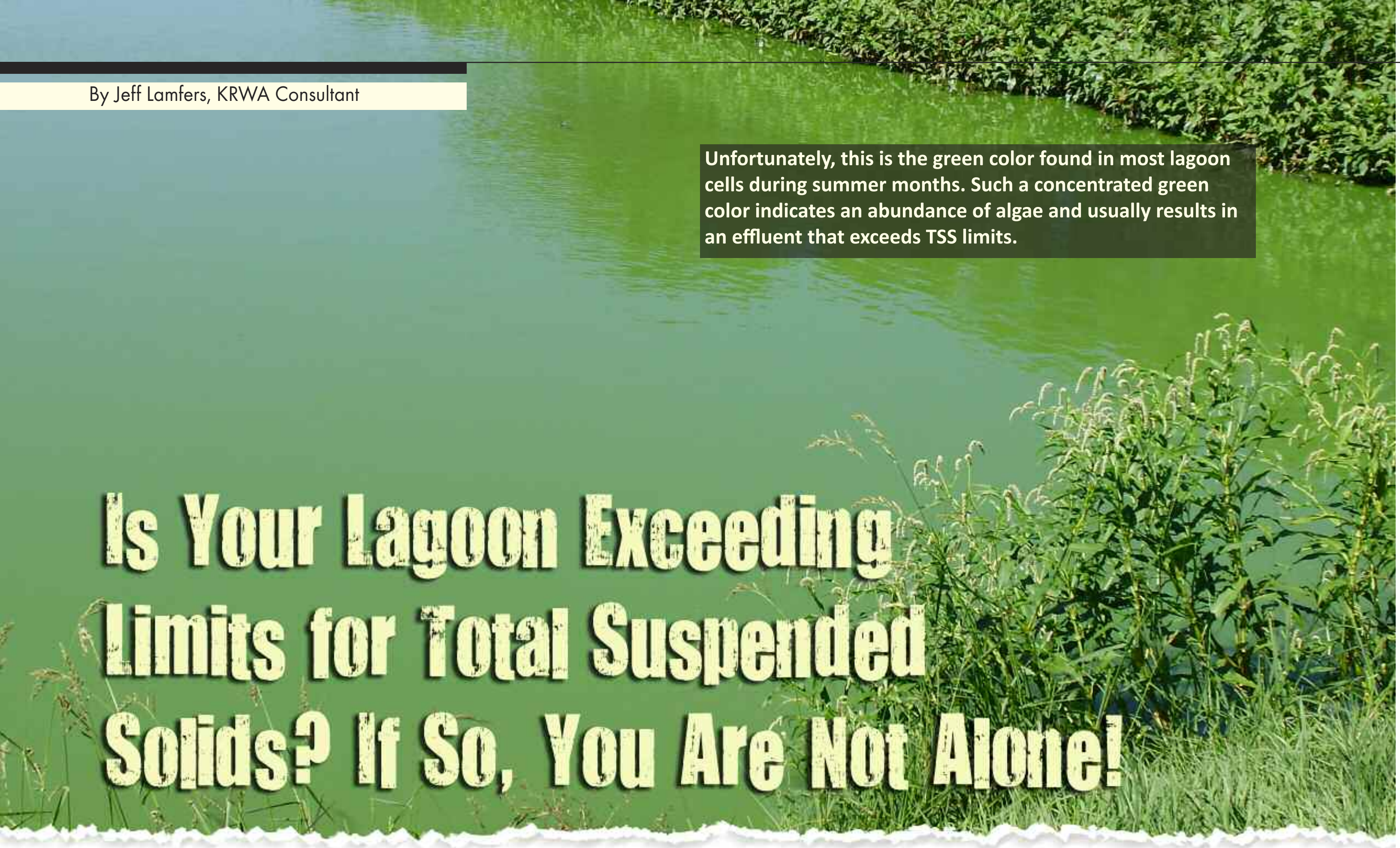
By Jeff Lamfers, KRWA Consultant

Is Your Lagoon Exceeding Limits for Total Suspended Solids? If So, You Are Not Alone!



Unfortunately, this is the green color found in most lagoon cells during summer months. Such a concentrated green color indicates an abundance of algae and usually results in an effluent that exceeds TSS limits.

In late summer and fall, many discharging lagoons have problems meeting limits for Total Suspended Solids (TSS). For most lagoons in Kansas that discharge, the TSS limit is a monthly average of 80 mg/L. And many of the wastewater systems referred to KRWA by the Kansas Department of Health and Environment (KDHE) are lagoons that have problems meeting TSS limits. Why is that? The reason can easily be explained by examining the biological processes that occur in lagoons.

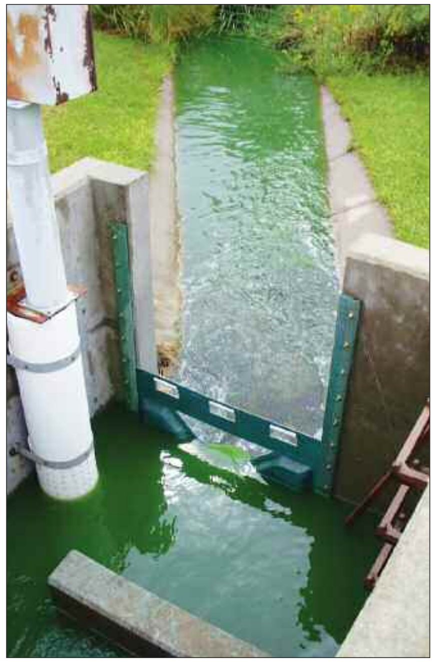
Lagoons are considered a form of "secondary treatment" as they rely upon biological processes to break down incoming organic matter (sewage). Lagoons rely upon facultative bacteria to decompose organic matter. This is probably the most important of the on-going processes in a lagoon. In order to accomplish such, the bacteria rely on a food source (sewage) and free available oxygen. Typically, there is not much oxygen, if any, in raw sewage. But once raw flow reaches a well-designed and operated lagoon, there is an abundant, reliable, effective source of oxygen – algae. Algae are green plants that go through a process known as photosynthesis. Photosynthesis is the process whereby all green plants, including algae, use nutrients, an energy source such as sunlight and carbon dioxide to produce more algae. And in the process they release a very important byproduct: oxygen. This oxygen released by algae is then used by facultative bacteria to break down organic matter. Consequently, the relationship between facultative bacteria and algae is very important in lagoons and essential in reducing BOD and ammonia levels in incoming raw sewage.

Obviously, the more algae present in a lagoon, the more oxygen is available. Both KDHE and KRWA staff compliment operators that the wastewater in their lagoons has "a good green color." That simply means that such an observation indicates sufficient dissolved oxygen is available. If the wastewater is any color other than green, then most likely, dissolved oxygen levels are much less, even possibly inadequate for breaking down raw sewage. Having that "good green color" in all cells but the final cell is very desirable and necessary if limits for BOD and ammonia are to be met. But a problem results if that "good green color" extends into the final cell of a discharging lagoon. Why? Because when an effluent sample is collected and analyzed by the laboratory, the TSS test procedure does not recognize the difference between "sewage solids" (sludge, bacteria, inorganic matter, debris, etc.) and algae. The sample is run through a filter which collects all solids, including algae. So, if the final cell is excessively green with algae, the concentration of algae alone may be enough to push the lagoon effluent over the TSS limit.

The question then becomes how does an operator deal with such a situation? Can the concentration of algae be controlled such that algae are present in high concentrations in all but the final cell? Theoretically in lagoons, the hope is that once flow reaches the final cell, most nutrients such as nitrogen and phosphorous have been removed and no longer contribute to producing more algae. Based on such theory, the final cell should be a polishing cell with clear wastewater where nutrient levels are low and no longer promoting photosynthesis, and thus algae. Unfortunately, this is rarely the case and the tools available to an operator to control algae in a lagoon are limited.

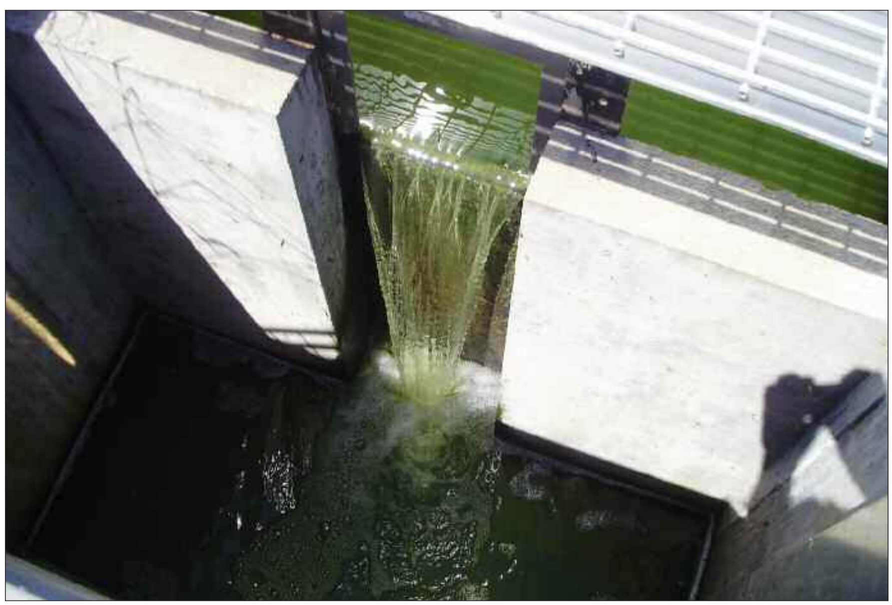
Using discharge structures with varying draw-off pipes

In my opinion, the most reliable way of meeting TSS limits consistently, even during summer months with concentrated algae due to long days and more direct sunlight, is to draw the lagoon effluent from below the water surface. Since algae need sunlight during photosynthesis, they tend to concentrate near the water surface. If you were to view a core sample from a lagoon, you would see algae (and the associated green color) in the top 18 to 24 inches, a sludge/solids layer on the bottom and then in between, a layer of clearer wastewater. In theory, this clear layer is influenced neither by surface algae nor solids on the bottom of the lagoon. Unfortunately, most lagoons draw their effluent from or very near the surface. But many consulting engineers over the past twenty years have started including discharge structures that allow drawing effluent from below the water surface. This improvement often includes two to three draw-off pipes at differing levels (elevations). Engineers will also often design the system so the last cell is deeper than the preceding cells, thereby giving the final cell a wider "clear layer" from which to draw a better quality effluent lower in TSS. Such final cells can be eight to twelve feet deep versus an average depth in primary and secondary cells of 4.5 to 6 feet. The upper draw-off pipe is often 1.5 to 2 feet below the water surface, the middle draw-off pipe is 3-6 feet below the water surface, and the lowest draw-off pipe is 1-2 feet off the bottom. Operation of such a setup typically recommends using the middle or lowest draw-off pipes during the summer when algae concentrations are high, and using the upper or middle draw-off pipes during the winter when algae are less concentrated and the bottom sludge layer can be deeper.



This photo shows an example of a typical lagoon effluent during summer months. Notice the bright green color. The operator had sampled this effluent several days prior to the photo being taken. The TSS concentration was 96 mg/l which exceeds their limit of 80 mg/l.

I often find operators who have such a set-up, either do not use it or don't understand how it can be beneficial in producing a better quality effluent. I encourage operators to check the plans or blueprints of the lagoons and see if they have such an arrangement. If so, begin collecting samples in clear, glass containers from each draw-off pipe, not for analysis by your laboratory, but simply for visual observations to see which pipe gives the clearest, less green effluent. Obviously, depending on factors such as wind and/or cloud cover, you may find that results differ from day to day. For example on a windy day, the final cell may not clearly stratify into distinct layers like it might on a calmer day. Also, the algae layer may not extend as deep if samples are collected at sunrise verses if samples are collected in the middle of the afternoon. The time of year can also influence the "clearness" of an effluent sample. During summer, the algae layer likely will extend deeper into the final



This photo was taken during the summer and shows a lagoon producing a high-quality effluent low in Total Suspended Solids. If sampled, this effluent should meet TSS limits. Note that it has a slight green color, but not the concentrated green color found in the other photo accompanying this article. This lagoon happens to discharge off the surface of the final cell. But fortunately, sufficient algae die-off occurs prior to discharging.

This lagoon is equipped with a discharge structure that allows drawing effluent at varying depths from the final cell. It is a good idea to "mark" each valve to ensure samples are collected properly In this case, "L" is for the lowest draw-off pipe, "M" is for the middle pipe and "H" is for the upper pipe.

cell than during the winter. During winter, the algae layer may not be as deep due to shorter days and possible ice cover that blocks sunlight. This likely explains why some lagoons have no problems meeting TSS limits during colder months, but have problems during the summer. Again, if your lagoon discharges, I encourage operators to check their plans and/or discharge structures to see if they are equipped with draw-off pipes at different levels. If so, begin experimenting to see which provides the clearest, best quality effluent. If KRWA staff can help make such a determination, please contact us. For some discharging lagoon systems, proper use of such a set-up can be the difference between compliance and non-compliance.

Covering discharge structures to block sunlight

Another improvement encouraged by KDHE is to cover the discharge structure with something that will block sunlight. This can be a piece of plywood or even a tarp. Probably the best solution is to use a piece of heavy-duty rubber floor mat, cut to size. Not only is it heavy enough that wind won't blow it away, but also easily removed when collecting effluent samples. In my opinion, this improvement provides better results in those lagoons that have low or very-low effluent flow. In such cases, effluent remains in the discharge structure long enough, that sunlight may affect it by promoting photosynthesis. However, if the lagoon always discharges at a high flow rate, the wastewater may not remain in the structure long enough for sunlight to have any adverse effect.

Recommendations on collecting effluent samples

I briefly covered this subject earlier in this article. But to summarize, if TSS is a problem, try collecting effluent samples earlier in the day versus the middle of a hot, sunny afternoon. Another suggestion is to try collecting samples after several days of cloudy weather. Again, with less sunlight hopefully algae are less concentrated in the effluent.

Collecting samples during months when samples should contain less algae should be another consideration. This is especially true for lagoon systems that don't always discharge. In such cases, try to manage the lagoon and the resulting discharge so that the discharge is during months where algae concentrations should be lower. For example, if possible, operators should avoid discharging and having to collect samples during the third quarter (July – September). Of all quarters, this is the quarter where algae are often a major problem. If you must discharge during the fourth quarter (October – December), I would delay collecting effluent samples until the end of the quarter with the hope that cooler weather and shorter days will lower the concentration of algae in the effluent. I am not sure there is much difference during the months of the first quarter (January – March). But during the second quarter (April – June), earlier should be better, trying to avoid June when algae blooms may be in progress. Finally, always flush out the discharge structure two to three days before collecting samples. Solids can collect in the structure or behind the weir over time and adversely affect effluent samples. I would not flush out the box at the time of sample collection as that could actually increase TSS levels by suspending more solids.

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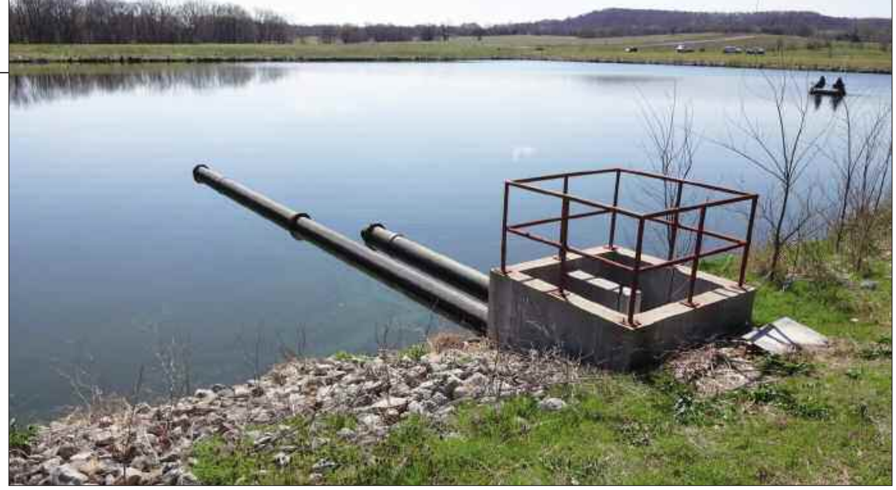
Other potential solutions

Finally, I would like to briefly review other options for lowering TSS in the lagoon effluent that have provided mixed results. But since biological processes differ from lagoon to lagoon, I thought worth mentioning them as they may prove beneficial for some:

- Introducing duckweed on the final cell: In theory this might actually work. Having a heavy duckweed layer on the final cell would provide a barrier to block sunlight and hopefully result in less algae in the cell and effluent. The obvious problem here is how do you ensure duckweed doesn't end up on the other preceding cells? All preceding cells, especially the primary, need to be barrier-free so algae have access to abundant sunlight and can provide sufficient oxygen for the facultative bacteria to break down incoming wastes. Based on my experience, once duckweed develops on a lagoon, it is very hard to eradicate. So, not sure this would be a recommendation I would suggest trying.
- Introducing grass carp (White Amur): This idea has been tried in a few lagoons, but with very little to no benefit. There should be plenty of dissolved oxygen in a final cell to support such fish. But it is my understanding that algae are not a preferred food source for grass carp. They will consume other aquatic plants before filtering algae out of water. Also, they don't usually reproduce naturally because they have very specific breeding requirements. They do grow quickly and can become quite large. I have had operators tell me that they thought grass carp actually caused higher effluent TSS due to stirring up solids on the bottom of the final cell. So again, I would proceed cautiously if considering introducing grass carp to your lagoon system. I would also suggest contacting KDHE beforehand. Consulting with a fisheries biologist with the Kansas Department of Wildlife, Parks and Tourism may also be a good idea.
- Using barley straw to control algae: I have written a previous article on this subject and it can be found in the November 2018 issue of *The Kansas Lifeline*. In short, when barley straw decomposes it

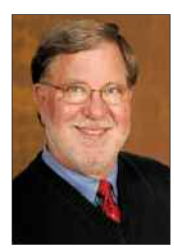


The discharge structure for this lagoon allows drawing effluent from two different depths of the final cell. Fortunately, the water level was down and the lagoon was not discharging so that this photo could be taken. Once a higher water level returns, the operator can then visually inspect water samples from each of the two depths to see which draw-off pipe produces an effluent with less green color and hopefully a lower Total Suspended Solids (TSS) concentration.

produces hydrogen peroxide which is toxic to algae. Problems with using barley straw include finding a reliable supply source and it's very labor intensive to use. Mesh bags must be stuffed with straw and then floats attached to the bags to make sure they stay on the surface and don't sink. Then the bags must be recovered every two to four weeks and replenished with new straw. There are suppliers out there, but most are out-of-state and can only be found on-line. The cost is usually not prohibitive. I suggest reading my previous article if interested.

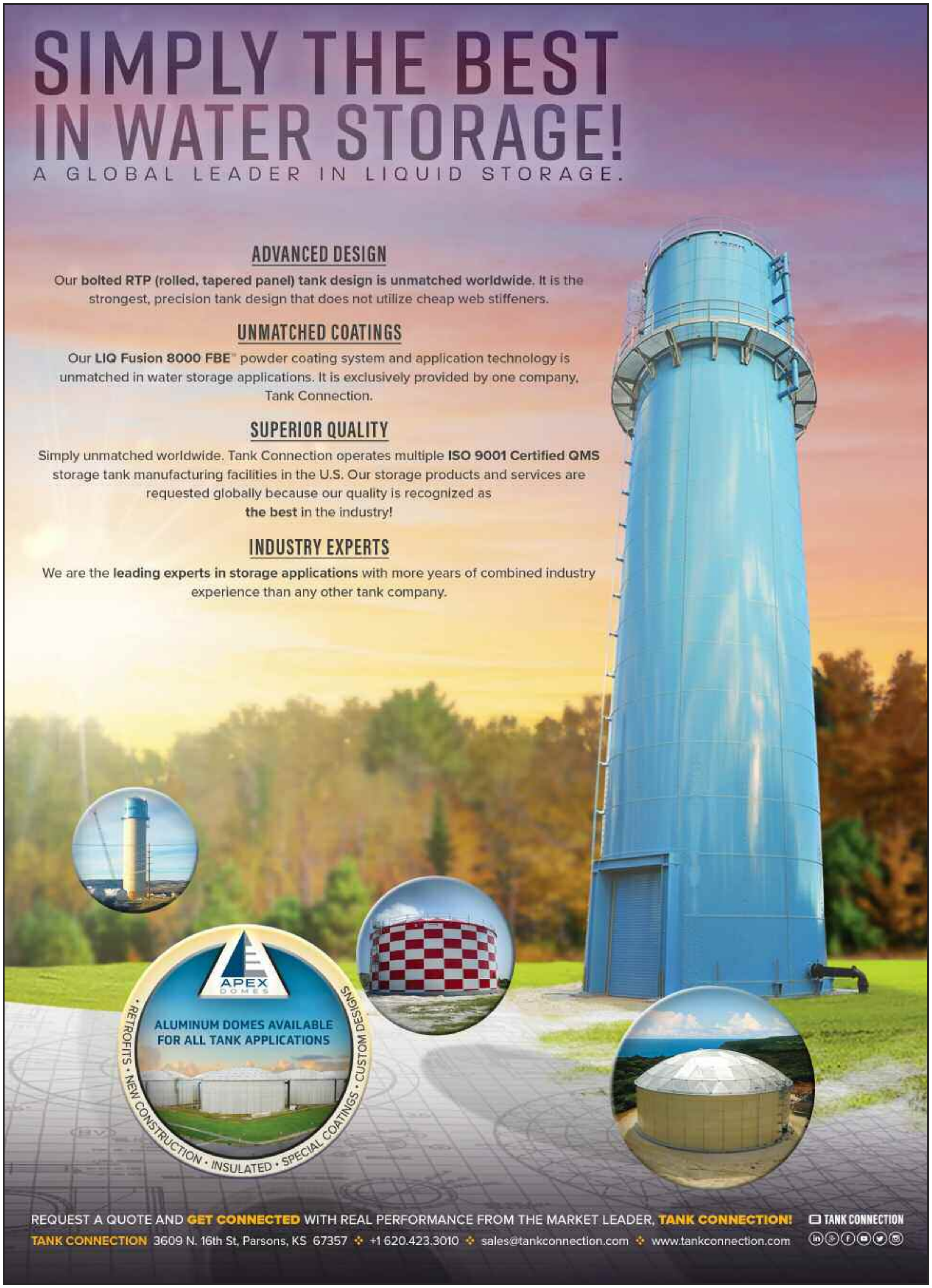
- Adding non-toxic, biodegradable dyes: In my opinion, this is an idea that deserves more scrutiny. These dyes can be found in USA Bluebook and are described as being non-toxic and biodegradable. They are available in different colors, but I would assume the blue-colored dye would work best in a lagoon. They supposedly float on the surface and provide a barrier that blocks sunlight and stunts algae growth. These dyes are used on many ornamental ponds found in parks and residential subdivisions. They usually provide good results. However, they are not approved for use by KDHE at this time. However, it may be an idea worthy of re-visiting. Another potential problem is that the dyes are not cheap and many gallons are often required to treat a large cell.
- Adding "Bird Deterrent Balls" to the final cell: These are hollow, black, UV-resistant, HDPE balls that float on the surface of the water and block sunlight. They contain sufficient ballast to ensure they are not blown away and typically have a 4-inch diameter. They are used primarily to discourage migrating waterfowl from landing and nesting on water bodies such as lagoons, settling ponds, reservoirs, etc. In the case of a lagoon, a boom would be installed across the final cell and then the balls added so they cover the water surface behind the boom. That might equate to covering about half the surface area of the final cell, especially near the discharge structure. Suppliers advertise additional benefits of odor control, controlling heat loss and evaporation, and preventing the growth of algae. I do not believe these have ever been used on a lagoon in Kansas, but may be worth considering. Again, cost could be an issue. But if the cost is the difference between building an additional cell and compliance versus noncompliance, they may be an option to consider.

As you can see, the options available for controlling algae in lagoon effluents are limited. But I also believe there is an effective, affordable solution available. It's just that we have not discovered it yet. I realize EPA and KDHE must set standards for suspended solids. But I think that is actually more important in mechanical plants that have short detention times and can potentially discharge mixed liquor solids that could adversely affect water quality in the receiving stream. It's unfortunate that algae can't be filtered out of a sample before TSS analysis so they are not included in the TSS test. I see farm ponds, lakes and reservoirs all across the state that discharge "green" water containing high concentrations of algae. Not sure exactly why it is such a major concern with waste stabilization ponds. But such is the challenge facing lagoon operators. If KRWA can be of assistance with your lagoon and/or any type wastewater or drinking water compliance issue, please feel free to contact the Association. I can be reached directly at either (913) 850-8822 or jeff@krwa.net.



Jeff Lamfers began work for KRWA in November 2008. Jeff has more than thirty years of regulatory experience in the oversight and operation of water and wastewater systems with the Kansas Department of Health and Environment.

He is a graduate of the University of Kansas with a degree in Environmental Studies with an emphasis in aquatic biology.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