Blue Frog ™ System Case Study:
Sludge Holding Pond

One of the main costs of handling municipal waste is disposing of settled sludge. Historical strategies are harder to implement today (e.g. burning, field spreading, ocean dumping). Much R&D has been done to recover methane from sludge. This strategy seems to work well when committed scientists are managing the process and less well when normal workers manage the process.

The BFS digests sludge in situ. The output is methane, CO_2 and ash (currently not-yet-observed).

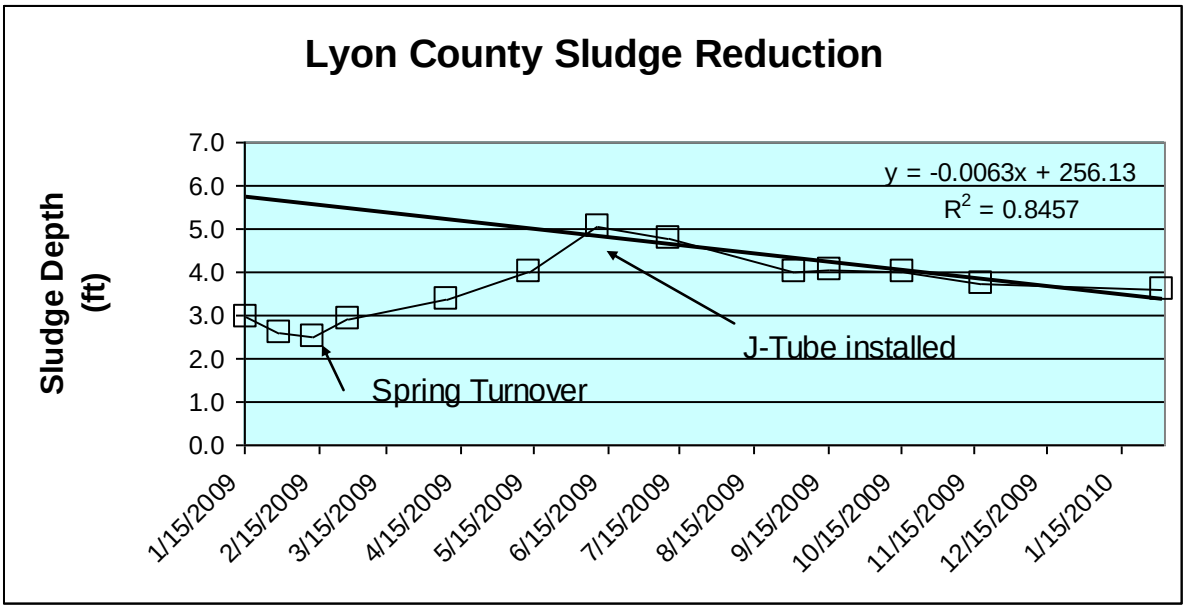
A system was installed in Dayton, Lyon County, NV. Lyon County has 4 sequential batch reactors discharging once per day into the sludge holding pond. Permitted flow is 1.5MGD

Objectives

1. Reduce odor
2. Reduce sludge
3. Save energy.

Results

1. Since the J-tubes were installed, sludge has decreased .19cm/day (R^2 = .85; 8months)
    a. When the BFS was first installed, there was a horizontal inlet at the 36" depth. This aggressively circulated the water, resulting in rapid sludge digestion.
    b. Sludge in a sludge holding lagoon is stratified with recalcitrant, heavy debris at the bottom and soft sludge between the bottoms and the free water.
    c. The aggressive circulation led to more rapid sludge digestion (-.47cm/day sludge depth (R^2 = .84); two months)
    d. As sludge digests, gas is formed which occludes on adjacent solids, reducing the macro density of said solids.
    e. During the Spring Turnover, great sheets of very old sludge erupted to the surface and created horrific odors.
    f. The J-tubes were installed to specifically slow down the rate of digestion.
        i. The water temperature in November, 2009 averaged 10.0°C and 5.5°C in February in the top 36" of the water column.



2. The algae ring around the pond waterline/berm interface grew from a couple of inches to 4 feet. Algae dye-off created a new-to-this-lagoon malodor.
    a. As the surface water clarified, light was let into the top water layer; algae grew because of the high N&P concentration in sludge supernatant.
    b. Lyon County was previously planning to increase berm height by 2m, doubling the pond holding capacity.
        i. Lyon County will increase the berm angle to 1:1 at the waterline and down 1meter. The dead algae's angle of repose will make the algae slide down into the dark where it will be digested with other sludge solids.
3. We experimented with a steel auger impellor versus a plastic propeller impellor. Within a month, the auger flights were completely blocked with struvite crystals ($(NH4)MgPO4\bullet 6H_2O$).
    a. We are experimenting with ways to crystallize struvite to remove P from concentrated wastewater.
4. The number of BFs will be increased from 4 to 6 to create balanced counterclockwise flow around the berm and across the middle.
    a. BFs have 12 sections. Any number can be blocked off to create directional flow (as in an oxidation ditch). In this situation, the perimeter BFs have 2 sections blocked off. The central BF has 2opposing side sections blocked off, so flow is up-and-to-the-right and back-and-to-the-left. Thus the center circulator reinforces the counterclockwise flow.
    b. The perimeter BFs help scrub dying algae off the berm without causing berm erosion.

5. The Lyon County lagoon is 175ft x 375ft x 6ft. There is a BF/CSTR and 3 perimeter BFs. After the berm raise, the pond will measure ~210ft x 420ft x 12ft.
6. The revised design will have a BF/CSTR, 4 perimeter BFs (in each corner) and a central bi-directional diagonally-situated BF. Each BF will have directional flow to reinforce counterclockwise flow with no dead spots.

Calculation

A directional BF has effective flow for 100m (more flow per section).

Install a directional BF near the corner with the J-tube situated to "catch" the upstream BF discharge and the directional discharge to pass it along to the next downstream BF.

Install a bi-directional BF in the center of the lagoon 150ft from the narrow berm. Install additional bi-directional BFs every 300ft.

There is no calculation for BOD reduction because the supernatant is discharged back to the treatment plant. The objective is to slow the rate of sludge digestion such that sludge levels decline slowly and consistently.

On new lagoons, the client specifies how much holding capacity they want. The BFS design is strictly about a BF/CSTR (to select for sludge digesting organisms) and obtaining dead-spot free surface circulation.

Caveat: some ponds are not regular and extra circulators may be needed. This is easy for one skilled in the art to design.

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