A METHOD TO ELIMINATE ANAEROBIC ODORS, REDUCE SLUDGE VOLUMES AND INCREASE BIOLOGIC TREATMENT EFFICIENCY IN EFFLUENT TREATMENT PLANTS

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ABSTRACT

Objectives of this yearlong project have been to eliminate anaerobic odors, reduce sludge volumes and improve effluent treatment efficiency by using a patented additive which increases cellular metabolism for microorganisms that occur naturally in effluent treatment systems. The newsprint mill's effluent treatment system combines aerated stabilization and an activated sludge plant. Changes noted in the system include a reduction of anaerobic odors from aerated basins, improved solids capture in the secondary clarifier by over 35% and reduced secondary wasted solids in excess of 70%. The biomass, originally showing old septic conditions, is now mainly bacteria, indicating a younger, healthier sludge. No negative impact to effluent quality was observed. The plant can now operate with higher MLSS concentrations with good settling which lowers effluent BOD and TSS and reduces the volume of secondary solids.

INTRODUCTION

Traditional thought in wastewater treatment says that organic matter plus bacteria with aeration and detention time would yield carbon dioxide, water and residues similar to composted matter. However, as changes in organic waste content and quality occur, the biological community responsible for stabilizing the organic load has trouble keeping pace. These changing conditions, and other outside forces, have required operators to look for alternate means to help the biological process cope with ever-changing conditions. The approach described in this paper looks at maximizing the potential of the existing biological community to treat the incoming organic matter through the addition of a patented biostimulant.

Most waste streams contain enough of the basic building blocks to keep a biological community working. In some cases micronutrients, such as nitrogen, phosphorous and iron, help the process toward completion. For decades, the waste treatment field thought this process was completed when discharge water met a "mandatory quality". Left out of this equation, however, were the residuals (sludge) that were removed from the waste stream or stockpiled in various lagoons, ponds, or other holding facilities. As times change, the focus of treatment must also change to include reduction of these residuals.

Conventional methods treat these residuals to a "stabilized" point. The degree of stabilization depends upon outside factors such as detention time, temperature, pH, moisture and organic loading. Usually a stabilization point occurs at the cellular level where some molecular activity has not taken place due to a lack of a substrate, a trace compound or some other microbial substance that keeps the reaction from taking place (Gerardi, 1994). Once this niche is filled, the reaction proceeds and subsequent reactions occur, moving the whole process towards completion.

The method described here looks at starting biological reactions at the cellular level by using a small amount of an organic stimulant. Higher dosages of the biostimulant increase the rate of biological activity, pushing the biological breakdown of organic matter beyond current "stable" points.

Odors are generated in a variety of places in the waste treatment system. In aerated lagoons, variations in organic loadings can quickly lead to consumption of the available oxygen, overloading the treatment system. Overloaded conditions cause the biological community to function less effectively, creating septic conditions in the lagoons, build up of sludge and release of offensive odors. These septic conditions cause the generation of hydrogen sulfide, methyl-mercaptens and other gases by anaerobic decomposition. If the biological community is in good working order when these gases are released, then facultative and aerobic bacteria will convert these gases and other intermediate compounds, and no odors are produced.

Effluent treatment systems in the Pulp and Paper Industry are coming under more stringent environmental constraints worldwide. Effluent discharge permits may require more BOD and TSS reduction under the changing U.S. EPA effluent guideline limits. Mills must dispose of primary and secondary solids captured and generated in these plants. Typical methods for solids disposal are land filling, land application or incineration as a fuel. Costs for sludge removal and processing are increasing: disposal sites have more restrictions. As populations increase near wastewater treatment sites, odors become a more significant issue.

DESCRIPTION OF NEW TECHNICAL WORK

The Smurfit Newsprint Corporation, Newberg Mill, began a program in August 1994, to biologically reduce solids and odor and improve efficiency in the effluent treatment plant. The program involved adding a patented biostimulant, BYO-GON PX-109 ®, to increase the activity of naturally occurring microorganisms. The State of Oregon Department of Environmental Quality requested increased monitoring of effluent nitrogen and ammonia concentrations during the initial six months of the biostimulation program. In December, 1994, the mill began extensive nutrient testing throughout the effluent treatment plant to increase effectiveness of the program. This report describes plant operations during 15 months of the biostimulation program.

The biostimulant was patented by the Research Corporation of the University of Hawaii upon the discovery of an alkaloid that increases cellular metabolism for a wide variety of microorganisms. The product is a precurso to cellular-level enzymatic activity at dosages of 0.3 to 1 ppm.

DESCRIPTION OF EFFLUENT TREATMENT PLANT

Wastewater from this mill, averaging 42 MLD (million liters per day) (11 million gallons per day) is treated with a combination of aerated stabilization lagoons (ASB) and an activated sludge plant (ASP). The treatment plant consists of a primary clarifier, a 340 ML (90 MG) aerated stabilization lagoon (NL), an activated sludge plant consisting of a 15 ML (4 MG) aeration basin with a secondary clarifier, and a 190 ML (50MG) aerated stabilization lagoon (SL) prior to discharge. Secondary solids removed from the secondary clarifier are split to the aeration basin as recirculated activated solids (RAS) and to the primary clarifier are split to the aeration basin as recirculated activated solids (RAS) and to the primary clarifier as wasted activated solids (WAS). Solids removed from the treatment plant through the pirmary clarifier are dewatered and burned as fuel.

Historical Operation of Plant Prior to Biostimulation Program

Prior to August 1, 1994, the effluent plant had the following pre-treatment operating conditions.

1. *Fifty-four percent of the aerated stabilization lagoon volume was bottom sludge.*

2. *Offensive odors were emitted from the NL, secondary clarifier, and sludge press building.*

3. *Secondary clarifier performance was marginal and erratic.*

4. *Treated effluent was well within the NPDES permit discharge limits.*

BIOSTIMULATION PROGRAM

During the 15 months of the program, plant operators learned how to regulate a more active biomass and observe its impact on the treatment plant. The initial goal was to slowly increase biologic activity without upsetting the treatment plant. As the activity of the biomass increased, experience and confidence enabled operators to achieve various goals. The program has gone through four periods, summarized briefly below:

Phase One: slowly increase activity of biomass in the primary clarifier and NL, without affecting treatment system effluent quality (duration, 3 months)

Phase Two: focus on developing a higher rate of activity in the NL and ASP, moving treatment from the primary clarifier to the NL (duration, 3 months)

Phase Three: gradually slow biological activity in the NL while maintaining good treatment efficiency (duration, 6 months)

Phase Four: begin increasing biological activity to regain treatment efficiency experienced in Phase Two and early Phase Three.

Phase One

Treatment began on August 1, 1994, with a shock dosage applied to the NL and a small daily dosage applied at the inlet to the primary clarifier. The strategy was to initiate activity in the NL and slowly change the type of biological activity in the primary clarifier and downstream. The overriding concern at this stage was to have no negative impact on effluent quality.

Observations

1. Within three days of starting treatment, the secondary clarifier began to capture more solids, reducing secondary clarifier effluent TSS from 100 mg/l to 60 mg/l. Standard deviation plots of secondary clarifier effluent TSS also show that solids are settling more consistently with less daily fluctuations.

2. Offensive odor from the NL disappeared but returned after 30 days; odors never left the press room.

3. Final effluent from the SL showed no change from before treatment.

Discussion of Phase One. *The biomass was stimulated enough to increase the efficiency of the secondary clarifier on a continual basis and, for a short period, reduced odor from the NL. These changes indicated a reduction of soluble organics in the overlying water in the NL. Odors returned due to increased activity of the sludge in the NL and the inability of the organisms in the overlying water to keep pace with the additional releases. Some of the biostimulant was lost with the sludge sent to the press room, effectively under dosing the NL. The reduction, then the return of odor on the NL, indicated increased biological activity from the shock dosage could not be maintained by the initial treatment strategy. The biomass in the NL required more direct stimulation to reduce odor from this basin and to increase downstream activity levels.*

Phase Two

On November 8, 1994, the treatment strategy shifted to develop a much higher rate of biological activity in the NL and downstream by directly treating the NL at higher dosages. Increased nutrient testing began in December 1994, to ensure the biomass had proper nutrient levels.

North Lagoon Observations

1. The offensive odor was gone from the NL within a week of increasing dosage while odor from secondary solids was reduced within 2 months.

2. Dissolved oxygen levels on the NL remained at 0.1 to 0.2 mg/l during this period.

3. Biomass in the NL (and the activated sludge basin) changed from bacteria, stalked ciliates and rotifers to predominantly bacteria, while color of aerated water changed from a dark grayish-black to a light brown.

4. NL influent TSS decreased, while NL effluent TSS increased.

Discussion of North Lagoon Changes. *Offensive odors from the NL were mainly due to hydrogen sulfide gas generated during anaerobic decomposition of sludge by sulfate-reducing bacteria. Aerobic bacteria consumed the available oxygen in the surface waters, allowing release of offensive odors. Stimulation of mibrobes in the NL sludge blanket developed a more complex biological community as evidenced by the change in biomass and color of water to a less septic condition. Facultative organisms became more dominant in low oxygen environments like the NL, satisfying their oxygen need from chemically bound oxygen. Sulfides and other intermediate compounds were utilized by various species of bacteria as food and energy sources. Development of a more complex biological community kept the system from going septic, producing fewer offensive odors.*

Blackish-gray water, offensive odors, rotifers, poor settling and fluctuating TSS and BOD levels characterize a poorly functioning biological community and old, septic conditions. As the biomass was activated, a shift took place toward development of a lighter brown color and a predominantly younger bacterial population.

By November 1994, the primary clarifier had a new polymer injection system which increased solid capture and reduced the volume of solids going to the NL. During the same period, however, effluent TSS from the NL increased, the exact opposite effect one would expect. Effluent solids normally increase during warmer summer months, not during the winter. This could be caused by the conversion of soluble

BOD into suspended solids by microbial activity in the NL. Effluent BOD from the NL in December 1994, showed a 33% decreased compared to the preceding months.

Activated sludge plant observations. Beginning in December 1994, the operation of the activated sludge plant began to change.

1. *MLSS concentrations began to decrease, resulting in lowering of wasting rates from 2.3 to 0.4 MLD (0.6 to 0.1 MGD) to rebuild solid inventories.*

2. *As MLSS levels increased, wasting rates remained low, resulting in a reduction to wasted secondary solids from the plant. Wasted secondary solids were reduced from 17.6 tonnes per day (19.4 tons/day) in the 23 month period before treatment, to 4.7 tonnes per day (5.2 tons/day) from November 1994 through March 1995, a 73.4% reduction.*

3. *Most secondary solids are now recirculated within the plant.*

4. *Secondary solids continued to settle well in the secondary clarifier, reducing the carryover of solids to the SL. The secondary clarifier performed more consistently with less day to day fluctuation. From September 1994 through March 1995, effluent TSS averaged 64.4 mg/l, compared to 100.2 mg/l in the preceding 20 months, representing a 36.8% improvement in solids capture. Inconsistent performance in April, July, and August 1995, was related to specific operational problems discussed later in this paper.*

5. *During this phase, the sludge press room used less polymer. It is well known that secondary solids are more difficult to dewater than primary solids and require more polymer for dewatering. With fewer tons of wasted secondary solids taken from the system, the dewatering operation required less polymer.*

Ammonia Nitrogen defiency. Ammonia is added to the NL influent and urea to the ASP as nutrient sources. The SL effluent was tested for ammonia monthly. In early December 1994, the biomass was very active and ammonia became non-detectable in the plant's effluent. Nutrient testing at four locations throughout the plant for ammonia nitrogen and orthophosphate determined that ammonia nitrogen was non-detectable in the NL, ASP and in the plant's final effluent, thus limiting biologic activity. The plant already contained sufficient sulfur and iron to satisfy the biomass. The addition of ammonia into the NL was increased.

Summary of Phase Two. The key element during this period was the development of a more active biomass in the NL and activated sludge plant. Higher dosages led to a more active biomass, quickly reduced odors in the NL, reduced solid inventories downstream and maintained good settling. The reduction to secondary solids appears to be directly related to the ability of a more efficient biomass to consume a portion of the suspended solids generated by the conversion of soluble BOD. Indications are that the NL would show sludge reductions with continued treatment at high dosages.

<u>Phase Three</u>

February 9, 1995 was the start of Phase Three to slow down biological activity in the NL and see if the benefits from the previous period would remain. Phase Two developed a more complex biologic community operating at a higher rate of activity. Lower dosages would gradually slow down this process over several sludge ages.

Observations

1. *Offensive odors remained unnoticeable from the NL until August, 1995, when high solid loading into the NL overloaded the system (see discussion below).*

2. *The volume of wasted secondary solids continued to show more than a 60% reduction from previous levels, even with solid overloading in August.*

3. *Secondary clarifier effluent TSS was slightly higher than in Phase Two and showed poor performance during a peroxide trial in the pulp mill and overloading as discussed below.*

Discussion of Phase Three. The return of offensive odors with overloading indicated that, as with any diverse biological community, effects of lower dosage rates appear only when a major event takes place. The system showed that plant performance at lower rates was acceptable. But at this lower activity level, there was not enough activity in the biomass to stabilize the upsets of results of trials introduced into the system. Reduced performance of the secondary clarifier during this period indicated that a higher level of biological activity provides more consistent performance and aided in maintaining higher levels of treatment efficiency.

Performance of Plant During Process Upsets or Trials

Bleaching trial. From March 21 to May 5, 1995, the mill conducting a bleaching trial, using hydrogen peroxide, bisulfite and a chelating agent. The downstream effect on the effluent treatment plant was felt quickly. Total oxygen demand on the NL increased, shocking the biomass, which decreased floc-forming micro- organisms. With poor floc formation, solids settled poorly in the secondary clarifier, allowing solids to pass into the SL. Effluent TSS from the SL increased slightly while effluent BOD rose to high levels. Emergency addition of pure oxygen into the lagoons re-stimulated the biomass. Settling and BOD removal improved at the end of the peroxide trial.

The chelating agent used in the peroxide trial reacts with iron, making iron unavailable to the biomass as a nutrient source. Any residual chelating agent that is still active would react with iron in the mill effluent. Bisulfite will increase the oxygen demand. With full implementation of peroxide bleaching scheduled to take place in late September or early October 1995, the mill has implemented procedures to test for residual bisulfite and active chelating agent, thereby reducing any downstream impact on the biomass.

Reduced efficiency of the primary clarifier. Beginning in June and continuing into August, 1995, the primary clarifier polymer injection system experienced inconsistent operation and the primary clarifier was taken off line in June for maintenance. During this period, the treatment plant experienced record high levels of solid loading throughout the plant. Pure oxygen was again used in the NL to increase dissolved oxygen levels. Effluent TSS from the plant, however, stayed within NPDES permit limits.

Discussion of process upsets and trials. When the peroxide trial began, activity of the biomass had slowed down from the higher rate established in Phase Two. The plant was unable to effectively handle the stress to the system brought about by loss of key nutrients, resulting in effective loss of biomass. In hindsight, a more active biomass prior to the start of peroxide and solid overloading would have helped treatment efficiency.

Phase Four

The goal was to regain the benefits developed in Phase Two and early Phase Three with a more active biomass by increasing the biostimulant on August 25, 1995. With a more active biomass resident in the NL, the plant would be in better condition to handle process upsets and continue a high level of treatment efficiency. Results showed that offensive odors had again disappeared from the NL. Effluent TSS from the secondary clarifier was at levels higher than those seen in early 1995. This is common after the series of events that took place in the first three quarters of 1995. The biological community had to shift to accommodate for the change in nature of the waste water loadings (for example, the addition of peroxide bleaching). The building of a sustainable biomass to consume this food base takes time.

North and South Lagoon Sludge Volumes

Sludge volumes int he NL have been slowly decreasing over the last 5 years while the SL has been fairly constant. The increase in effluent TSS from the NL, beginning in January 1995, indicated soluble BOD in the NL sludge blanket was being converted to TSS. Record high TSS loadings to the NL in July and August 1995, were not reflected in higher sludge volumes on the survey conducted in November 1995. These two facts suggest that the sludge blanket in the NL was more stabilized and was still being reduced in volume. With the current treatment program activating the biomass in the NL-ASP treatment segment, all the biostimulant is consumed prior to the SL. Activity of the SL biomass was very low but showed more stable performance.

CONCLUSIONS

The addition of the biostimulant has changed the nature of the biomass in the plant to a more complex, bacterially-based population. Higher levels of biologic activity have developed significant changes in the day-to-day operation of the effluent treatment plant.

1. *Offensive odors are gone from the first aerated stabilization basin (NL) and reduced from secondary wasted solids.*

2. *Wasting of secondary solids from the activated sludge plant is reduced by more than 70% on a consistent basis.*

3. *The secondary clarifier effluent TSS is 35% less and the ASP can operate with higher MLSS concentrations.*

4. *The effluent treatment plant is more stable during process upsets.*

Prior to treatment, lack of oxygen developed a largely anaerobic environment, releasing offensive odors. During treatment, development of a more complex biological population stimulated activity of facultative organisms which consumed sulfides as they were generated, eliminating hydrogen sulfide and other anaerobic odors. The active biomass also consumed secondary solids more efficiently, reducing the volume of wasted secondary solids. Settling of secondary solids improved due to better flocculation of solids, healthier sludge and breakdown of cell walls as the decomposition process was driven more towards completion.

The preceding 15 months have shown that with a managed biostimulation program, the resident biological populations can change and become more active. Rates of biological activity are controllable *by regulating the dosage of biostimulant, along with an understanding of the processes necessary to maximize biologic activity. The end result is fine tuning of atreatment plant to increase the reduction of sludge volumes, eliminate offensive odors and stabilize the treatment process. The method described here drives the treatment process further towards completion while utilizing existing treatment facilities. A more active biomass is a viable asset for the effluent treatment plant.*

REFERENCES

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