Bioaugmentation Remediates Heavy Organic Loading in Municipal Oxidation Pond in Drakenstein, South Africa

Location: **Drakenstein Municipality, Western Cape Province, South Africa**

Background:

The primary influent pond is in a series of seven oxidation and maturation ponds serving the municipality of Drakenstein, S. Africa. This system was designed to allow the final maturation pond to be a polishing pond for nitrification to allow effluent of suitable quality to be discharged to the river. However, due to the high level of incoming organics the initial ponds are not effective enough to allow the system to work as designed. The key to this system is to improve treatment in the initial influent pond to a level that allows efficacy in the remaining system.

Drakenstein Municipality was approached in mid-October 2009, with a request to participate in a field trial for the bioremediation of wastewater/sewerage effluent. The municipality offered Pond #1 at the Gouda sewerage oxidation and maturation pond site. This site was deemed ideal for the trial, as the two influent ponds (Pond #1 and Pond #2), are practically the same in size and conditions. Pond #1, being the primary influent pond, had higher average values for Chemical Oxygen Demand (COD) and Suspended Solids (SS).

Objective:

The water conditions in Pond #1 were found to be above the Department of Water Affairs (DWAF) limits on both the COD and SS for the "discharge of wastewater into a water resource (1999)". The 7-year average and August 2009 water parameters, taken from the municipal laboratory results are given in the table below. These parameters give the starting point for the remediation.

PARAMETER	7 YEAR AVERAGE	AUGUST 2009	DWAF LIMIT
COD	410	388	75
SS	78	177	25
pH	8.6	7.8	5.5 - 9.5

Fig. 1: *Data on organic loading in pond #1 prior to treatment.*

The goal of a successful field trial is to reduce the pH, COD and SS values being equal to or lower than the DWAF limits and/or remediation of the water to the point where the water is able to support the natural aquatic flora and fauna associated with a settling dam.

In order to keep the field study true to conditions generally found in the Southern African arena, no special or proprietary equipment was used in the application of the bioremediation product. The product was poured by hand standing on the edge of the dam. As a boat was available for the initial inoculation, product was poured from the boat as it was tracked diagonally across the dam.

The dosing regime for the MICROBE-LIFT® products is shown in the table below. Dosage is shown in gallons. The MICROBE-LIFT® formulation was added at the calculated standard dosage for a volume of effluent equal to 2000 m^3

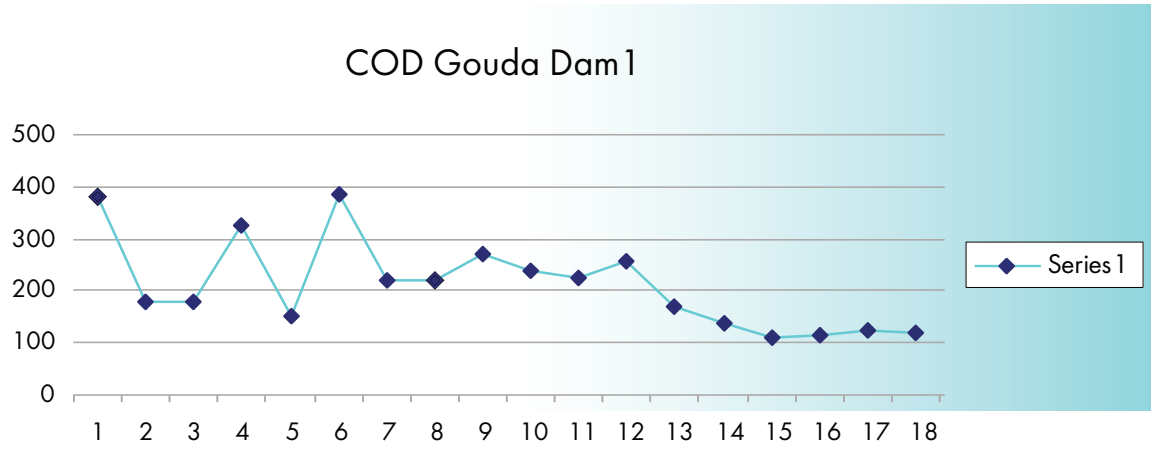
PRODUCT	WEEK 1	WEEKS 2 - 5	WEEKS 6 - 27	ADDITIONAL
	Inoculation 12/10/2009	per week	per week	For 2 weeks 05/02/2010
MICROBE-LIFT® #1	16	8	2	
MICROBE-LIFT® #2				3

Fig.2: *This chart represents the dosage schedule for the field trial. During the trial it was decided to add another MICROBE-LIFT® product, for two weeks to assist in degrading bottom solids.*

Samples were drawn from the same area as those drawn for the municipal samples. This sampling area on the southern side of the dam, 10m from the southeast corner, provides a small concrete platform where hand samples may be gathered. Duplicate samples were taken on a weekly basis, or more often if deemed necessary. The sample was collected in sterile 1-liter sample bottles with sealable lids. Once the sample was taken the lid was sealed and the sample packed into a polyurethane cooler to keep the sample temperature stable. Sealed samples were delivered to the laboratory for analysis.

Results Achieved:

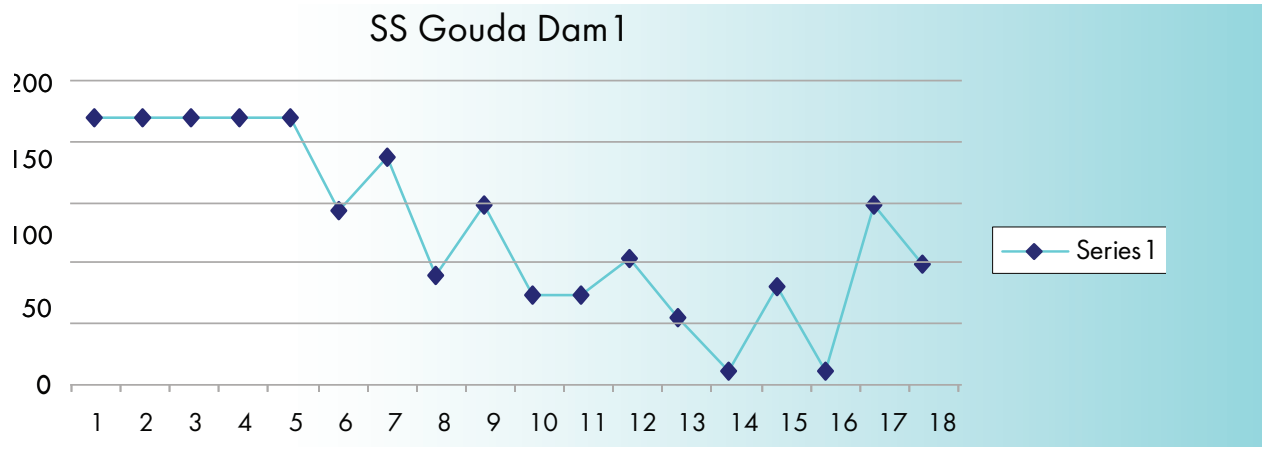
The following graph shows the COD (chemical oxygen demand) data in pond #1for the 18 weeks of the trial:



The results show the downward trend of the COD and SS values, these being the two main indicators of water quality. The pH value measured was well within limits at all times during the trial.

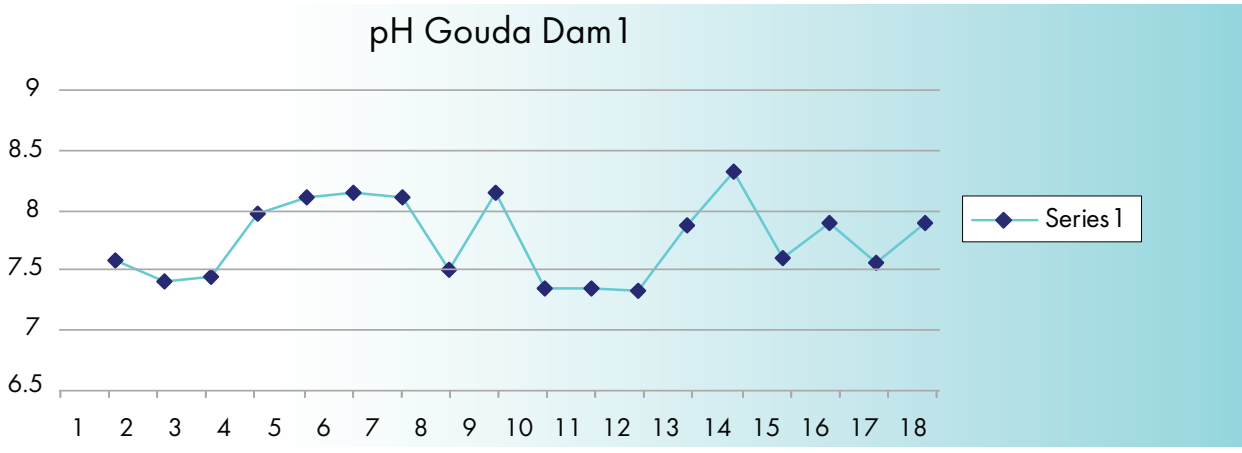
The overall downward trend of COD is due to the ongoing oxidation of organics and inorganics present in the water plus the corresponding suspended solids released to the water as the solids in the benthic sludge layer are solubilized. This trend will continue until the benthic sludge layer is removed and a steady state between influent and effluent from the pond is achieved. It is estimated that this value will reach DWAF limits by week 22 and can be accelerated with the application of a second **MICROBE-LIFT®** product if required. The spikes seen at weeks 4 and 6 are due to the release of soluble organics from the benthic sludge layer, due to the population growth of the bacterial consortium.
The decline shown from week 12 to 18 is due to the addition of 6 gallons of **MICROBE-LIFT®** SA over weeks 11, 13 and 16 to accelerate the solubilization of the sludge layer. Further application of the second product is required to reduce the COD value to below 75 mg/l.

Suspended solid (SS) data for the trial period are provided below:



The overall downward trend of the SS value is due to the ongoing solubilization of organics present in the benthic sludge layer and the corresponding release of soluble organics suspended in the water. The spikes seen at weeks 7, 9, 12, 15 and 17 are due to the release of soluble organics and inorganics from the benthic sludge layer, due to the addition of **MICROBE-LIFT®** SA. This product is specifically formulated for the biological oxidation of slow-to-degrade organic solids. Once a steady state of oxidation is reached between influent and effluent this value will remain substantially below the DWAF limit of 25 mg/l.

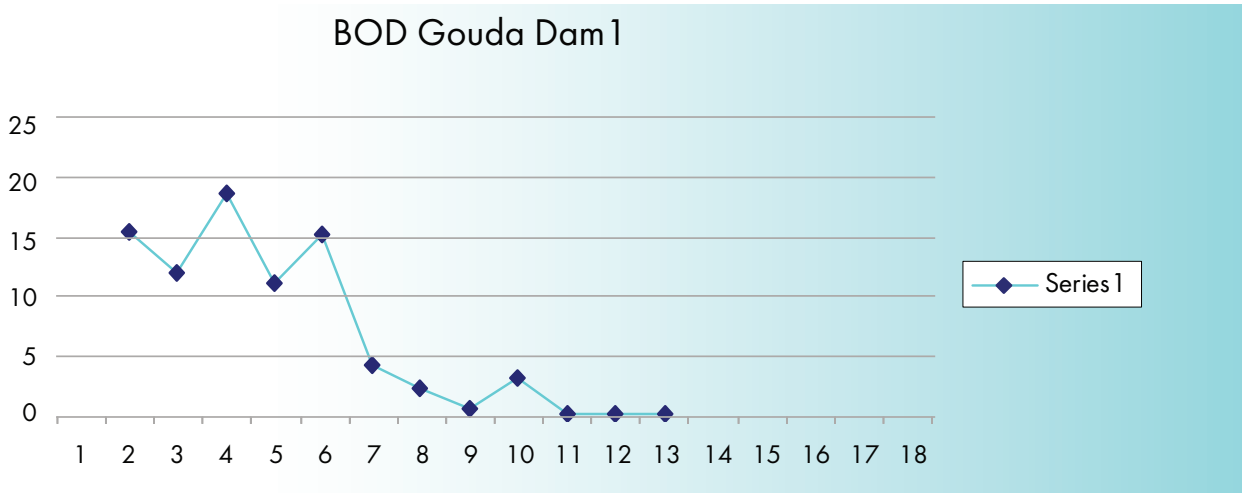
pH remained in the 7.5 to 8.5 range throughout the trial as shown in the graph that follows:



Throughout the trial, the pH varies from 7.5 to 8.5.

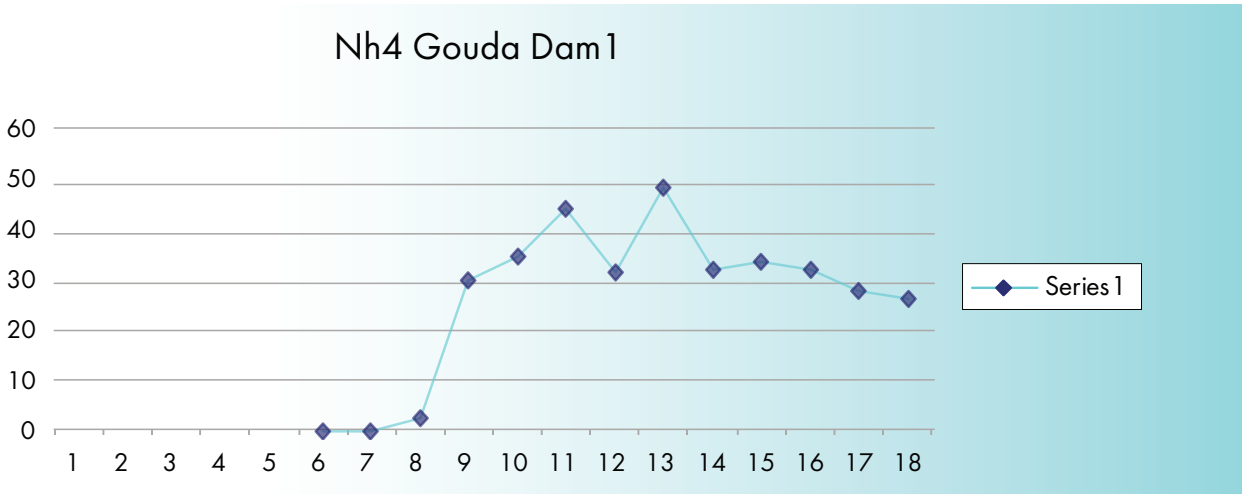
The pH has remained well within DWAF limits for the 18 weeks of this trial. This value is not expected to change by any great amount in future. The small variations seen are usually due to the breakdown of organic acids that lower the pH. In the anaerobic conditions in the benthic zone it is not uncommon for the formation of these organic acids by acetogens.

BOD (Biological oxygen demand) levels are indicative of the biodegradable portion of the waste. The excellent reduction of BOD shows the efficacy of the bioaugmentation program.



As can be seen from the graph, the majority of organics present in the pond were solubilized and oxidized between weeks 6 and 13. The sampling and analysis for BOD was discontinued after a 3-week steady state was incurred. The spikes seen at weeks 4, 6 and 10 are due to the population growth in the bacterial consortium after dosing. The COD and SS values tend to lag the BOD trend by approximately 2 weeks, this is due to the action of the bacterial consortium on the more easily oxidized organics as opposed to the more difficult to solubilize organic sludge.

Ammonia (NH_4) elevates as sludge containing nitrogenous compounds is broken down.



As the breakdown of organic sludge solids in the benthic layer throws ammonia into the water phase, they will be removed over time by heterotrophic uptake or through natural nitrification and denitrification. During nitrification ammonia is converted to nitrate and then into nitrogen gas and released. The ammonia is expected to drop to the 0.1 to 0.2 ppm range as the COD value is dropped to below 75mg/l.

Significant events

As can be seen from the graphs, after the initial inoculation of the MICROBE-LIFT® product in week 1, the bacterial consortium growth peaked in week 3. From this peak the organic/inorganic sludge layer in the benthic zone began to be solubilized. As dosage continued further peaks were experienced with each dosing until week 10, by which time the BOD had normalized. The COD, however, remained stubbornly in excess of 200 mg/l. In order to assist the reduction of the COD value, MICROBE-LIFT/SA was added in weeks 11, 13 and 16. The addition of SA then provided the catalyst for COD reduction as the insoluble components of the benthic sludge layer were solubilized and freed for oxidation. Due to the large sludge component deposited over years, this value will reduce below the 100 mg/l as the final sludge layer is oxidized.

It is interesting to note that the natural aquatic fauna returned to the pond in week 13, where a population explosion of Daphnia, Platana and other aquatic life appeared. This aquatic life is still present in the pond and the possible introduction of fish is being investigated.

Conclusions:

Using the calculated dosage rates, bioremediation of the pond was achieved in 13 weeks. This was a week longer than the original estimation of 12 weeks. Bioremediation has dropped the BOD, SS and COD and led to the appearance of natural fauna in week 13. Interestingly the fauna appeared at the peak of the ammonium cycle, where it is shown that ammonium is not harmful to certain fauna at the pH levels experienced.

In March 2010, Gouda began a rehabilitation process for the ponds and piping, which resulted in the ponds being pumped to very low levels. The low levels exposed inaccessible areas of the ponds and have given new insight into the COD value seeming to stabilize at approximately 100 mg/l. Significant sludge deposits were exposed in the corners of the pond. These deposits were not picked up in sludge sampling due to their placement. It is clear that the mid and lateral-mid sections of the pond have been cleared of sludge and the remaining corner pockets are responsible for the COD plateau at 100 mg/l. With the ongoing dosage of the SA product these deposits will be oxidized and the COD and NH4+ values will drop to below the DWAF limits.

The Following Benefits Accrued From This Field Trial:

- Due to the oxidation of pollutants, the wastewater and effluent can be brought to within DWAF limits for release into receiving waters in approximately 12 weeks. This figure may be manipulated by the addition or subtraction of product quantities.
- This bioremediation takes place in situ with NO additional mechanical intervention, therefore no capital investment in plant expansion, machinery, or energy is required.
- This bioremediation takes place in situ with NO chemical or enzyme intervention; therefore no additional pollutants are introduced.
- Odors are eliminated within approximately one week after initial inoculation of product.
- The action of the bacteria consortium has as an additional beneficial side effect. Due to the reduction of odor, less mosquitoes and flies were observed.

- As the sludge is oxidized the current extremely expensive cyclical dredging of ponds is reduced to an absolute minimum, if required at all.
- The contamination of groundwater is also remediated over time, as the anaerobic constituents of the bacteria consortium will permeate the soils with the pond water, thereby reducing the need for re-lining of ponds.
- As a result of treatment, the pond is in a state where fauna such as indigenous fish or others may be introduced. With a small investment in facilities, the area could be used for public recreation such as picnics, angling, bird watching etc.

For more information on MICROBE-LIFT® Technology contact
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