Modified Lignite:
Solving age old problems of odour and solids accumulation

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Banff Water and Wastewater Seminar
March 2002

Introduction

We currently live in an environment in where all forms of organisms have come to fill specific niches or roles, allowing for a diverse community and hierarchical structure which regulates many factions crucial to live on earth.

Without plants aerobic life on earth would cease to be; the absence of micro-organisms would halt the cycling of nutrients and carbon, the building blocks of life itself.

SHAC Environmental Products Inc. has taken the approach that in order to assist in environmental management we have to work in unison with the environment. What this amounts to is a belief that using inorganic chemical or mechanical methods to assist with problems of a biological nature are misguided and will ultimately fail.

Therefore, our approach has been to develop products and techniques which improve the existing conditions for the microbial community and stimulate this community to work and reproduce quickly and more efficiently. The end result is an environment which has no residual or harmful by-product from the treatment, while the problems concerning odours, solids, etc. have been removed.

Microbiology and biodigestion highlights

The term 'microbe' includes a host of organisms including bacteria, fungi, protozoa, and others. These organisms work together to degrade organic matter into its constituent elements and compounds. No single microorganisms can do this without the assistance of others. Organic decomposition is a structured event, which must follow a sequential procedure to be completed.

At a general level, microorganisms fall into categories based on the type of respiration they utilize to metabolize organic matter. These categories are aerobic, anaerobic and facultative. Aerobic refers to organisms which require oxygen for respiration, anaerobic do not require oxygen or very little, and facultative can exist under either condition.

Of course, many other variables assist in designating which organisms will inhabit a particular environment, but this classification always plays a role in developing the community. Each group of organisms may have members which can exist under one of these conditions, but remember, no single organism can complete decomposition on their own.

Furthermore, microbial activity is reduced or increased based on environmental conditions such as temperature, pH. Also, the presence of inorganic chemicals, disinfectants, salts and mechanical manipulation can alter and disturb the conditions of the microbial environment enough that activity becomes significantly reduced or dominated by a single group of organisms, again hindering the completion of organic decomposition.

If environmental conditions are altered quickly many microorganisms can be destroyed. More often the conditions are altered over a greater time period and the organisms have a chance to become dormant, a method of self-preservation employed by many bacteria, fungi, etc. to survive under poor living conditions.

With the aid of the natural components of lignite coal, SHAC Environmental Products Inc. has developed management solutions which enhance the environment by reducing environmental contamination and increasing microbial activity. The combination of these mechanisms effectively reduce solids and odour, while improving water/wastewater quality.

Functional mechanisms of 'modified lignite coal'

The result from our modification of lignite coal leaves us with a liquid organic product which contains fractions of very fine carbon particles, organic acids and minerals.

First, the carbon fraction has the ability to act as a 'neutralizer' and/or a coagulant, thereby adhering to particles as well as absorbing excessive nutrients and toxicants which may be reducing the optimum conditions for microbial activity.

Second, under this improved or neutralized environment the resident, indigenous microbes are presented with a concentrated form of organic acids, micro-nutrients and minerals. Many of these naturally occurring organic acids and compounds are known to increase microbial activity to the extent that even dormant micro-organisms can be stimulated back into a state of active biodigestion and reproduction.

Testing our hypotheses

Of course, these mechanisms were once theoretical in regards to 'modified lignite coal' and based on the research of others found throughout many texts, journals and research papers. However, in the past seven years we have conducted our own trials and continue to do so in order to expand upon our knowledge of the product and its attributes. The results of these trials have been very enlightening, and they speak to the multitude of applications and the overall efficiency of the product. As you will discover, this product has proven itself repeatedly whether it be in regards to improving water clarity and quality, or reducing solid waste and odours.

Water treatment studies

1. Lake Horney, Florida - 2000

'Pilot study to reduce organic sediments and improve water clarity using modified lignite coal'

Important Terms

Secchi disk - a weighted disk which is divided into quadrants which are alternately coloured black and white. The disk is a common limnological tool used to measure turbidity (clarity) of a water body.
Limnology - The study of fresh water ecosystems.

Background:

This urban lake covers approximately 6.5 acres, and contains about 4 million gallons. In the past the lake has been drag-lined in the 1970's, dried from drought in 1985 and monitored extensively since 1991. During the monitoring period leading up to treatment with *'modified lignite coal',* the lake had been classified as eutrophic due in great part to urban storm-water runoff.

The lake was characterized by significant amounts of highly organic sediments and historical degradation of water quality.

The goals of this study were to monitor water quality and sediment characteristics after treatment of the lake with 'modified lignite coal'. The results were compared to the findings produced over the past ten years of water quality and base-line sediment information.

The study was conducted by Madrid Engineering with the help of Dr. John Davis of Environmental Services and Permitting in Florida.

Results:

Water Clarity

Results prior to treatment indicated that the Secchi disk readings were very poor from March to May of 2000, ranging from 6-8.5 inches (0.15-0.21 meters). This was well below the nine year average of 19 inches (0.49 meters). Three months after treatment with 'modified lignite coal' (August 2000) Secchi disk readings had improved to 32 inches (0.81 meters), an improvement in water clarity of 81-74%. Even in comparison to the nine year average this finding was a 40% improvement in water clarity. Four months after treatment of the lake with 'modified lignite coal' the water clarity reached the point where it was clear to the bottom, a point never reached in nine years of observation on Lake Horney.

Organic sediments

Analysis of organic content in sediment samples taken from the lake indicated a 20% reduction of organic content 7 weeks after treatment with 'modified lignite coal', this was a decrease from 81% to 61% organic matter.

Three months after initial treatment of this lake 9 inches (0.225 meters) of sediment had been decomposed and removed from the lake bottom. A conservative estimate was produced indicating that this 9 inches of sediment removed represented approximately 4,800 cubic yards of sediment.

Table 1. 2000 Lake Horney, Florida - Water clarity results

	Historical average (1991-2000)	Pre-treatment (May 2000)	Post-treatment (August 2000)
Secchi Depth (cm)	49	15-21	81

Table 2. Sediment depth and organic content results

	Pre-treatment (May 2000)	Post-treatment (Aug.2000)
Sediment Depth (meters)	3.6m	3.2m
Organic Content	81%	61%

2. Trihalomethane precursor study, Southern Alberta - 2001
Investigating the production of trihalomethane precursors correlating to the treatment of drinking water storage ponds with 'modified lignite coal'

Important Terms

Trihalomethanes (THM) - A general term which encompasses all by-products produced from the combination of chlorine with organic matter or dissolved organics and are considered carcinogenic.

NSF - National Sanitation Foundation

Chlorophyll *a* - Is a measurement used to assess the concentration of algae present in a sample of water and is important in this study as algae and any organic by-products of algal respiration could be regarded a THM precursors.

Background:

SHAC Environmental Products Inc. has received, from Health Canada and Alberta Environment, a letter of 'no objection to the use' of its 'modified lignite coal' product in water storage facilities. This was granted as a result of the product gaining NSF approval for drinking water additives. However, town operators still requested that a study be conducted to ensure that the result of treating water with 'modified lignite coal' would not increase the potential for trihalomethanes in water which was to be chlorinated.

The site used was a fully operational water storage and treatment facility in Southern Alberta. Water samples were collected from the supply, storage and filter treated stages at the facility prior to treatment of the storage facility with the 'modified lignite coal'. In addition, sediment probes were also taken prior to treatment of the storage pond.

Samples of water were analyzed for any variable which could combine with chlorine to form trihalomethane by-products (namely anything containing organically bound carbon). Therefore, surface samples of the pond were analyzed for Chlorophyll *a* concentrations, while profile samples were analyzed for Total Organic Carbon (TOC) and Total Suspended Solids (TSS). Background samples were compared to samples taken after treatment for up to a year after initial treatment.

Results:

Sediment probes

Probes were made along a preset transect across the width of the storage pond. The average from these samples indicated that the sediment load in the treated pond reduced from 7.5cm prior to treatment, down to 1.25cm the following year, a reduction of 83%. Furthermore, 90% of this observed reduction was visible within 3 months of

treatment. That is, the sediment had already been reduced from 7.5cm to 1.90cm in 3 months time.

Water quality

Samples collected and analyzed for all THM precursors indicated that no reduction in water quality was attributable to the treatment of this storage pond with 'modified lignite coal'. More specifically, Chlorophyll *a* concentrations varied but never exceeded the level found in initial samples taken prior to treatment. Likewise TOC values never exceeded levels found in initial, pre-treatment samples.

TSS levels were observed at levels which were twice as high as the original values, however these readings correlated with the fall 'fill up' which is necessary as the water is supplied by irrigation canals. Due to drought conditions this irrigation water contained high levels of suspended solids, thus increasing the turbidity of all storage ponds utilizing this source. Samples of this supply water correlate with these findings. Therefore, no increase of THM precursors were found to be attributable to the treatment of water storage ponds with 'modified lignite coal', even though the product itself is organically based and a significant reduction of organic sediments was observed.

Wastewater treatment studies

1. Sewage treatment lagoon solids reduction trials, Southern Alberta - 1999

'Investigation into the reduction of solids corresponding to the treatment of the sewage with 'modified lignite coal' within a small municipal waste treatment lagoon'

Background:

The site chosen for this study was a fully functioning waste treatment facility, receiving sewage for approximately 1000 residents, in addition to several small industries/businesses and a significant summer increase due to tourism. The facility was designed with 5 separate ponds, four of which were capable of retaining 180,000 gallons of waste each. The final pond was much larger and functioned as an evaporation pond. Two of the ponds (cell #1 and #2) had been used alternately to receive waste directly from the town lift stations, anaerobic/settling ponds. One of these ponds had become almost entirely filled to capacity with solid material, the other was half filled with solids. The remaining 2 ponds (cells #3 and #4) did not have nearly the solids build-up of the first two ponds. Cells #3 and #4 were considered to be facultative ponds and could be adjusted to receive waste from either cell #1 or #2.

All of the ponds were probed initially to observe the level of solids present and the 'overhead capacity' of fluid material remaining. Once this was completed, anaerobic cell #1 (nearly filled with solids) was isolated from the flow of sewage and treated with 'modified lignite coal'. One month later the suspended contents of this treated pond were

pumped to the second anaerobic cell. The first cell was again filled with material from the town lift stations, retreated and kept under isolation. Cell #2 was also treated at this point. Another month later cell #1 was removed from isolation and placed back into regular sequence with the remaining ponds.

Results:

After the first month cell #1 had increased its capacity by nearly 2 feet (375 cubic meters). Once both ponds had been treated and normal circulation was restored, the following measurements indicated that within a 13 week treatment period 4 feet of solids (750 cubic meters) had been removed from cell #1 and 1 foot (188 cubic meters) of solids had been removed from cell #2. That is, approximately 40% of the solids initially present in cells 1 and 2 were decomposed and 20% of the capacity had been restored in 3 months of treatment with 'modified lignite coal'.

In addition, probing of cells 3 and 4 did not indicate that any significant amount of solids from the anaerobic ponds were transferred into the facultative ponds, therefore no capacity was lost in sequential ponds within the system. As well, by the end of 13 weeks, increased percolation was observed in cell #3 even though this pond had never received product.

Cost effective

It was estimated that this treatment, when continued at a regular maintenance dose for two years would achieve the same effectiveness as dredging at a cost of less than 1/3 of that attributable to mechanical removal and residual relocation.

2. Northern Alberta wastewater case studies, 2001-2002

Table 1. Solids reduction results

Site Number/ Population	Percent Organic Sludge Reduction	Treatment Time Elapsed
#1/6000	28%	5 months
#2/5600	28%	1 year
#3/1700	28%	3 months
#4/1100	30%	4 months
#5/150	33%	9 months

3. A Case Study –
'Solids and odour control, while savings pay for treatment'

- In Southern B.C. a town has been using 'modified lignite coal' for three years, in lagoons as large a 6 million gallons which service approximately 2800 individuals.

- Prior to treatment this facility used heavy aeration to control odours and create an environment dominated by aerobic digestion.

- Within 2 months of 'modified lignite coal' treatment this site had no odour control issues and solids were actually reducing rather than building-up the way they had with aeration.

- Total solids were observed to have reduced in the treated cells by an conservative estimate of 2225 cubic yards in 2 months.

- Three years later this site is continuing to use the 'modified lignite coal' with no reported solids or odour problems. In addition, this treatment is being performed at a significant savings in comparison to the previous method of aeration treatment.

Related studies

1. Iowa State University - 1995
'Testing '*modified lignite coal*' as an agricultural waste additive for odour reducing capabilities'

Important Terms

VFA - Volatile fatty acids; important organic acids which correlate to offensive odours in such material as agricultural waste (manure).
Significance level - Indicates the statistical certainty of the findings by indicating the probability of repeated tests finding the opposite conclusion.

Background:

It was suggested from historical references of literary and journal accounts that 'modified lignite coal' may have the ability to reduce odours normally associated with agriculturally related waste products (eg. manure). A 35-day trial was conducted by Dr. Dwaine Bundy and Dr. Jun Zhu of Iowa State University to investigate this attribute.
Columns of manure were collected, arranged and treated for study purposes.

Results:

Odour threshold values were found to be 83% reduced among treated columns compared to control columns at a significance level of P=0.01, suggesting that the results were very significant.

Corresponding volatile fatty acid analysis indicated that treated columns contained significantly reduced VFA's in comparison control columns. This is significant as VFA's are representative potential odour production.

2. PMU microbial populations – 1997

'Investigating the effect of '*modified lignite coal*' on microbial activation and antimicrobial/toxicant neutralization'

Important Terms

Antimicrobial - For the purposes of this study, this term is meant to refer to any chemical or constituent portion of sewage waste which may inherently reduce microbial activity (eg. industrial salts, bleach, etc).

Dormancy - A state in which an organism is in a self preserving mode and not fully functioning as an interactive part of its environment, usually as a result of poor environmental conditions which would make survival difficult. This state is one in which the organism can become active again under improved environmental conditions. For many microbes this transition from dormancy to activity and back again can occur quickly, as well as multiple times.

Background:

Waste collected from the Pregnant Mare Urine (PMU) processing plant was very odourous and due to disinfection protocols and extremely high pH the final waste was not particularly active in terms of microbial activity or breakdown of ammonia inputs and organic matter. A large sample of this material was collected and mixed into various dilutions with distilled water and 'modified lignite coal' in order to investigate the presence of microbial activity and the successional variation of the microbial community based on treatment versus control conditions. Furthermore, anaerobic and aerobic growth chambers were created under both treatments in order to investigate the varied microbial community responses under these conditions.

The addition of 'modified lignite coal' to samples of this PMU waste had been expected to increase microbial activity in the manner that had been observed under normal treatment conditions (eg. sewage treatment facilities). However, in the past microbial activity had been insinuated as a result of odour reductions, solid reductions and gas bubble production. This result had not yet been tested under microscopic analysis.

Therefore, microscopic observations were made to draw conclusions regarding the increase of microbial activity and the consequent odour and organic nutrient reduction.

Results:

A significant increase in microbial activity was observed in samples of PMU waste which had been treated with 'modified lignite coal' compared to the control and 'distill water only' treated waste.

This result was observed both under aerobic and anaerobic conditions.

This suggested that even under rather amicrobial conditions 'modified lignite coal' was capable of stimulating significant microbial activity and growth. It is theorized that this is a result of the refined carbon neutralizing antimicrobial or toxic compounds and the liquid organic suspension stimulating or activating the microbes from their dormancy.

Summary

Studies conducted for more than 8 years indicate that ‘modified lignite coal’ increases microbial activity, resulting in more effective decomposition of organic matter and reduced volatilization of odourous gases.

‘Modified lignite coal’ also seems to act as an effective water clarifier, reducing turbidity caused by organic particulates and reducing discoloration resulting from dissolved organic matter. Furthermore, the microbial consumption of organic nutrients seems to immobilize nutrients, reducing the supply of available nutrients to phytoplankton (algae) thus reducing algal bloom potentials.

With the aid of ‘modified lignite coal’, SHAC Environmental Products Inc. is proud to offer a unique blend of simple solutions and assistive management services to eliminate some of the most difficult problems found in water and wastewater management.