Bioaugmentation with MICROBE-LIFT® Technology Remediates Polluted Drainage Retention Pond in Penang, Malaysia

Location: **Penang, Malaysia**

Background: S-10 is a flood mitigation river water holding pond in Penang, Malaysia. Drain water from Georgetown is channeled into this 150M x 85m x 2m deep retention pond before being discharged into the sea. Excess water in the pond is either drained into the sea during low tide by opening the tidal gate or through mechanical pumping when sea level is higher than the pond water level. The retention pond prevents ingress of salty seawater into Georgetown and allows free flow of surface drain water during heavy rain that coincides with high sea water level.

Fig. 1: *Picture of S10 flood mitigation holding pond in Penang.*

Fig. 2 *Additional pictures of the pond and drainage system*

Fig. 2 & 3: *Additional pictures of the pond and drainage system.*

This drainage allows discharge of both ground surface water during heavy rain and discharge of wastewater including domestic sewerage and wastewater from commercial and industrial operations. Discharge of untreated grey water forms the bulk of the water flowing into the pond on dry days. The influent water pollution level is significantly diluted during heavy rain. Influent BOD ranges from 40 mg/l to 250 mg/l and COD has a low value of 100 mg/l to as high as nearly 1,000 mg/l. The influent water also carries a very high concentration of suspended solids and floating debris. Most of the floating debris is trapped at the grit chamber just before the pond entrance and is physically removed on a regular basis. There is a high concentration of suspended solids that have settled into the pond as bottom sludge.

The pond has accumulated a bottom sludge layer exceeding a half-meter in only a year of operation. If left untreated, the pond would be fully filled with bottom sludge within a few years and would be incapable of fulfilling its intended purpose as a flood mitigation pond. In addition to the sludge problem, extreme malodor emanating from the pond has affected nearby residences and has become a significant problem for the Jabatan Pengairan Dan Aliran Negeri (JPS). JPS has also expressed interest in reducing pollution to below Standard B before discharging into the sea to prevent harm to marine life. Standard B specifies BOD <50 mg/l and COD <100 mg/l.

The pond has an estimated volume of 25,000 m^3. On dry days, the grey water from Georgetown forms the bulk of the influent water. The estimated flow rate is 5,000 m^3 per day. This gives an average of five days retention time, which is ideal for biological treatment. The flow rate during heavy rain is not known; it is estimated at several times that of the normal dry day flow rate. The water in the pond can be completely replaced after a few days of heavy rain.

Objective

A bioaugmentation treatment program was developed to remove bottom solids and improve degradation of the waste organics. MICROBE-LIFT® technology, was recommended. MICROBE-LIFT® is a highly active liquid bioculture developed and manufactured by Ecological Laboratories Inc, USA. MICROBE-LIFT® contains a wide range of microorganisms elected for proven degradation capabilities targeting difficult to degrade organic waste components.

According to plan, treatment was conducted from the 29th of August 2005 to the 5th of March in 2006. A 10 ppm inoculation was performed on day one, a day affected by heavy rain immediately after inoculation. This was followed by an 8 ppm dose three days later followed by five additional doses of 4.5 ppm in the first month. Maintenance doses of less than 2 ppm, 12 gallons per week, were applied for the remaining period of treatment. Since retention time is limited due to increased rainfall and biodegradation can be enhanced by aeration, BioAktiv, an all natural mineral compound for oxygenation was added weekly to support MICROBE-LIFT® technology's stimulating enhanced degradation rates.

Results Achieved:

The first result noted within the initial month of treatment was the significant reduction in malodors experienced by workers and nearby residences. The bad odor was essentially eliminated throughout the treatment period in the pond area, with the exception of malodors near the influent to the pond on water that had not yet been treated. The S-10 MICROBE-LIFT® Bioremediation Project was showcased at the National Environment Seminar on 14-16 Dec. 2005, as organized by the JPS in Penang. Delegates invited to the site on 15 Dec 2005 confirmed that odor was no longer noticeable around the pond. Only from the incoming, untreated water were malodors noted.

As another indication of improved treatment, water samples of the pond also showed higher transparency (less turbidity) than in the past.

Water samples at the influent point of the pond and the effluent point near the discharge tidal gate were taken twice a month to monitor water parameters. BOD, COD, TSS, and total NH_4 were measured. The sludge thickness was also measured on the day of inoculation followed by three more measurements during the treatment period. Sludge thickness was measured by means of a sludge judge, a transparent glass tube inserted into the pond until it contacted the hard bottom.

The tube is then closed and brought to the surface where the captured column of sludge can be measured. An independent lab conducted the water sampling and analysis. The six-month treatment results are tabulated on the next page:

JPS Penang Retention Pond Project

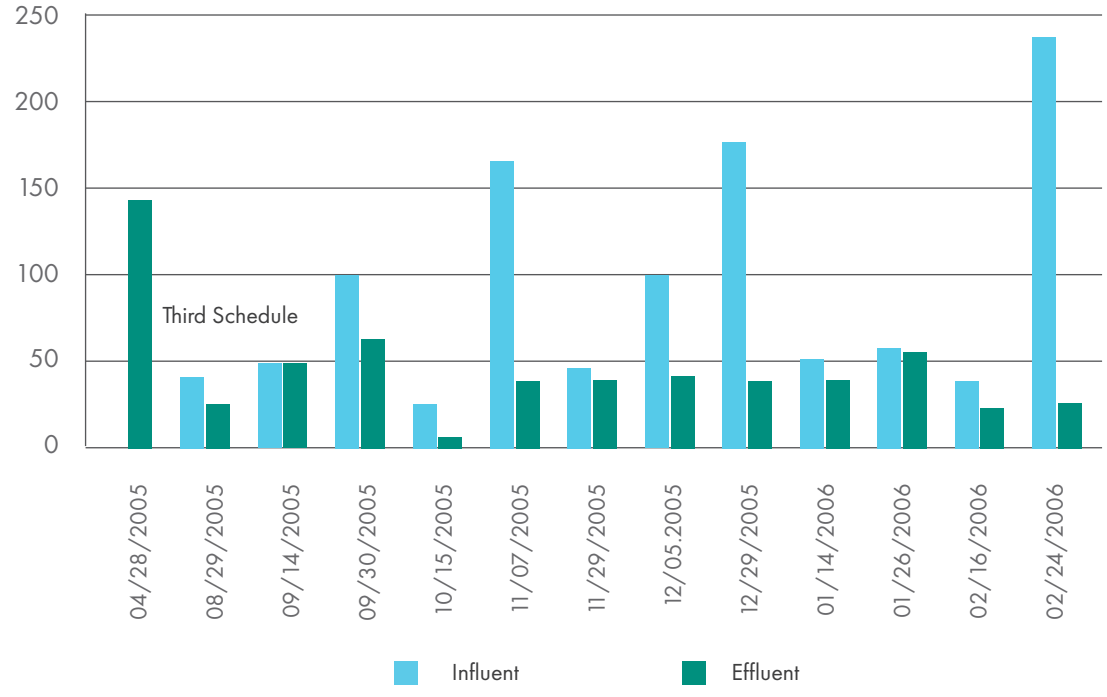
Water Parameter Measurements

Day	Date	Influent (at pump hose outlet)				Effluent (at discharge outlet)			
		BOD mg/l	COD mg/l	TSS mg/l	NH_2 mg/l	BOD mg/l	COD mg/l	TSS mg/l	NH_2 mg/l
	04/28					142	522	196	11.4
1	08/29	42	162	34	11.4	23	98	26	12.2
16	09/14	49	189	45	12.2	48	185	45	20.2
32	09/30	98	383	180	1.9	63	431	52	11.2
47	10/15	28	113	59	11.7	7	42	44	12.2
70	11/07	167	571	113	18.6	39	256	125	13
92	11/29	45	178	34	2.1	39	196	42	11.6
98	12/05	100	408	77	11.4	43	187	18	11.7
122	12/29	178	695	20927	20.4	40	167	51	9
138	01/14	52	197	71	15.4	39	161	56	14.4
150	01/26	59	279	70	15.6	56	223	41	15.6
171	02/16	39	158	50	20.6	22	86	41	13.6
179	02/24	235	975	598	17.4	24	95	37	8.6

Fig. 1: *This table shows actual data from the test period April 2005 through February 2006. Note the high effluent levels of BOD, COD, and TSS prior to treatment that were never reached again during treatment.*

Fig. 2: *The dramatic differences between influent BOD and the effluent levels show the treatment achieved through bioaugmentation. Note that treatment substantially improves after the first two months after the microbes have had a chance to establish themselves.*

Influent versus Effluent BOD



Influent versus Effluent COD

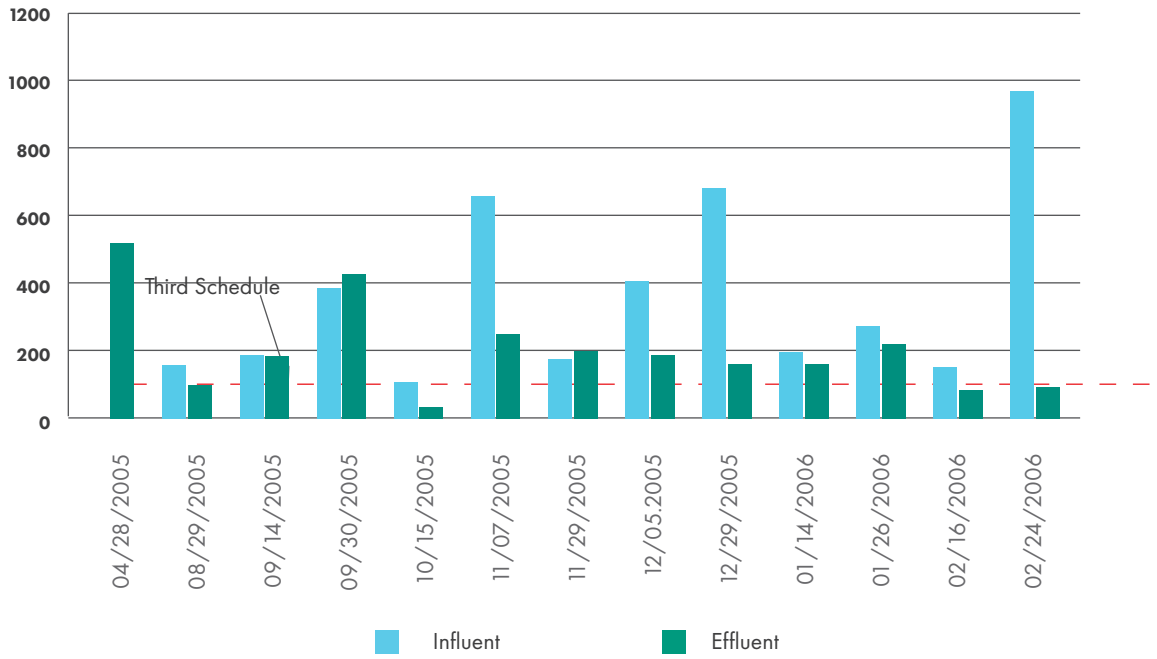


Fig. 3: *Consistent with the BOD data, COD results validate improvement in treatment. Data from the first two months represents a baseline prior to treatment, while the data thereafter shows substantially increased treatment based on greater differences between influent and effluent levels.*

The most significant change between influent and effluent water parameters occur after the first two months of treatment. This effect is typically seen in bioaugmentation applications, as the microbes inoculated require time to grow and establish themselves within the ecosystem. Significant water parameter improvement is observed starting in mid-October 2005. The data would not show much improvement during periods of heavy rainfall when influent water pollution levels are low. It was also noted that the water in the pond forms a circular motion when large volumes of water were discharged through the tidal gate or was being pumped out. The influent and effluent water was well mixed by this circular motion. As such, the water in the pond became more homogeneous and shows less difference between influent and effluent water samples. This factor explains the apparent non-performance of water parameters on 29 Nov 2005 and January 2006.

The bottom sludge continued to be reduced throughout the treatment period, and was practically eliminated by Feb 2006.

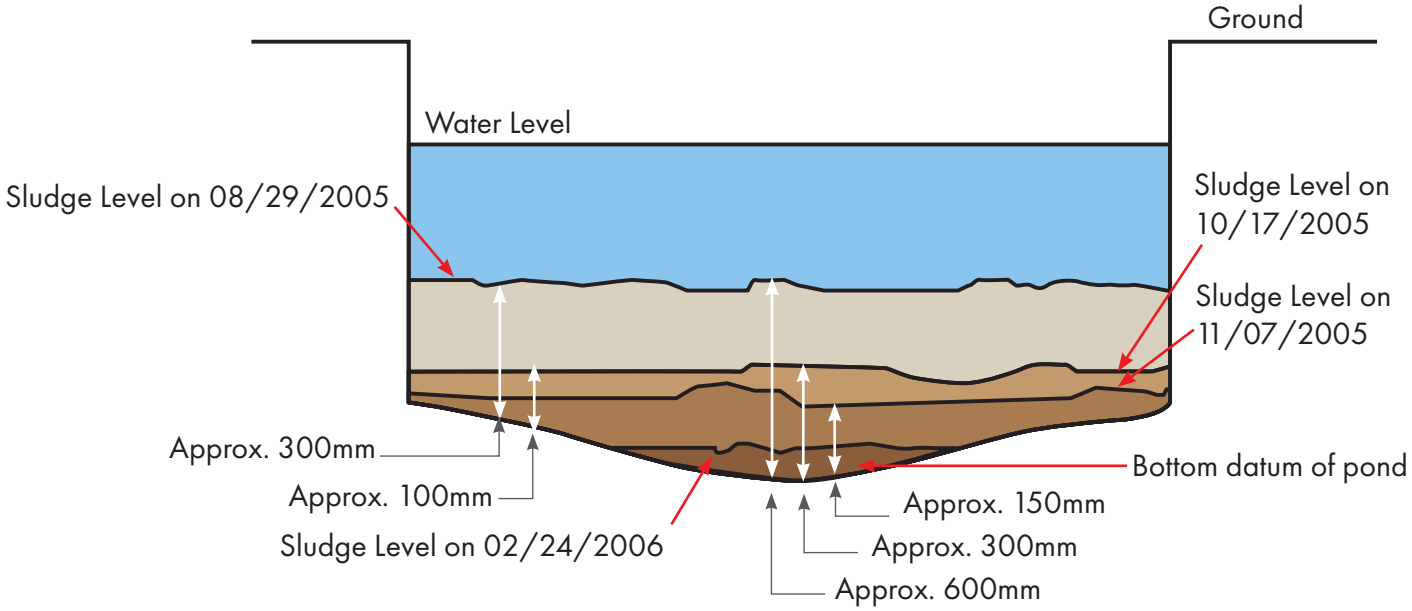
Average Sludge Level

Date	Side of Pond (mm)	Center of Pond (mm)
08/29/2005	300	600
10/17/2005	100	300
11/07/2005	80	150
02/24/2006	0	45

Fig.4: *This chart shows removal of accumulated sludge deposits ranging from a remarkable 93% to 100%*

Schematic Presentation of Sludge Thickness During the Treatment Period

Fig. 5: *This is a visual schematic of the reduction of bottom solids by the bioaugmentation program. A tremendous volume of sludge was virtually eliminated by biological degradation.*



The breaking up of bottom organic sludge often contributes to increasing amount of pollutants in the water as seen in the water parameters during the first two months of treatment.

It is important to note that as these bottom solids are degraded they are first broken down into smaller, soluble components that add to the water parameters of BOD, COD, and TSS until they too are degraded. This is another factor seen in the water parameters during the first two months. As the bottom sludge is reduced we expect to see faster improvement in the influent vs. effluent water parameters. This is clearly reflected in the effluent water parameters taken on 24 Feb. 2006 where the discharge of BOD, COD, and TSS now meet the Standard B regulatory requirement despite the pond experiencing the highest pollutant input load during the entire treatment period.

Based on comparing the initial benchmark sludge measurement with the most recent measurement made on 24 Feb 2006, an estimated 6,000 m^3 of sludge has been degraded by MICROBE-LIFT® technology's environmentally friendly bioremediation process. Based on RM 80 per m^3 of dredging and dumping cost, the biological sludge removal saved the Board over half a million ringgitt, making it a very cost effective solution. And in addition, MICROBE-LIFT® technology eliminated the bad odor in the surrounding area of the pond and improved the quality of the water before discharge to the sea.

In this trial, led by Goh Kwang Beng of MICROBE-LIFT® ASIA and Oakwell Engineering Ltd of Singapore, MICROBE-LIFT® achieved results well beyond JPS's initial targets of odor control and water quality improvement. MICROBE-LIFT® technology improved the water quality to obtain parameters better than the required Standard B, effectively eliminated the odor problem, and achieved sludge reduction far exceeding expectations. This sludge reduction has restored the pond to its intended function.

For more information on MICROBE-LIFT® Technology contact
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