Shell-BP Oil Terminal Wastewater Cleanup: Case Study of BioPetroClean One-Time Service for Accumulated Wastewater

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With increasing of legislation over the past decade, partnered with the heavy enforcement and supervision of these laws, oil terminal waste water treatment has become an increasingly difficult, costly, and time-consuming ordeal. Typically, contaminated water stored in tanks unnecessarily use up portions of a terminal's valuable space. This type of storage is unavoidable when an upset occurs at a facility. In a recent problem of waste water storage and purification involving Shell and BP's South African oil refinery (SAPREF), a unique one-time solution was put to the test.

SAPREF Accumulated Wastewater Dilemma

SAPREF is a joint venture between Shell SA Energy and BP Southern Africa. It is southern Africa's largest crude oil refinery, with a refining capacity of 8.5 million tons a year. SAPREF has been in operation since 1963, and currently employs 620 permanent staff members. SAPREF is both ISO 9001 and ISO 14001 certified.

SAPREF was searching for a solution for accumulated wastewater that had been in tank storage for several months. The wastewater had been collected by SAPREF in response to an upset at the refinery, and was stored until the best solution could be found for its treatment. The water was highly polluted with phenol and other contaminants, and could not easily be brought down to acceptable discharge levels (see Table 1).

Ronnie Muruven, production unit manager at SAPREF, was placed with the task of finding the best solution to dispose of this water. According to Muruven, "We were determined to find a solution that would not only treat the water, but would be a cost-effective and environmentally responsible solution for Sapref". Muruven spent months searching and reviewing several treatment options, including discharging directly into the municipal sewer, but due to the level of contaminants was unable to find a resolution. SAPREF then came across BioPetroClean (BPC). BPC proposed a one-time on-site service solution they believed would take care of Sapref's problem.

BPC is a company that provides biological solutions for industrial waste water management. As part of their services, they offer one-time service solutions. By studying water samples from different companies BPC creates site-specific bacterial and nutrient cocktails to clean contaminated water sources.

BPC first considered installing a continuous mode, skid-mounted system as a solution for SAPREF. After analysis they realized that due to the level of contamination, coupled with the estimated flow rate of the process, it would take nearly two months in order to clean the 5,000 m^3 of wastewater. BPC decided to approach the problem from a different point

of view, and implemented a new one-time service solution for SAPREF. Their decision was to treat the water directly inside the contaminated storage tank by introducing the selected bacteria, calculated inorganic nutrients and providing aeration conditions in a batch-mode system.

Lab Analysis of SAPREF Wastewater

The cocktail is comprised of a distinctive mixture of naturally-occurring bacteria that feed on petroleum hydrocarbons and other organic compounds. In order to ensure optimal bio-degradation of the contaminated water, this cocktail is then combined with a proprietary nutrient-mix. The process is then maintained in a balanced state of bacterial growth and organic compound degradation through an automated system.

The SAPREF water samples taken to the BPC lab were analyzed and treated in a two-stage process:

Stage 1: Analysis: Series of laboratory analysis (which included bacterial concentration, TOC, TPH, COD, phenol, UV scan, salinity, pH etc.) performed to characterize the contaminated water prior to any treatment.

Stage 2: Batch-Mode Laboratory Experiments: performed in order to optimize bacterial and treatment conditions. Based on previous analyses the lab selected various bacteria from the water samples, then began a variety of batch-mode treatments under differing conditions. The purpose of which was to identify the optimal treatment conditions for the site-specific case.

For the purpose of identifying the optimal bacteria and treatment conditions, a selection of batch-mode treatments were performed under simulated conditions mimicking the SAPREF conditions. The results were presented to SAPREF personnel in a detailed report that included comparison values of all measured parameters and associated treatment protocols, cost estimate, and necessary time needed to complete the task.

Table 1: BPC Lab Analysis of SAPREF Wastewater: Before and After Treatment

Lab Analysis of SAPREF Wastewater: Before and After BPC Treatment					
Parameter	Unit of Measure	Before Treatment	After BPC Treatment (BIO1)	% Reduction	Analytical Method
COD	ppm	2,000	400	80%	EPA 410.4
Sulphides	ppm		<0.1		EPA 376.2
TPH	ppm	15	0.5	97%	FTIR, EPA 418.1
Phenol	ppm	85	2	98%	GC-MS EPA 8270
Turbidity	NTU	20	10	50%	Photometric DIN EN 27027
pH		7	7.5		Electrode

Selection of Batch-Mode Treatment

Batch-mode treatment was chosen in this case as an optimal alternative to continuous-flow treatment. Rather than continuously adding, treating, and discharging wastewater as in continuous-mode treatments, batch-mode treatment typically involves gathering a specified quantity of water for treatment with either chemical or biological means. Batch-mode treatment ensures that the overall levels of discharged waters are the same. Once the water is treated this way it can be directly discharged all at once.

For accumulated water, a one time batch process is more efficient and less expensive than a continuous process. To begin with, a continuous process requires at least two tanks, a reservoir tank and a bioreactor, whereas a batch process can be carried out in one tank.

Installation of the BPC Solution

Following completion of the laboratory analysis, BPC proceeded with an on-site installation. The storage tank itself, which held 5,000 m^3 of contaminated water, was turned into a bio-reactor, by introducing aeration diffusers through a roof opening to the bottom of the tank. The selected bacteria were introduced to begin the process. An automated monitoring system, complete with online sensors, was installed next to the tank to ensure balanced degradation levels were maintained.
The BPC system installation was fully automated, maintaining complete self-stabilization at all times. Any change in parameters, such as temperature, DO and pH, were immediately detected by the bio-reactor's sensors. This information is then communicated to the control system, which immediately makes the necessary adjustments. Reports and system logs are generated automatically, and the system can also alert support personnel via SMS.

Batch-Mode Treatment Results

The process was successfully completed in a one-time batch mode. Cleaning of the wastewater took two weeks including installation and implementation. At the end of the two weeks the water had been brought down to acceptable discharge levels. Due to the types of bacteria used and their high specific biological activities, no aggregates were formed during the process. BPC's process is designed to allow each bacterium to act as a single cell, thereby increasing the surface available for the process and enabling biodegradation at a much higher level of efficiency.

The results at SAPREF were a sludge-free output that did not require any additional filtration treatment to remove the bacteria cells before discharge. The output could safely be returned directly to the environment.

SAPREF Wastewater Levels After Treatment

Contamination levels were reduced to government discharge requirements (see Table 2, figure 1). The main source of pollution in SAPREF's wastewater was phenol. Phenol levels were brought down from 100 to below 1 ppm, ten percent of required levels. Similarly, TPH was reduced significantly below regulation levels, from 15 to <0.5 ppm, again lower than required levels. Turbidity was reduced from 25 to 7 NTU, while COD was brought down by 95% from 2000 to 100 ppm.

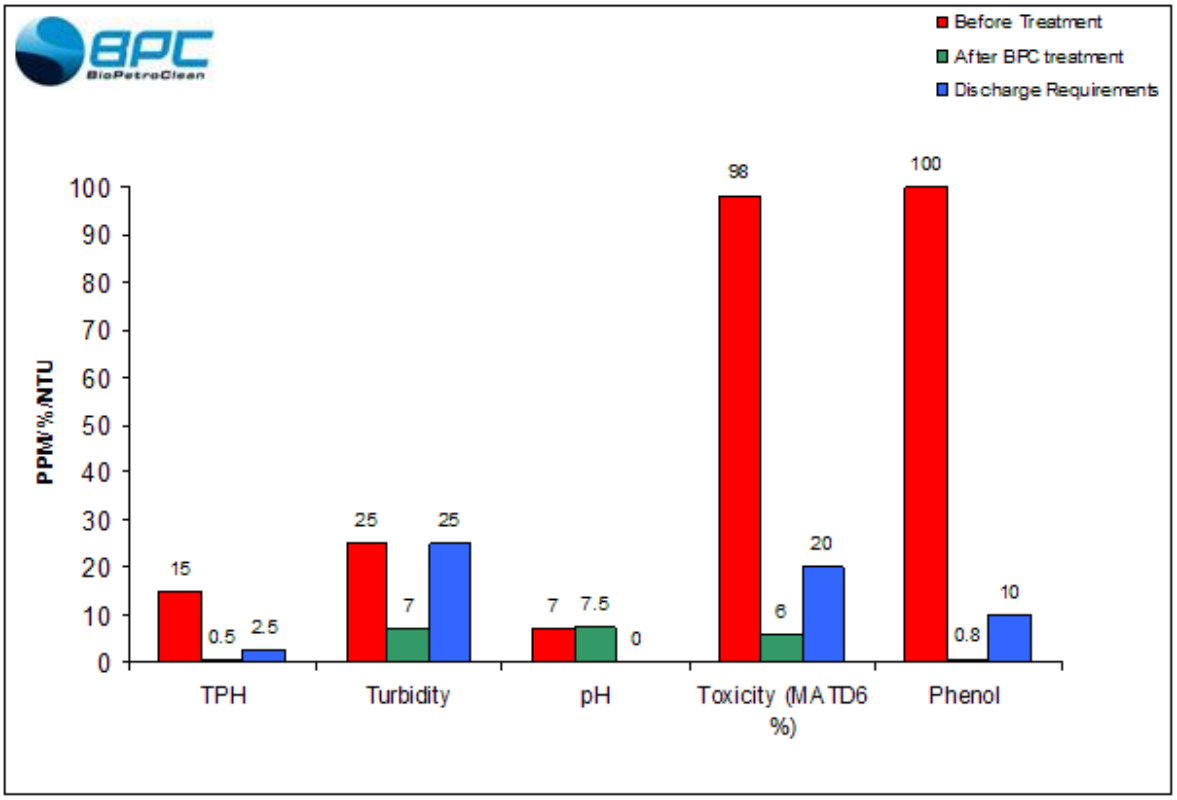
At the start of the process local EPA agents tested the wastewater for toxicity levels (MATD6 testing). This analysis is used to determine the overall quality of the water. It is done by measuring the toxic effect of the bulk water on different organisms including bacteria. By exposing these organisms to a variety of concentrations of the wastewater, it can be determined what level of toxicity the water is at, and how low it needs to be reduced to for the organisms to survive, grow, and reproduce in it.

The test showed SAPREF wastewater levels to be at 98% toxicity, highly dangerous to discharge to the environment. The EPA prohibits facilities from discharging any pollutants at such a toxic level. By the end of BPC treatment the toxicity level of the wastewater was brought down to 6%, less than half of EPA discharge requirements.

Table 2 : Contamination level - Before and After BPC Treatment of Sapref Wastewater

Contamination Levels: Before and After BPC Treatment of SAPREF Wastewater				
Parameters	**Before Treatment**	**After BPC Treatment**	**Discharge Requirements**	**% Reduction**
Oil / TPH (ppm)	15	<0.5	2.5	97%
COD (ppm)	2,000	100	100	95%
Turbidity (NTU)	25	7	25	72%
pH	7	7.5	5.5-9.5	
Toxicity (MATD6 %)	98	6	20	94%
Phenol (ppm)	100	0.8	10	90%
Settleable Solids %		<0.04	0.2% (= 2ml/Lit)	

Figure 1: SAPREF Wastewater Treatment Levels and Government Required Levels



Conclusion

The BPC treatment at SAPREF, from installation to discharge, was completed within two weeks. Since the tank itself was used as the bioreactor a much smaller on-site footprint was left behind, as no additional personnel were needed, the system proved to be a highly cost-effective solution for SAPREF as well.

By customizing a solution for SAPREF, and working in a batch-mode rather than continuous-mode treatment, BPC was able to assist SAPREF in its goal of finding a cost-effective, reliable, and environmentally-responsible solution to its wastewater disposal needs. With the low concentration of bacteria that was used during the process, SAPREF was able to discharge its wastewater without the additional expense of processing it for sludge removal. The process did not interfere with SAPREF's ability to maintain a working terminal, and did not use any unnecessary valuable space. SAPREF personnel were extremely satisfied with the results they received, as well as all costs and minimal time associated with it.

Figure 2:
Conversion of accumulated Wastewater Storage Tank to BPC Bioreactor