A Novel Biological Approach for Treatment of Stripped-Sour Water

Netta Hirshberg, Account manager, BioPetroClean LTD
14th Imber st. Petach Tikva, 49511, Israel
Tel: 972-3-9214564
Fax: 972-3-9215068
Email: netta@biopetroclean.com
Web: www.biopetroclean.com

Crude oil containing sulfur, often in the form of hydrogen sulfide, in excess of 1%, is referred to as sour crude oil. Refineries that process sour crude oil generate sour water in multiple ways. The processes of desalting, fractional distillation in atmospheric or vacuum towers, cracking in thermal or catalytic units, and hydrodesulfurization (HDS) all contribute to a sour water by-product. Other significant sour water contaminants include ammonia, phenol and cyanide.

The first level of treatment for sour water is typically done in a sour water stripper, whereby large quantities of hydrogen sulfide and ammonia are steam-stripped from the water.

However, the high contamination level found in the remaining stripped sour water requires additional treatment prior to discharging into the environment or recycling for other refinery processes.

Refinery Wastewater Treatment

At this stage, many refineries send the stripped sour water, together with other refinery wastewater streams, for further wastewater treatment, as illustrated bellow.

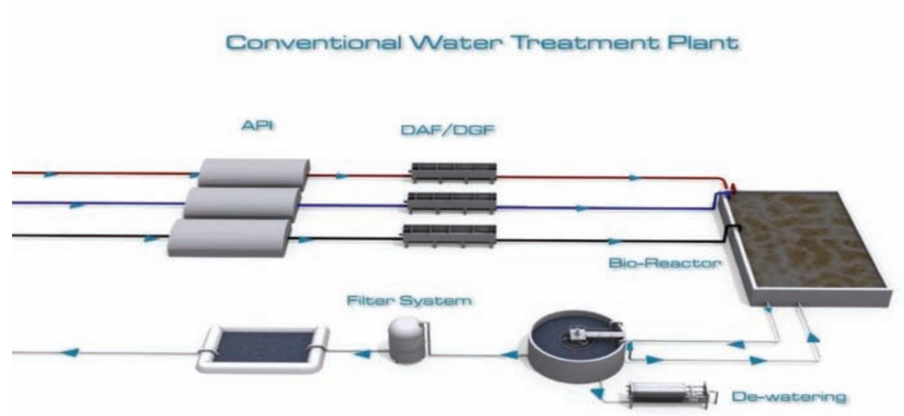


Figure 1: Conventional Water Treatment Plant

Typically, the combined effluent undergoes a gravitational separation (API). Due to density differences, free oil is separated from the water and forms an oily upper layer which is then skimmed off. Heavy components such as sand or other particles are collected from the bottom of the tank, and the water flows to the next separation step. Dissolved Air Flotation (DAF) or Dissolved Gas Flotation (DGF) mainly allows separation of dispersed oil from the water. The separation is accomplished by forcing air into a solution within the wastewater through a high pressure system. The pressure is then released, causing the air to form tiny bubbles which adhere to the oil globules. This process elevates the oil globules which can be easily extracted by skimming or filtration. The pre-treated wastewater subsequently undergoes a biological treatment in which dissolved contaminants are biodegraded. The most common biological method is known as activated sludge. The dissolved contaminants are consumed by the microorganisms within the tank to form additional bio-mass (sludge). Water and sludge are washed out of the bioreactor and into a clarifier. The solid waste (sludge) that settles on the bottom of the clarifier is composed of both live and dead bacteria. Approximately 50-70% of this sludge is transported back to the bioreactor (note the two-way arrow between the clarifier and the bioreactor) in order to continually re-activate the biological process. The other half of the sludge is fed into a de-watering system for removing additional water and is then disposed of in a landfill. The effluent from the clarifier passes through a filtration unit (usually ultra-filter) into a settling pond and only then is ready for discharge.

Challenges in Stripped Sour Water Treatment

The composition of stripped sour water is not constant and due to fluctuations in the types and levels of contamination, it often is the cause of upsets and overloads during the treatment process.

Attempts at mixing and diluting the stripped sour water with the main refinery effluent stream, prior to the primary treatment, has not met with high-levels of success. In many cases, even after dilution, the contamination level is too high, causing a toxic effect on the microorganisms in the biological process, which lead to a system failure.

An additional problem is that the typical biological process does not always reduce the contamination levels to the required discharge levels. This is especially true when the initial nitrogen or phenol levels of the stripped sour water are high. In such cases the final nitrogen and phenol levels in the treated water might not meet discharge requirements, even after the complete treatment process.

Even in cases where the activated sludge treatment succeeds in meeting with the required discharge levels, the process yields a high sludge level that translates directly into higher disposal costs.

An Alternative Biological Approach as a Solution

A recently developed biological method for wastewater treatment, known as the Automated Chemostat TreatmentTM (ACT) appears to provide a potent solution for the existing challenges in this field. This new biological concept is based on maintaining a pre-selected bacterial "cocktail" at a stable, low concentration while monitoring the system with a fully automated control unit.

The first essential aspect of this biological method lies in the meticulous selection and culturing of bacteria from pre-treated waters which are then specifically designed for any given wastewater type. These bacteria are naturally occurring, without alteration or genetic engineering.

The increased homogeneity of the cocktail ensures a more targeted and effective bio-degradation of the polluted water content. The tailor-made bacterial cocktail is so specifically designed for the water-type and the on-site environmental conditions, that some designs can even yield a bacterial cocktail that is tolerant to extreme environments such as high temperatures (up to 45 ºC) or high salinity (up to 4%).

Additionally, as the bacteria concentration is kept at a minimum throughout the process, aggregate formation is prevented. This approach increases the surface area available for the bacterial bio-degradation process, with a resultant higher quality of effluence. Moreover, the low cell concentration ensure that a young cell population is maintained, keeping sludge-buildup at a minimum and cell efficiency at a maximum.

Lastly, the process is continuously monitored by a control system, designed to overcome system fluctuations. The monitoring occurs both in pre-treated influent as well as within the bioreactor. The fully-automated control system maintains a permanent homeostatic state, and can handle a variety of contaminants and waste capacities.

This type of custom-designed solution effectively decreases the issues surrounding the treatment process. The sludge levels that are produced throughout the biological processes are significantly lower in comparison to sludge levels produced by traditional treatments. This directly translates into a cost reduction, as less handling of by-products is required.

Implementation

The modular approach provided by this solution allows for on-site implementation leveraging existing infrastructure. As such, when treating stripped sour water streams, the ACT system can be integrated in a complementary fashion with the refinery main-stream process. Alternatively, it can be implemented as a completely separate process, solely dedicated to the stripped sour water stream. In the first option, stripped sour water passes through the API and DAF units and then enters the ACT bioreactor. Following the biological treatment, the treated stripped sour water can be returned to the main bioreactor for further biodegradation, filtration and discharge. In the latter option, after undergoing API and DAF treatments, the stripped sour water can be biologically treated in the ACT bioreactor, filtered, and then directly discharged to the environment.

The complete separation of the stripped sour water from the main stream is advantageous in two regards. Firstly, such water, after proper treatment, can be recycled for additional usages in various refinery processes. Secondly, the total organic load in the main-stream is significantly decreased, allowing for higher treatment capacity and efficiency.

Case Study

The efficacy of the ACT technology in treatment of stripped sour water was recently demonstrated by BioPetroCleanTM (BPC), developer of ACT.

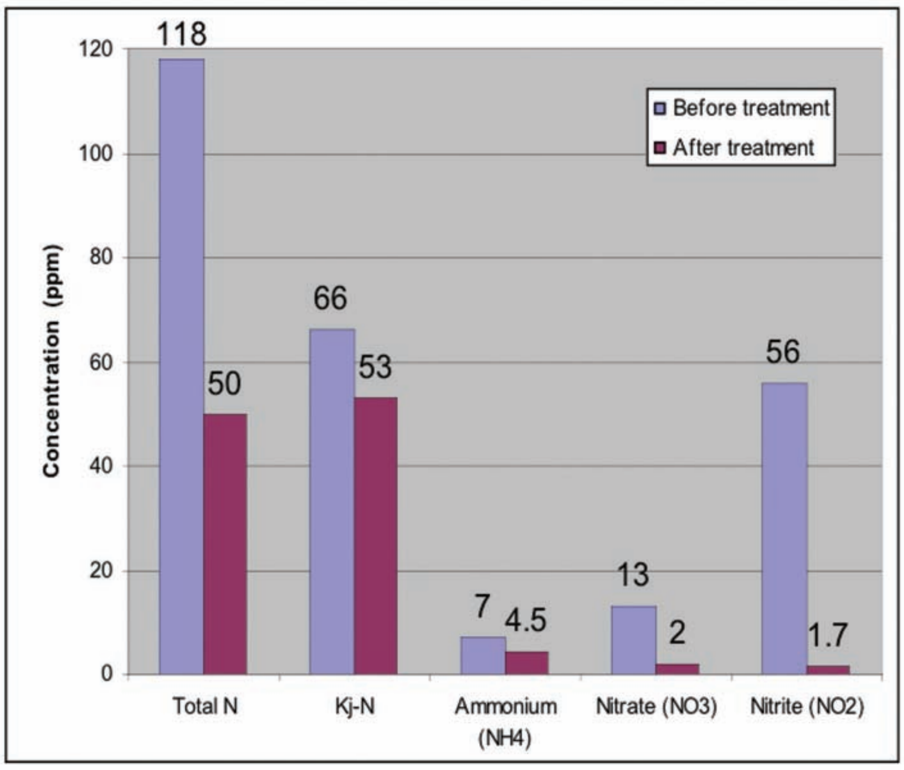
A stripped sour water sample was treated using the BPC-ACTTM technology in a continuous mode. During the treatment process, the water was analyzed for nitrogen, phenol, solid levels, COD and TOC reduction. The water in the reactor was kept at room temperature, and at a constant DO and pH. In addition to the high carbonaceous contaminants, the treated water contained high levels of nitrogen and phenol. During the BPC-ACTTM process, the carbon uptake was very high. The total organic carbons (TOC) were consumed at an efficiency level of 75%. In correlation, COD was consumed at an efficiency level of 85% and the TPH was consumed at an efficiency level of 99%. In addition, the phenols were also consumed to an extremely low level of 0.1 ppm (99% reduction).

The nitrogen uptake during the ACT process was particularly interesting in this project.

As shown in the graph below, the biological process alone (without any filtration) reduced the total nitrogen levels to a final amount of 50 ppm, indicating that 58% of the nitrogen was consumed by the bacteria. During the bioprocess different forms of nitrogen were measured (ammonium, nitrate, nitrite, Kj-N, N-total).

Parameters	Unit	Before Treatment	After Treatment	% Reduction	By Standard Method
COD	PPM	2480	372	85	Photometric EPA 410.4
TOC (NPOC)	PPM	683	171	75	SM 4310 B
Oil/TPH	PPM	8.3	0.1	99	FTIR EPA 418.1
Phenol (C6H6O)	PPM	14.60	0.1	99	Photometric
Turbidity	NTU	545	28.60	95	Photometric DIN EN 27027
TSS (105)	PPM	45	103	----	SM 2540 D

Table 1: Carbons uptake during the BPC-ACTTM process for a refinery stripped sour water



Graph 1: Biological reduction of the different nitrogen forms during the BPC-ACTTM process

It is important to note that the measurements were performed on mixed water from the bio-reactor without any precipitation of the bacteria. Therefore, the difference of 68 ppm in the total-N levels before and after the ACT process, presents the fraction that was evaporated from the system, and not assimilated in the bacterial cells

The reduction of N-total is mainly derived from a decrease in the nitrite from 56 ppm to 2 ppm. This is a very interesting finding as usually, ammonia is a preferable nitrogen source over nitrite. Apparently, the unique technology of ACT resulted in a bacterial cocktail that prefers nitrite as a nitrogen source. It is commonly known that de-nitrification occurs under anaerobic conditions, which raises the question of how such de-nitrification occurred in the continuously aerated bioreactor. However, this phenomenon of N-total reduction under aerobic condition is field proven as demonstrated in this case. It has also been previously documented in scientific literature (Aerobic de-nitrification by a newly isolated heterotrophic bacterium strain TL1, T. Lukow and H. Diekmann, 1997). This paper indicates that this phenomenon is actually widely distributed in sewage plants.

In summary, stripped sour water is a typical wastewater stream in refineries. Due to its contaminants profile and its fluctuating nature, this stream is often the cause for upsets and overloads in the treatment process. In this article, the feasibility of the BPC-ACTTM process in treating such water is demonstrated. The biological process alone (without any post-treatment) resulted in a very efficient carbon and nitrogen uptake, with significantly lower sludge levels. The results clearly indicate that implementation of the BPC-ACTTM technology for stripped sour water treatment (either prior to the activated sludge stage or as a replacement to it) will lead to reduced overloads at an over-all increased capacity, and at lower operational costs.

New Surface Water Management Planning Contract Awarded

Independent engineering and environmental consultancy, **Royal Haskoning** (UK) announce that it has won a competitive bid to provide Surface Water Management Planning services and a Water Cycle Study for a consortium of Stafford, Lichfield, Tamworth and South Staffordshire local councils in the UK. The work, when completed, will inform the councils' planning and urban development strategies for the next two decades by identifying areas at high-risk of surface water flooding. The study will also provide a thorough assessment of surface water flood risk and valuable forward planning information on water resource and sewerage capacity.

The decision to appoint Royal Haskoning was heavily influenced by the firm's extensive flood risk management experience, in particular work with the Environment Agency, for whom Royal Haskoning provides National support on both the Strategic Flood Risk Mapping (SFRM) and National Engineering and Environmental Consultancy Agreement (NEECA) Frameworks. With surface water management only recently coming under the auspices of local authorities, the collaboration of these four councils represents one of the first concerted efforts into surface water flood management planning and will direct the course of the communities' residential and commercial building, transportation, and other major infrastructural projects.

The Surface Water Management Plan will be delivered in two stages. The first preparatory phase will comprise the development of a steering committee, consisting of key project stakeholders. Royal Haskoning will then perform high level analytical modelling of flood risk in the four local authority areas. The second phase will entail a more detailed risk assessment, evaluating the findings from phase one and presenting these to the steering committee for actionable next steps. The project will be entirely funded by the councils, with the first set of evidence to be presented by Royal Haskoning in early Spring 2010.

Reader Reply Card No 110

Thames Water Selects Black & Veatch for £100m Sewage Plant Expansion Contract

Black & Veatch (UK) has been selected by Thames Water as principal contractor to upgrade and extend Mogden Sewage Treatment Works in West London. Construction will start in spring 2010 to significantly reduce the amount of storm sewage that overflows into the River Thames during heavy rainfall when the site becomes overloaded. As principal contractor, Black & Veatch is responsible for the engineering, procurement and construction of the extended works. Steve Shine, Thames Water's Chief Operating Officer, said, "This work marks a fundamental step in improving the quality of London's iconic river. We inherited a Victorian sewerage system, which is struggling to cope with the demands of 21st Century London. Since it was built, the capital's population has more than doubled, climate change is bringing less frequent but heavier rainfall and many green spaces have been concreted over preventing natural drainage. "Although our sewage works operate well under stable dry weather conditions, in heavy rainfall excess flows pass through storm tanks, which provide a lower standard of treatment, and overflow into the tidal stretches of the River Thames - rather than having sewage back up on to the streets or even into people's homes.

"The improvements at Mogden Sewage Works, which currently serves 1.9 million Londoners, will enable the site to treat 34 per cent more sewage and allow for a six per cent population increase until 2021. As well as significantly reducing sewage discharges, these improvements will help reduce odour at the site, as storm tank use will be reduced, and new and existing equipment will be covered."

The plant's treatment capacity will be increased by 34 per cent. In addition to reducing storm water discharges, around 40 per cent of the energy required to treat storm and wastewater will be generated onsite from renewable biogas – a byproduct of the sewage treatment process. The improvement works will be carried out over a three-year programme. According to Tony Collins, Managing Director for Black & Veatch, "The Mogden project is a great opportunity for Black & Veatch to deliver a first-class plant for Thames Water and its customers. We have a great team in place who can call on Black & Veatch's expertise from anywhere in the world to add value to the project."

Reader Reply Card No 111