Upset prevention in biological water treatment facilities

Upsets in biological water treatment systems create serious operating problems that could adversely affect the overall performance and effluent quality in refinery water treatment applications. **Netta Hirshberg** of BioPetroClean reports on an advanced technique – Automated Chemostat Treatment™ – that detects and responds to inlet fluctuations and helps maintain biological activity in difficult conditions.

Recovery from an upset in a wastewater treatment system requires significant time and resources to remedy, but early identification and detection can prevent costly downtime and effluent quality problems.

An upset is an unexpected deviation of one or more parameters in the inlet stream that leads to a partial or complete process failure. The event could be a transient deterioration in treatment performance that is either temporary or sustained, depending on the type of influent disturbance. These episodes often lead to a dramatic increase in water contamination levels, which evidently do not comply with regulations.

Biological wastewater treatment systems are especially susceptible to various types of upsets. These transient changes caused by the plant upset can adversely influence the microbiology and, ultimately, the overall performance of the treatment process. This can jeopardize the health of the biological system, and in severe cases, can lead to a complete collapse of the bacterial population, thus bringing the entire process to a halt.

Even well performing plants suffer from identifiable upsets three to four times a year, lasting approximately 3.5 days on average. During such periods, plants are usually forced to divert contaminated streams to storage, leading to large quantities of wastewater with problematic characteristics that do not meet local regulations for discharge.

Most facilities are not only susceptible to upsets; they often do not know the cause of the upset even after it occurred. Without early identification of upsets, the operators need to deal with such events after they occurred rather than taking measures to prevent them. Hence, characterizing the various causes for process upsets are of great importance. A survey on refinery causes reveals that most upsets are caused by operational factors and influent disturbances. The most common causes are related to abnormal contamination levels such as increased organic compounds, toxicity, oil and grease, heavy metals, ammonia and sulfides; nutrient deficiency; or abnormal environmental conditions, including pH, temperature, salinity and radiation. Moreover, 50 percent of biological wastewater facilities experience upsets are caused by organic overload or increased toxicity (Reference 1).

Key considerations in system resistance to upsets

The high susceptibility of biological systems to various upsets requires an efficient identification and response system to inlet fluctuations within a short time frame. It is important to identify the parameters that will most likely reflect a potential upset. This decision depends on the plant's process history, available detection equipment, and their reliability. Once such parameters are chosen, their red (alert) level should be determined. This can be the maximum or minimum value, depending on the type of parameter chosen as an indicator. In case parameters such as concentration of ammonia or phenols are chosen as upset indicators, a maximum red level is defined. A minimum red level is usually defined in cases when pH or concentration of nutrients is chosen as indicators.

One of the biggest challenges in designing an upset prevention system is setting the red line. Setting it too high may not prevent the upset from occurring, leading to a partial or complete shutdown of the system. In contrast, setting parameters too low may lead to frequent false alarms, damaging the credibility of the alert system. This issue gets even more complicated, as in some instances the rate of change also has a negative effect on the biological system. For example, a gradual increase in temperature may be tolerable, whereas a sudden increase may be harmful.

An additional consideration in designing such systems is the response time of the measuring equipment. Naturally, prevention is more efficient when results are provided quickly, but short response time often depends on availability and cost of instrumentation. One should bear in mind that prompt measurements are not always a necessity. The reactor volume or process flow can compensate for this instrumental challenge in some cases. An additional consideration is the type of action taken when a potential upset is

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The BioPetroClean control unit helps prevent upsets in biological treatment systems.

detected. The cause of upset, the sensitivity level of the biological system, and the process configuration are some of the factors affecting this decision.

Novel biological method

A biological method for wastewater treatment, known as Automated Chemostat Treatment™ (ACT), provides a potent solution for the existing challenges in the field of upset detection and recovery, according to BioPetroClean, the company that developed ACT. This new biological technology 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 water that are specifically designed for any given wastewater type. These bacteria are naturally occurring without alteration or genetic engineering. The more homogeneous nature of the cocktail ensures a more targeted and effective biodegradation of the polluted water content. The bacterial cocktail is tailor-made for the water type and on-site environmental conditions and have been proven to withstand extreme environments such as high temperatures (up to 45°C) or high salinity (up to 4 percent), and high contamination level.

Additionally, keeping bacteria concentration at a minimum throughout the process prevents aggregate formation. This approach increases the surface area available for the bacterial biodegradation process, resulting in higher quality effluent. Moreover, the cell population is maintained young, keeping sludge-buildup low and cell efficiency at a maximum. Lastly, the process is continuously monitored by a control system designed to overcome system fluctuations. The fully automated control unit monitors both the pre-treated influent and the water within the bioreactor. In case abnormalities are detected, it can immediately react based on pre-determined algorithms to maintain steady conditions within the bioreactor.

The ACT system, complemented by a sophisticated and automatic proprietary control unit that continuously monitors the inlet, is an efficient solution for upsets in the wastewater treatment process. The ACT technique can be implemented in several configurations in order to prevent and handle upsets. It can be applied as a back-up system for pre-existing biological systems such as activated sludge or membrane bioreactors. The control unit can be placed upstream from the current installed bioreactor. If an upset is detected, the system can immediately respond by automatically shifting the water stream into an alternative ACT-Bioreactor. The highly stable ACT system can treat the problematic water, which can then be redirected into the main biological system.

An alternative configuration can be tailored for plants with one or more problematic streams that lead to a continuous overload on the biological system. In such cases, the stream can be treated separately by the ACT system in order to prevent upsets in the main biological system. The treated water can then be combined with the main stream and further treated by the main biological system. Otherwise, the ACT system can serve as the sole biological system in which the treated water can undergo final polishing and be discharged.

Summary

Upsets create severe operating problems for biological wastewater treatment systems and usually yield effluent with contamination levels that do not meet regulatory requirements. BioPetroClean's ACT technique represents a revolutionary advance in biological wastewater treatment solutions that can prevent these problems. This system is comprised of two main components: a bioreactor containing a cocktail of naturally-occurring bacteria tailored for the water type and environmental conditions and a control unit that continuously monitors various parameters of the inlet wastewater and the contents of the bioreactor. The ability to detect and respond to inlet fluctuations and to maintain biological activity under non-optimal conditions makes ACT a viable solution for refinery water treatment processes that are prone to various upsets.

Reference:

1. Love Nancy G., Bott Charles B., 2000, A Review and Needs Survey of Upset Early Warning Devices, Water Environment Research Foundation