In recent years, anaerobic wastewater treatment has become a technology of growing importance, especially for highly polluted wastewater from the Sugar & Distillery industries.

Most Sugar & Distillery industries waste waters contain high loads, mainly of easily biodegradable organic pollutants, which make them suitable for anaerobic treatment. An aerobic post-treatment can further reduce the residual BOD₅ and COD₇ down to very low values. In the case the factory effluent is a combination of different process flows, of which some are less favourable for biological treatment or require appropriate processes, the anaerobic and aerobic treatment designs must be adapted accordingly. The availability of different types of methane reactors in combination with the possibility to remove nitrogen and phosphorus together with the remaining organic pollutants in the aerobic post-treatment, require the anaerobic/aerobic treatment system to be very flexible. The different types of methane reactors are discussed with special attention to applications in the Sugar related industries. The advantages of the combined anaerobic / aerobic treatment are discussed.
1. **INTRODUCTION**

In recent years, anaerobic wastewater treatment has become a technology of growing importance, especially for highly polluted wastewater from the Sugar & Distillery industries.

In India alone, for instance, there are nearly 300 alcohol distilleries. Most of the plants use cane molasses as raw material. This waste product of the sugar industry contains, next to sugar, a lot of organic matter, which ends up in the wastewater. A typical 25,000 l/d alcohol distillery produces over 25 ton COD/d as waste. Molasses derived wastewaters are also produced by the yeast factories, citric acid factories, and by monosodium glutamate (MSG) factories.

Typical aspects of these wastewaters are:

1. **Concentration:** COD concentration varies between 10,000 and 100,000 mg/l, and even 300,000 mg/l for MSG factories. Salt concentration can amount to e.g. 10,000 mg Cl-/l or 8,000 mg K+/l.

   The concentration of different salts (especially the Na+/Ca2+ ratio) is believed to have influence on floc formation in the methane reactor, but also greatly affects the required aeration power for aerobic treatment and the consumption of chemicals in the physico-chemical post-treatment.

2. **Sulfate content:** Sulfate is present in medium to very high concentrations, especially when sulfuric acid is used in the factory. Sulfate is reduced to hydrogen sulfide during anaerobic digestion, which causes partial inhibition of the methane fermentation.

3. **Ammonia content:** Ammonia, present in the wastewater or generated out of organic nitrogenous compounds, also causes inhibition at high pH levels. Beet vinasses contains considerably more nitrogen than cane vinasses due to the presence of nitrogen rich compounds such as betains. Degradation of these compounds during methane digestion results in release of ammonia. As a consequence, the COD/TKN ratio of only 15 can be used, compared to approx. 50 for cane vinasses.

Two major advantages of anaerobic wastewater treatment explain this progress at the expense of the classic activated sludge treatment:

- the sludge growth (expressed as kg biosolids per kg of COD removed) is significantly less compared with the aerobic treatment (only 10 to 20%)
- a considerable energy saving is attained as costly aeration power requirements are avoided and energy-rich biogas is produced as a by-product.

Other advantages of an anaerobic treatment are:

- lower nutrient requirements
- lower plan area requirements because of higher volumetric loading rates
- lower capital investment and overall operation costs.
However, due to stringent removal efficiencies of COD, BOD and nutrient, an aerobic post treatment is often required. Advances in membrane technologies like Ultrafiltration/Microfiltration followed by Reverse Osmosis ensures standards for Total Dissolved Solids (TDS) reduction as specified by Pollution Control Boards (PCB) are also met. More importantly use of membrane technologies ensures source reduction of raw water required, product recovery (fibers, chemicals, emulsions, etc.), reduced effluent quantity and quality through recycle and reuse of treated Sugar effluents.

Ion Exchange Waterleau Ltd. (IEWL) in association with Waterleau/Biotim N.V., firms has specialized in anaerobic/aerobic wastewater treatment, solid waste treatment & gaseous industrial effluent treatment. We have focused our efforts towards complete treatment of the most difficult and most concentrated effluents generated by Sugar & Distillery industries. Ion Exchange Waterleau Ltd. (IEWL) also offers products and technology for environmental pollution control to other industries like fermentation industry, the starch, breweries, paper and related industries.

Today, anaerobic treatment is the preeminent technique as first step in treating wastewater from Sugar & Distillery industries. The anaerobic treatment is based on a microbiological process, namely methane fermentation, which occurs in an anaerobic environment. Numerous species of bacteria have to cooperate in order to convert it to a mixture of methane and carbon dioxide, called biogas. The bacteria are generally present as sludge flocs or bacterial clusters (aggregates). This process has been traditionally more complex and consequently harder to control than the aerobic biological process used in the classic activated sludge wastewater treatment. In the past 10 years, a better understanding of the microbiology of anaerobic processes has resulted in the successful development of new, improved and practical systems.

The appropriate methane reactor type must be chosen depending on the composition of the factory effluent. So, one of Ion Exchange Waterleau Ltd. (IEWL) motto is ‘know your wastewater’. Successful anaerobic wastewater treatment is only possible if the characteristics and specific problems for each individual wastewater are known in advance. The immense diversity in industrial wastewaters creates the need to have several different treatment techniques at your disposal, each of them offering the best solution for a particular type of wastewater.

The most important process parameters that must be taken into consideration when choosing the reactor configuration are:

- the organic loading of the wastewater (COD)
- the biodegradability (as indicated by the BOD/COD ratio)
- the temperature of the wastewater
- the versatility of the wastewater composition
- the presence of inhibitory or toxic compounds such as ammonia, sulphate or heavy metals
- the availability of seed sludge
- the technical skill of the local future operators.
Ion Exchange Waterleau Ltd. (IEWL) offers a complete range (four types) of design concepts that can be applied for anaerobic wastewater treatment. They are commonly classified as:

1. Anaerobic Contact (AC) Reactor.
2. Upflow Anaerobic Sludge Blanket (UASB) Reactor
3. Anaerobic Filter (AF)
4. Hybrid Type of Reactors (UAC + UACF).

In addition, we offer “state of art” LUCAS® aerobic cyclic activated sludge process and INDION® membrane systems for post treatment and recycle of anaerobically treated effluents.

In this Sugar we will restrict our discussion to anaerobic processes offered by us.

2. **ANAEROBIC PROCESS OPTIONS**

2.1. **The Anaerobic Contact Process**

The Anaerobic Contact reactor was one of the first reactor types to be used for anaerobic wastewater treatment. It is a simple concept, mainly consisting of a completely mixed reactor followed by a conventional sludge settler or a parallel plate sludge separator.

Inside the methane reactor the active anaerobic sludge is kept in suspension by mechanical mixing. The settled sludge is continuously recycled from the sludge settler to the reactor. More recently, INDION® ultrafiltration has been used as an alternative for biomass separation.

Although the anaerobic contact process does not allow high organic loading rates (preferably lower than 5 kg COD/m³.d), this concept is still used. Among other reasons are the great simplicity and the stable operation at varying conditions. When the wastewater characteristics are not all that favorable for anaerobic treatment (high ammonia concentration, high Ca²⁺ content,…), the AC process remains a good alternative.
2.2. **The Upflow Anaerobic Sludge Blanket Process (UASB)**

The Upflow Anaerobic Sludge Blanket reactor (UASB) was a successful improvement for anaerobic wastewater treatment. High volumetric loading rates (up to 10-15 kg COD/m$^3$ per day) can be reached on certain wastewaters. The reactor can be divided into three different areas: 1) the sludge bed, 2) the sludge blanket, and 3) the three-phase separator. By natural selection for good settling sludge, most of the active sludge will be present at the bottom of the reactor.

The wastewater is fed at the reactor bottom through a distribution system. While flowing upwards through the dense sludge bed, the organic pollutants are converted into biomass and biogas. This biogas creates a more turbulent area above the sludge bed, called the sludge blanket.

On top of the reactor the three-phase separator first separates the biogas from the sludge-water mixture. Then, because of the lower turbulence, the sludge will begin to settle and return to the sludge blanket. To improve the sludge-water separation, parallel plates can be installed inside the separator to increase the settling surface area.
2.3. **The Anaerobic Filter Process (AF)**

Biofiltration uses bacterial immobilization by means of slime films on an inert support material and the entrapment of sludge flocs within the macro-porous structure of the carrier material to retain as much of the active sludge as possible.

Especially designed carrier materials are available, usually made of polyethylene or polypropylene. They are highly voided to reduce the risk of clogging and have high specific surfaces between 100 and 200 m² per m³ carrier material.

Anaerobic filters are used whenever non-granular or non settleable sludge is expected and when available area is limited. The high biomass concentration inside the reactor allows volumetric loading rates of 5 to 10 kg COD/m³ per day. A disadvantage of the Anaerobic Filter is the relative high cost of the carrier material.
2.4. **The “Hybrid” Processes**

Hybrid Type of reactors are a combination of an Upflow Anaerobic Sludge Blanket reactor with an Anaerobic Filter or an Anaerobic Contact process or a combination of the three types.

The first Hybrid Type of reactor is similar to an UASB, except for the three-phase separator. The separator is replaced by a layer of floating carrier material. This material serves a double function: 1.) to separate and retain a large fraction of sludge in the reactor before the effluent leaves the reactor, and 2.) to carry active sludge in the porous space of the carrier material itself. This type of reactor is called the Upflow Anaerobic Contact Filter reactor (UACF).

The second Type of Hybrid reactor has recently been developed for wastewater showing no granule formation and requiring a longer hydraulic retention time. It is called the Upflow Anaerobic Contact reactor (UAC). This reactor allows some biomass accumulation in the lower part of the reactor. The reactor is not totally mixed which is the case for the Anaerobic Contact (AC) reactor but is equipped with a sophisticated influent distribution system similar to the one for the UASB reactor. The three-phase separator is replaced by an external crossflow parallel plate separator of our newest design (Sepafloc®).

In the last several years we have designed and constructed several anaerobic reactors for Sugar & Distillery industries.

**Continuous Stirred Tank Reactor Process:**

Continuous Stirred Tank Reactor Process is a high rate process in which anaerobic digestion take place in the mesophilic range of temperature, that is 37-39 Deg C and at a pH around 7.2.

As in the case of UASB and UAC processes described above, all three stages of anaerobic reaction viz. Hydrolysis, Acidogenesis and Methanogenesis are carried out in a single reactor. The reactors are fitted with central mixers and lateral agitators to ensure complete mixing of the spent wash effluents inside the reactor. The reactor also has a recirculation arrangement of settled solids from treated spent wash in order to maintain adequate population of microorganism in the reactor/process.

This reactor design is ideal for treating yeast free spentwash effluents having high COD (in the range of 1,20,000) and high BOD (40-45,000). IEWL reactor designs ensures more than 65-70% COD reduction, consistent production of bio-gas produced by anaerobic digestion. The Biogas is collected from the top of the reactor and conveyed to a gas holder located near the reactor and equipped with a floating roof.

Common & Coherent features of IEWL reactors are essential safety equipments such as breather valves, flame arresters, etc. Additionally IEWL also provides design, engineering and supply of biogas engine of internally acclaimed and proven makes alongwith extensive service support to its customers in the industry.

**CONCLUSIONS**
Anaerobic wastewater treatment has become a technology of growing importance, especially for concentrated wastewater. Economic advantages such as a much smaller energy required and a much lower sludge production explain this progress. Generation of methane gas that is converted easily into energy source (heat/power) resulting in lower and attractive paybacks on investment has resulted in anaerobic wastewater treatment process as a preferred choice of mature and reliable technology.

However, the design of a new anaerobic treatment plant has to be carefully considered. Every wastewater is different and not every wastewater is suitable for anaerobic treatment. Especially the choice of the reactor type is very important and it has a major influence on the performance of the wastewater treatment plant. Therefore selection of effluent treatment process vendor having long standing experience in Process Design, Engineering, Construction and After Sales Service including trouble shooting becomes a necessity to make an appropriate design, and to be able to guarantee good results.

Thanks to the experience built up through the years and the presence of a skilled staff, Ion Exchange Waterleau Ltd. (IEWL) is able to offer a custom made solution for treating & recycling most kind of wastewater from Sugar industry.

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