EFFLUENT TREATMENTS OF PULP AND PAPER INDUSTRY - ANAEROBIC BACTERIAL DEGRADATION

- Puri,S.C.* and Chawla,J.S.*

INTRODUCTION

The anaerobic fermentation process converts organic material to high energy biogas which is composed of methane and carbon dioxide. The process nas been used in waste treatment to produce biogas for at least one hundred year.

Recently industry has changed from resources destroying aerobic to resource-conserving anaerobic waste water treatment. By anaerobic treatment a combination of energy deficient waste water purification and energy recovery in the form of biogas production can be achieved. These facts are of great interest for pulp and paper industry which is a major source of organic pollution.

BASIC FACTS

A fast degradation of organic material takes place alongwith the release of considerable amount ,of heats under aerobic conditions. The major part of degradation is brought about by bacteria and fungi. End products are new microbial cells and carbon dioxide. The active organism can utilize a large amount of the energy stored in the organic materials degraded and they grow fast. Aerobic degradation (in the presence of oxygen) of glucose takes place in the following way:

$$C_6H_{12}O_6 + O_2 = CO_2 + 6H_2O + \text{New Cell and Heat.}$$

Thus in aerobic condition, approximately 60% of energy available in glucose is stored in new cells and 40% is lost as heat. Under anaerobic conditions i.e. in the absence of molecular oxygen,the energy yield of micro-organism is low and particularly the methanogenic bacteria grow slowly. Glucose is degraded as:

$$C_6H_{12}O_6\ 3CH_4 + 3CO_2 + \text{New Cells} + \text{Heat.}$$

Here 90 % of energy is recovered in the form of methane, 8 % of energy is available in the new cells as glucose and 2 % lost as heat. Therefore heat loss is about 20 times higher under aerobic than under anaerobic conditions when glucose is degraded.

---

*Regional Research Laboratory, Jammu Tawi.

Organic material is anaerobically fermented by bacteria stepwise to methane (50 - 70 %) and CO_2(30 - 50 %) with the production of bacterial cells. The biogas has an energy content of 18-24 MJ/m^3 compared to value of 373 MJ/m^3 of pure methane. If waste water contains lignified cellulose, the hydrolysis i.e. liquefaction is a rate-limiting step. When soluble substrates are treated, the conversion of acetate to CH_4 and CO_2 is considered as rate-limiting steps. When the process is poorly functioning then accumulation of propionic and butyric acid takes place.

WASTE WATER : Waste water from pulp and paper industries often contain toxic components which can inhibit biological treatment. Some of these originate from wood e.g. diterpene resin acids, diterpenealcohols, long chain unsaturated fatty acids and juvabiones. Others compounds that are formed during pulping and bleaching by chlorination are chlorinated resin acids, phenols, fatty acids and chlorinated lignin residues. Originally conventional anaerobic treatment required highly concentrated waste water and now it has been found that there is no concentration limits for this treatment as the concentration of inhibiting substances does not always influence the BOD_7. Even if BOD_7-Concentration remain constant, the content of toxic compounds may vary considerably with severe consequences for biological treatment systems. Although the active microorganism have a remarkable ability to adapt to toxic compounds, it sometimes becomes necessary to remove most of the toxic matter before biological treatment takes place. Two possible pretreatments to detoxify the waste water are foam separation and chemical precipitation. An example is sulphide ion which inhibit anaerobic degradation, especially methane formation. Sulphide inhibition be avoided by precipitation with ferrous salt.

It is usually necessary to adjust the pH and to add Nitrogen and Phosphorus nutrients before anaerabic treatment of waste water from pulp and paper industries. Many waste waters from pulp and paper industries have been anaerobically treated in laboratory, pilot or full scale systems. Certain waste waters e.g. condensates are successfully treated while other containing toxic matter in black liquors and bleaching effluents cannot be treated.

Mill sludge & fibre sediments : Anerobic decomposition of cellulosic material is common natural process occuring in lake sediments, landfill waste disposal sites and in the stomachs of ruminating animals. Pulp and paper industries discharge large quantities of fibres and different types of sludges. There wastes correspond to large quantities of energy consumed by the treatment and disposal processes and large amounts of potential energy and the recovery of potential energy the demand for using anaerobic treatment of these wastes has greatly increased.

Many types of waste water from the pulp and paper industry have been successfully treated anaerobically on a laboratory and pilot scale All these experiments have been of great value to prove the high potentials of anaerobic treatments but also to emphasize the weak points of the process.

The black liquors effluent were treated in a fixed, expanded and fluidized anaerobic filter. Both waste waters treated and untreated was analyzed for toxicity for aquatic species still had high toxicity. The toxicity was reduced by anaerobic treatment. Full scale anaerobic treatment coupled by an aerobic polishing reduces the toxicity.

Large quantities of fibres from pulp and paper industry are deposited as bottom sediment if not removed and may effect downstream industries. In many cases the fibre sediments are contaminated with organic and inorganic compounds which cause environmental problems. It is important to remove these fibre sediments and effective dredging and dewatering technique has to be developed. Presently there is no serious interest in the reuse of fibres recovered from the sediments within pulp and paper industry but they will also represent a valuable source of energy which can be reused by anerobic treatment.

The economic value of the biogas produced represented about 150 % of the estimated investment cost of the anaerobic treatment plant. Economic benefits are also achieved by drastic reduction of the sludge volumes that have to be dewatered and deposited. A rough estimate shows a volume reduction of 80-90 %.

FUTURE SCOPE

It is thus clear that anaerobic treatment is a powerful tool in an effort to improve wastewater treatment system for pulp and paper industry especially when waste and energy benefits are taken into consideration.

Further studies are needed to generate basic information necessary for full scale application. It is undoubtedly important to handle each waste water as a unique substrate. This means that each waste water has to be carefully examined with respect to the following parameters among others.

- Toxicity
- pH regulation
- requirements of nutrient
- sensitivity against shock loadings.

There is further scope of study dealing with anaerobic treatment of some different types of waste sludges originating from the pulp & paper industry. The purpose is to confirm the technical and economical potentials of separate or combined treatment of different sludges primarily those which are characterized as difficult to handle by conventional methods.

REFERENCES

1. Hobson, P.N.Bousfield and Summer, R.Crit Rev. Environ Control, 4, 131 (1974)
2. Bryant, M.P., J.Animal Sci.48, (1979).
3. Hobson, P.N., Experientia, 32, 206(1982).
4. Tooo,T.,Tani,Y., and Ono, K.J.Ferment Technel,46,569 (1968).
5. FukuZami, T.,Nishido, A.,Aoshimu, K. and Minami, K., MokuZai Gakkaishi, 23, 290 (1977).
6. Ota, M.,Durst, W.B.,and Dence,C.W.,Tappi, 56 (6),139(1973).