

The utilization of undefined mixed microbial cultures in waste-treatment processes is typical and unavoidable. Waste-water treatment constitutes one of the largest-scale uses of bioprocesses. Mixed cultures are also utilized in the anaerobic digestion of waste materials. Cellulase producers, acid formers, and methane producers are typical organisms involved in the anaerobic digestion of cellulosic wastes. However, attempts to encourage the growth of a particular species on waste materials have been made.

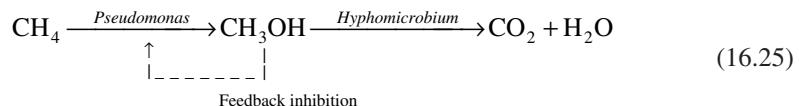
The Symba process was developed in Sweden for treating starchy wastes, particularly those from potato processing. This process utilizes *Endomycopsis fibuligera* for amylase production and a yeast, *Candida utilis*, for the utilization of sugar molecules produced from the hydrolysis of starch. Single-cell protein (SCP) is produced simultaneously with potato waste treatment.

Corn and pea wastes are also treated by a mixed culture of *Trichoderma viride* and *Geotrichium* sp. *T. viride* produces cellulase to break down cellulose into reduced sugar molecules, and *Geotrichium* produces amylases to break down starch into reduced sugar molecules. Both organisms utilize reduced sugar molecules for growth.

A mixed culture of *Candida lipolytica* and *Candida tropicalis* has been grown on hydrocarbons, *n*-paraffins, or gas oil for single-cell protein (SCP) production purposes in both laboratory and pilot-scale operations. The utilization of a mixed culture of yeasts was proved to yield better product quality as compared to pure yeast strains.

Gaseous hydrocarbon substrates like methane can be utilized by certain bacteria to produce SCP. Several experimental studies have shown that mixed cultures of methane-utilizing organisms grow faster than pure cultures.

Certain methane-utilizing species of *Pseudomonas* oxidize methane to methanol. However, *Pseudomonas* is inhibited by the end product, methanol. Inclusion of a methanol-utilizing bacteria such as *Hyphomicrobium* into the growth medium eliminates the problem of methanol inhibition. This relationship is mutualistic in the sense that *Pseudomonas* supplies carbon source (CH_3OH) for *Hyphomicrobium*, and *Hyphomicrobium* removes the growth inhibitor (methanol) of *Pseudomonas*.



16.6. BIOLOGICAL WASTE TREATMENT: AN EXAMPLE OF THE INDUSTRIAL UTILIZATION OF MIXED CULTURES

16.6.1. Overview

Waste materials generated in a society can be classified in three major categories:

1. Industrial wastes are produced by various industries, and waste characteristics vary greatly from one industry to another. Industrial wastes usually contain hydrocarbons, carbohydrates, alcohols, lipids, and aromatic organics. Industrial wastes are rich in carbon compounds and usually deficient in nitrogen (high C/N ratio);