AEROBIC AND ANAEROBIC WASTE WATERTREATMENTSASMICROBIAL FUEL

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Abstract: - Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of oxygen leads to controlled conversion of complex organic pollutions, mainly to carbon dioxide and methane. Anaerobic treatment has favorable effects like removal of higher organic loading, low sludge production, high pathogen removal, biogas gas production and low energy consumption.

Psychrophilic anaerobic treatment can be an attractive option to conventional anaerobic digestion for municipal sewage and industrial wastewaters that are discharged at moderate to low temperature.

Keywords anaerobic biodegradation, anaerobic processes, anaerobic wastewater treatment, energy recovery.

Microbial fuel cells (MFCs) are emerging as promising technology for the treatment of wastewaters. The potential energy conversion efficiencies are examined. The rates of energy recovery (W/m3 reactor) are reviewed and evaluated. Some recent data relating to potato-processing wastewaters and a hospital wastewater effluent are reported. Finally, a set of process configurations in which MFCs could be useful to treat wastewaters is schematized. Overall, the MFC technology still faces major challenges, particularly in terms of chemical oxygen demand (COD) removal efficiency.

*INTRODUCTION *

Microbial fuel cells (MFCs) are a promising technology for sustainable wastewater treatment. ... Anaerobic treatment of wastewaters is substantially less energy intensive than aerobic treatment, however it takes longer to accomplish due to the inherently slow growth process of anaerobic microorganisms.

Aerobic treatment systems such as the conventional activated sludge (CAS) process are widely adopted for treating low strength wastewater (< 1000 mg COD/L) like municipal wastewater. CAS process is energy intensive due to the high aeration requirement and it also produces large quantity of sludge (about 0,4 g dry weight/g COD removed) that has to be treated and disposed off. As a result, the operation and maintenance cost of a CAS system is considerably high. Anaerobic process for domestic wastewater treatment are an alternative, that is potentially more cost-effective, particularly in the sub-tropical and tropical regions where the climate is warm consistently throughout the year.

Anaerobic digestion consists of several interdependent, complex sequential and parallel biological reactions, during which the products from one group of microorganisms serve as the substrates for the next, resulting in transformation of organic matter mainly into a mixture of methane and carbon dioxide. Anaerobic digestion takes place in four phases: hydrolysis/liquefaction, acidogenesis, acetogenesis and methanogenesis. To ensure a balanced digestion process it is important that the various biological conversion processes remain sufficiently coupled during the process so as to avoidthe accumulation of any intermediates in the system.

Microorganisms from two biological kingdoms, the Bacteria and the Archaea, carry out the biochemical process under strict anaerobic conditions (Parawira, 2004).

AEROBICANDANAEROBICRESPIRATION

Both aerobic and anaerobic respiration involve chemical reactions which take place in the cell to produce energy, which is needed for active processes.

Aerobic respiration takes place in the mitochondria and requires oxygen and glucose, and produces carbon dioxide, water, and energy. The chemical equation is $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (glucose+oxygen-> carbon dioxide +water).

Anaerobic respiration also produces energy and uses glucose, but it produces less energy and does not require oxygen. This is useful in tissues which have a high energy demand such as in working muscles, in which there is not enough oxygen to produce all the energy needed by using aerobic respiration alone. Anaerobic respiration takes place in the cell cytoplasm and produces lactic acid. The chemical equation is $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$ (Glucose

-> Lactic acid). The lactic acid then needs to be oxidised later to carbon dioxide and water afterwards to prevent it building up. This process requires oxygen and therefore following anaerobic respiration there is oxygen debt in the cell, as oxygen is needed to break down the lactic acid produced.

***AEROBIC VS. ANAEROBIC RESPIRATION:-**

Aerobic respiration, a process that uses oxygen, and anaerobic respiration, a process that doesn't use oxygen, are two forms of cellular respiration. Although some cells may engage in just one type of respiration, most cells use both types, depending on an organism's needs. Cellular respiration also occurs outside of macro- organisms, as chemical processes—for example, in fermentation. In general, respiration is used to eliminate waste products and generate energy.

Comparison chart:- **Definition :-**

Aerobic respiration uses oxygen. Anaerobic respiration is respiration without oxygen; the process uses a respiratory electron transport chain but does not use oxygen as the electron acceptors.

Cells that use it :-

Aerobic respiration occurs in most cells.Anaerobic respiration occurs mostly in prokaryotes.

Amount of energy released-

High(36-38ATPmolecules) Lower (Between 36-2 ATP molecules)

Stages:-

Glycolysis,Krebscycle,ElectronTransportChain.
Glycolysis, Krebs cycle, Electron Transport Chain.

Products-

Carbondioxide,water,ATP. Carbon dixoide,reduced species,ATP.

Site ofreactions-

Cytoplasm and mitochondria. Cytoplasm and mitochondria

Reactants-

glucose,oxygen glucose,electron acceptor(not oxygen)

Combustion-

complete incomplete

Production of Ethanol or Lactic Acid-

Does not produce ethanol or lactic acid Produce ethanol or lactic acid.

Contents:-

Aerobic vs. Anaerobic Processes-

Aerobic processes in cellular respiration can only occur if oxygen is present. When a cell needs to release energy, the cytoplasm (a substance between a cell's nucleus and its membrane) and mitochondria (organelles in cytoplasm that help with metabolic processes) initiate chemical exchanges that launch the breakdown of glucose. This sugar is carried through the blood and stored in the body as a fast source of energy. The breakdown of glucose into adenosine triphosphate (ATP) releases carbon dioxide (CO_2), a byproduct that needs to be removed from the body. In plants, the energy- releasing process of photosynthesis uses CO_2 and releases oxygen as its byproduct.

Anaerobic processes do not use oxygen, so the pyruvate product—ATP is one kind of pyruvate—remains in place to be broken down or catalyzed by other reactions, such as what occurs in muscletissueorinfermentation.

Lactic acid, which builds up in muscles' cells as aerobic processes fail to keep up with energy demands, is a byproduct of an anaerobic process. Such anaerobic breakdowns provide additional energy, but lactic acid build-up reduces a cell's capacity to further process waste; on a large scale in, say, a human body, this leads to fatigue and muscle soreness. Cells recover by breathing in more oxygen and through the circulation of blood, processes thathelpcarryawaylacticacid.

*Fermentation-

When sugar molecules (primarily glucose, fructose, and sucrose) break down in anaerobic respiration, the pyruvate they produce remains in the cell. Without oxygen, the pyruvate is not fully catalyzed for energy release. Instead, the cell uses a slower process to remove the hydrogen carriers, creating different waste products. This slower process is called fermentation. When yeast is used for anaerobic breakdown of sugars, the waste products are alcohol and CO2. The removal of CO2 leaves ethanol, the basis for alcoholic beverages and fuel. Fruits, sugary plants (e.g., sugarcane), and grains are all used for fermentation, with yeast or bacteria as the anaerobic processors. In baking, the CO2 release from fermentation is what causes breads and otherbakedproductstorise.

***Krebs Cycle-**

The Krebs Cycle is also known as the citric acid cycle and the tricarboxylic acid (TCA) cycle. The Krebs Cycle is the key energy-producing process in most multicellular organisms. The mostcommonformofthiscycleuses glucose as its energy source.

During a process known as glycolysis, a cell converts glucose, a 6-carbon molecule, into two 3-carbon molecules called pyruvates. These two pyruvates release electrons that are then combined with a molecule called NAD+ to form NADH and two molecules of adenosine triphosphate (ATP).

TheseATPmoleculesarethetrue"fuel"foranorganism

and are converted to energy while the pyruvate molecules and NADH enter the mitochondria. That's where the 3-carbon molecules are broken down into 2- carbon molecules called Acetyl-CoA and CO_2. In each cycle, the Acetyl-CoA is broken down and used to rebuild carbon chains, to release electrons, and thus to generate more ATP. This cycle is more complexthanglycolysis,and itcanalsobreakdownfatsandproteinsforenergy.

As soon as the available free sugar molecules are depleted, the Krebs Cycle in muscle tissue can start breaking down fat molecules and protein chains to fuel an organism. While the breakdown of fat molecules can be a positive benefit (lower weight, lower cholesterol), if carried to excess it can harm the body (the body needs some fat for protection and chemical processes). In contrast, the breaking down of the body's proteins is often a sign of starvation.

*__Aerobic and anaerobic Exercise-__

Aerobic respiration is 19 times more effective at releasing energy than anaerobic respiration because aerobic processes extract most of the glucose molecules' energy in the form of ATP, while anaerobic processes leave most of the ATP-generating sources in the waste products. In humans, aerobic processes kick in to galvanize action, while anaerobic processesareusedfor extreme and sustainedefforts.

Aerobicexercises,suchasrunning,cycling,andjumping

rope,areexcellentatburningexcesssugarinthebody, buttoburnfat,aerobicexercisesmust be done for 20 minutes or more, forcing the body to use anaerobic respiration. However, shortburstsofexercise,suchas sprinting,relyonanaerobicprocessesforenergybecause the aerobic pathways are slower. Other anaerobic exercises, such as resistance training or weightlifting, are excellent for building muscle mass, a process that requires breaking down fat molecules for storing energy in the larger and more abundant cells found in muscle tissue.

Evolution:-

The evolution of anaerobic respiration greatly predates that of aerobic respiration. Two factors make this progression a certainty. First, the Earth had a much lower oxygen level when the first unicellular organisms developed, with most ecological niches almost entirely lacking in oxygen. Second, anaerobic respiration produces only 2 ATP molecules per cycle, enoughfor unicellular needs, but inadequate for multicellular organisms.

Aerobic respiration came about only when oxygen levels

in the air, water, and ground surfaces made it abundant enough to use for oxidation-reductionprocesses.Not only does oxidation provide a larger ATP yield.

Purpose of the Research :-

The purpose of this research was to develop and test an anaerobic microbial fuel cell (MFC) at pilot-scale.In laboratory-scaleresearch,MFCshavebeenshownto simultaneously

treat organic wastewater and generate electricity.

However, most MFC studies have been limited tosmall(typically<250mL)batchreactorsusingasingle compound or simulated wastewater. This project operated 16 liter (L) reactor at a continuous flow using filtered municipal primary effluent as thefeedstock.

PotentialApplicationsoftheResearch:-

Anaerobic MFCs use substantially less energy to treat wastewater than conventional aeration technologies. It is estimated that wastewater treatment uses approximately 3% ofthe electricalpowerconsumednationwide(Logan,2005).By generatingrenewableelectricityon-site, MFCs could help enable municipal wastewater treatment plants to become self-sustaining.

Additionally,theextensionofMAC-GACMFCtechnology tohigherstrengthwastewaters,suchas thosegenerated in the food, beverage and dairy industries, have obvious application as sustainable, renewable energy production.

***WASTE WATER TREATMENTS ***

There are two types of biologically-based wastewater treatment processes: aerobic and anaerobic wastewater treatment. Aerobic processes use bacteria that require oxygen, so air is circulated throughout the treatment tank.These aerobic bacteria then break down the waste within the wastewater.

Aerobic Treatment-

Aerobic wastewater treatment is a process where bacteria utilize oxygen to degrade organic matter (generally quantified as biochemical oxygen demand or BOD) and other pollutants involved in various production systems. The two most common types of aerated wastewater systems are activated sludge systems and aerated stabilization basins (ASBs). ASBs are commonly found as treatment systems in the pulp and paper industry and are used in some municipalities, as well as other industries.

There are eight growth pressures that affect a treatment

system but we will review two major ones: oxygen and organic loading (BOD). In a typical wastewater treatment system, the influent coming into the system has the most BOD because it hasn't yet been treated. As the influent reaches the ASB, it enters an aerated environment where the degradation will begin. Different types of aeration are used in ASBs but the most widely used are either surface aerators or diffused aeration systems. When using surface aeration, multiple units are needed to be properly spaced to treat the water. Diffused aeration is normally air that is supplied by compressors or blowers and piped under the surface where the air is released evenly throughout the ASB. Occasionally, pure oxygen is utilized in wastewater treatment, but this is relatively uncommon in ASBs.

The degradation of BOD is achieved through aerobic bacteria in a system. The bacteria utilize oxygen as an electron receptor in order to convert the organic material (BOD or oxygen demand) to carbon dioxide. Via this process they multiply, which in turn creates more bugs to break down more BOD. As the water flows through the system, many changes will occur. As the amount of BOD in the system reduces, the total number of bacteria will also decrease. The oxygen demand, as measured by oxygen uptake rate (OUR) will decrease and the environmental will become acceptable for more advanced life forms, such as protozoa or metazoan. A few of the common higher life forms are: flagellates, free swimming ciliates, stalked ciliates, and rotifers. The higher life forms will feed on the dispersed bacteria and flocculated bacteria that have been formed after degradation has occurred. Higher life forms are an indication that most BOD has been removed from the system.

Anaerobic Treatment-

Anaerobic treatment is a process where wastewater or material is broken down by microorganisms without the aid of dissolved oxygen. However, anaerobic bacteria can and will use oxygen that is found in the oxides introduced into the system or they can obtain it from organic material within the wastewater.

Anaerobic systems are used in many industrial systems

including food production and municipal sewage treatment systems.
Anaerobic digestion is commonly used to treat sludges in the first areas of a wastewater treatment plant. This process is popular because it is able to stabilize the water with little biomass production. Anaerobic treatment occurs in many different stages. The key microorganisms are methane formers and acid formers. The acid formers are microorganisms that create various acids from the sludge. Methane formers convert the acids intomethane.

The two main anaerobic systems are batch systems and
continuoussystems.Inabatchsystem,thebiomassisadded into a reactor that is sealed for the rest of the digestion process. This is the simplest form of anaerobic treatment but can have odor issues associated with it. As the most simple, it is also one of the least expensive waystoachievetreatment.

SUMMARY

The feasibility of high-rate anaerobic wastewater treatment (AnWT) systems for cold wastewater
dependsprimarilyon:(1)thequalityoftheseedmaterialused and its development under sub-mesophilic conditions; (2) an extremely high sludge retention time under high hydraulic loading
conditions because little if any viable biomass can be allowed to wash out from the reactor; (3) an
excellent contact between retained sludge and wastewater to utilize all the available capacity withinthe

bioreactor; (4) the types of the organic pollutants in the wastewater; and (5) the reactor configuration, especially its capacity to retain viable sludge.