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Recycling of industrial effluent by UASB Reactor for pollution-free fluvial and groundwater regimes

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Abstract

Water, although abundant, is precious as only 0.003% of the total water reserve is available to us. With increasing industrialization and population growth, indiscriminate use of water is prevalent. This is leading to acute water shortage and drought like conditions in various areas. Judicious use of water and above all recycling is now the key to water conservation. Industrial effluent when treated through a UASB reactor, which has an anaerobic approach, makes the process highly cost effective. The treated water is fit for irrigation and industrial use. As a byproduct methane gas is produced which is relatively a clean source of energy. This reuse of wastewater reduces some pressure on natural water resources – both surface and groundwater. It also avoids transfer of pollutants from one fluvial regime to another in the interlinking of river basins.

Introduction

Three quarter of our earth is covered with water. Yet, water is precious. Out of the total water reserves only 3% is freshwater. Most of it is locked in polar ice caps and just 0.003% is available in the form of groundwater (Asano et. al., 1996). Rapid industrialization and population growth is putting a lot of burden on this resource. As per the United Nations estimates (UN, 2002) by around 2024, two-thirds of world population will be suffering from acute water shortage. Another consequence of industrialization is pollution. Rivers are being used to discharge the untreated industrial effluent leading to water pollution. With the project of interlinking of river basin in consideration, effluent water pollution may spread to other rivers. Ground water was previously considered to be very pure but, of late, contamination by leachates has been found. It has thus become important to treat these effluents so that water pollution can be reduced. Most of the current treatment plants use aerobic processes, which apart from being expensive to develop, require energy to maintain the oxygenation process. This makes them cost ineffective. This paper discusses development of a cost effective method to treat the effluent. A novel approach of using anaerobic reactor method is seen as an alternative to aerobic process. Anaerobic biomethanation is fast emerging as a wastewater treatment process. In this regard Upflow Anaerobic Sludge Blanket Reactor (UASB; Lettinga et. al., 1991) is discussed. In this reactor, waste water is distributed at the bottom of the UASB reactor and water travels in an upflow mode through the sludge blanket where the complex organic pollutants are broken down by the anaerobic bacteria. Various parameters recorded before and after

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treatment assess the quality of reclaimed water. The reclaimed water is suitable for irrigation. It can then be further purified and channeled into the river basins. Newer methods for development of UASB for domestic water treatment should be employed upon, so that our future is not marred by disarray and draught.

Role of water, recycling and exploitation

Excessive withdrawal for agricultural and industrial use is leading to lowering of water table. 60% of water withdrawn is only consumed the rest is lost due to evaporation.

The increase in population and rapid development has consequently led to an increase in demand for water withdrawal. A very large proportion of this withdrawn water gets polluted due to human activities. In India, about 93% of water withdrawn is used for agricultural sector, 5% towards industrial and 2% for domestic purposes (Kaushik et. al., 2002). Water pollution occurs in all these sectors and pollutants range from fertilizers to minerals to detergents.

Groundwater

Groundwater is around 9.86% of the total fresh water resources. Presently a decline of groundwater has been observed (Manocharachary et al., 2002). The reasons for this are: (1) water withdrawal rate is higher than the recharge rate, (2) the erratic and inadequate rainfall results in reduction in storage in surface reservoirs, (3) the building construction activities are sealing the permeable soil zone, reducing the area of percolation of rain water into subsurface and, thereby, increasing the surface runoff.

Upflow Anaerobic Sludge Blanket Reactor

The industrial effluents are a mix of various chemicals and waste water. For treating the effluents, a process that can sustain in high chemical concentrations is needed. The key feature of the UASB process (Grasius et. al., 1997) that allows the use of high volumetric Chemical Oxygen Demand (COD) loadings compared to other processes is the development of a dense granulated sludge (Soto et al.: 1997). Seeding is done to accelerate the system startup.

The industrial effluent in the form of sludge is canalized into the reactor (Fig.1). The process of treatment relies on the tendency of anaerobic bacteria to form flocs (microbial aggregates with low specific density) or granules (higher density microbial aggregates). These flocs or granules are retained in the reactor by an efficient gas/liquid/solid separator (GLSS) device located on the top. Waste characteristics and amount of organic content determine the nature of microbial aggregate. Carbohydrate rich waste leads to higher formation of granules. Granules are preferred because they separate easily due to high settling velocity. Granule formation can be enhanced by addition of extracellular polymers produced by bacteria and inorganic nuclei. Methanothrix, filamentous bacteria, is crucial for bonding the granule components together (Speece, 1996). The wastewater is distributed to the bottom of the USAB reactor (settling tank) and it travels in upflow mode through the sludge blanket. Upflow velocity is dependent upon

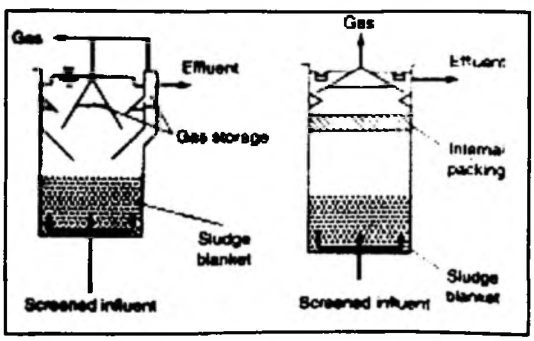

Fig.1: Schematic diagram of UASB Reactor

the influent flowrate and the reactor area. It is a critical design parameter and the peak velocity allowed is about 6m/hour. The GLSS is designed to collect the biogas, prevent solid waste washout, and help in separation of gas, solid particles and liquid. The design of the GLSS determines the quality of the treated water. GLSS consists of upside down 'V' shaped baffles to collect the sediments and gas. The effluent withdrawal system attached to the settling tank is the source for the treated water.

Various parameters such as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and the Total Suspended Solid (TSS) are recorded before and after the treatment to assess the quality of treated water (McCarty et. al., 1985). The whole process, being anaerobic, produces biogas as a byproduct. This gas is separated by the GLSS. The collected gas is used as a cheap and relatively pollution free energy source to produce electricity or for cooking. Advantages of UASB system include a simple reactor construction, high biomass concentration leading to high removal efficiency at high organic loading rates. Above all its low energy demand makes it highly cost efficient. Limitations include its sensitivity to hydraulic shock loads and, as high concentration of calcium or ammonium ion inhibits granule formation, for efficient management skilled supervision is necessary.

The reclaimed water can be used for various activities (Fig.2).

Conclusions

Simple design and power saving benefits make UASB a cost effective procedure for treating industrial effluents. Currently it is the industry standard for treatment of wastewater from industries like distilleries, sugar, tannery, milk etc. In the past few years, research is being conducted on Hybrid reactors which will supersede UASB reactors because of design improvements and fewer limitations. The reclaimed water obtained after treatment of effluents can then be used directly for irrigation, industrial and urban purposes. This way, the pressure on groundwater exploitation can be reduced to some extent. Apart from recycling of water, pollution reduction is also achieved through the UASB and the biogas obtained as the byproduct is used as an energy source. This dictates the threefold advantage of a UASB reactor. In the context of interlinking of river basins, such an efficient recycling can check transfer of pollutants from one fluvial regime to another.

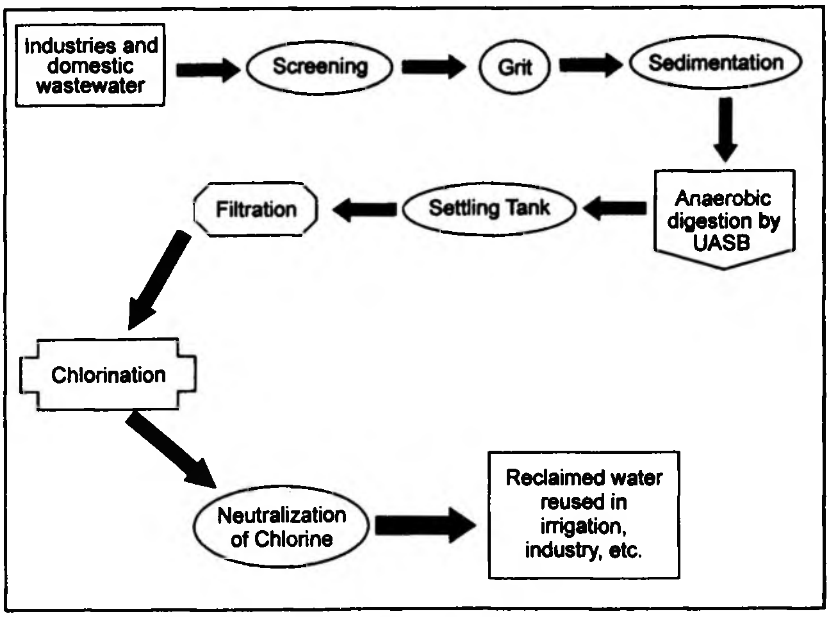

Fig. 2: Flow diagram for wastewater treatment and reuse

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