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The New Methods for Purifying the Industrial Effluents by Submerged Biofilm Reactors

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ABSTRACT

Life on the earth is dependent on dynamic interactions between its physical, chemical and biological components. In fact, all the individual processes are responsible for regulating the environmental equilibrium which can provide biosphere for multiple forms of human life. In order to overcome on shortcomings, the use of immobilized cell bioreactor technology which provides a valuable effective for treatment of waste water is discussed. An immobilized system which in this matter is applied is about absorbed or captured microorganisms in a solid substratum to retain them in a reactor or analytical system. The multiply of these immobilized cells is done when by nutrients be supplied and then migrate to the surfaces which are referred to biofilms. The biofilms can be developed on various support systems such as polypropylene pall, rocks, sands, charcoal, ceramics, and glass beads. The controllable reaction vessels which are used for these colonized surfaces are referred to bioreactors. Bioreactors in both up flows and down flows mode which use of either batch or continuous processes principle can be operated. Synchronic with development in biotechnology, there is also an extensive development in the field of bioreactors like: pumped tower loop reactor (*PTLR*)*, liquid impelled loop reactor* (*LILR*)*, multipurpose tower bioreactor* (*MTB*)*, fluidized-bed and packed-bed bioreactor, that in this article are discussed them.*

Keywords*: *Biofilm, Bioreactor, Effluent, Environment, Liquid, Waste Water

1. Introduction

These facts that increasing the human population and excessive agricultural activities and modern industrialization can damage environment and biosphere, as an important and serious problem are enumerated. The deleterious effects of human activities on the biosphere are collectively known as pollution. The pollution prevention and its controlling have been caused a major problem in present century. Waste waters management and environment protection is commensurate with social and economical relations and public health of society. The waste water of various industries is including the complex mixtures of solid materials and dissolved particles which have either high biological oxygen demand (BOD) or chemical oxygen demand (COD) values and it indicates their toxic effects on the plankton. Heretofore abundant researches that deal on activities for elimination, conversion the toxic pollution on industrial waste waters have been reported. There is a similar problem which is related to sewages produced due nutrients and beverage industries [1].

The influence of the ratio carbon-nitrogen and phosphorus concentration on the performance of a biofilm fluidized bed reactor has already bee used for denitrification [2]. The thickness and the density of the biofilms were related mainly with the shear stress in the reactor and the composition of biofilms was dependent on the composition of the medium and related with higher activities of the microorganisms. The surface concentration depended on the surface characteristics of the biofilms. The biofilm is a dynamical structure, in which formation of cracks and fissures is taking place continuously [3].

There are two process configurations based on the BAS reactors, for nitrogen removal from wastewater by integration of nitrification in biofilms and denitrification in suspension. The first setup consists of a conventional nitrifying BAS reactor coupled with a suspended biomass reactor. The second process configuration is a single BAS reactor which is sequentially aerated and non-aerated, by cyclically recirculation the off gas [4].

A wake model is used to predict the liquid holdup, while the solids holdup is obtained by iteration based on

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material balance [5].

The numerous numbers of both biodegradable organic particles and dissolved substances in the waste waters have high BOD value which must be reduced before disposal of them into sewerage [6]. BOD is the amount of dissolved oxygen which is consumed by a diluted waste water sample and is kept for a specified time (5 days) at 20˚C. The COD is an indicator of the overall parameter which by a hot and acidic solution of $K_2Cr_2O_7$ can be chemically oxidized [7].

2. Materials and Methods

In primary stage of waste water treatment usually the solid sediments such as grits, soils, the suspended large particles through grid and firm oil by suction are removed.

The secondary treatment is based on biological oxidation that its aim is reduction of effluent's BOD by using the activated sludge, trickling filters, lagoons and anaerobic digesters individually or in combinational formats.

These treatment methods are slow and occupy a large space and generate a large amount of sludge that is caused disposal problems. In biological activity on waste water treatment, free and suspended microorganisms such as activated sludge and fixed biofilm such as trickling filter are used [8]. The problem of activated sludge is production of a large amount of sludge and thereby barring the trickling filter. These shortcomings by using the bioreactors are eliminated in which the immobilized cells for treatment have been used.

An immobilized system is a system in which the microorganisms in a solid substratum either are superficiality absorbed or captured for maintenance in bioreactor. It is shown in the **Figure 1**.

These immobilized cells when be fed by nutrient materials then are multiplied and steadied on the surfaces which are entitled biofilm. Biofilms by various maintenance systems such as polypropylene pall rings, rocks, sand, charcoal, ceramics and glass beads can be developed [7]. The biofilm rectors have reaction ability. The bioreactors can be applied either up flow or down flow mode which use either batch principle or continuous process that these are shown in **Figures 2-5** [9].

The volumes of bioreactors for various usages are as **Table 1** [9].

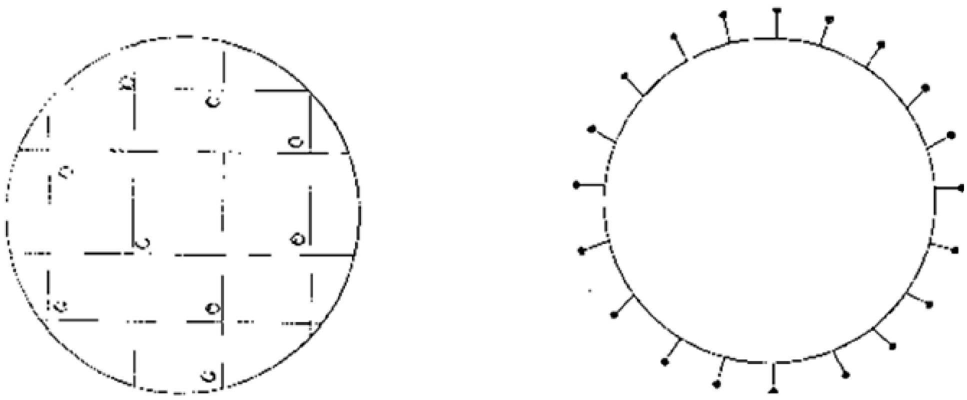

Figure 1. Approaches of immobilized biocatalysts.

Table 1. The volumes of used bioreactors in biotechnological processes.

Product groups	Bioreactor volume (m^3)
Beer, wine	1000
Cheese, bread, sauerkraut	200
Organic acids (citric acid, acetic acid)	100
Vitamins (Vit C, Vit E, $VitB_2$)	10 - 50
Enzymes (amylase, lactase, protease)	10 - 50
Antibiotics (penicillin)	200
Pharmaceuticals (insulin, interferon)	10
Biomass (bakers/brewers yeast)	200
Single cell protein	1500 (continuous)
Cheese industry	110
Milk processing	4150
Wine distillery	5600
Enzyme production	2000
Jam manufacture	430
Cane molasses distillery	1700
Yeast production	1280

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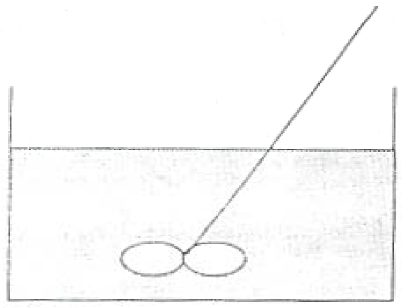

Figure 2. Batch reactor (Type 1 of bioreactor).

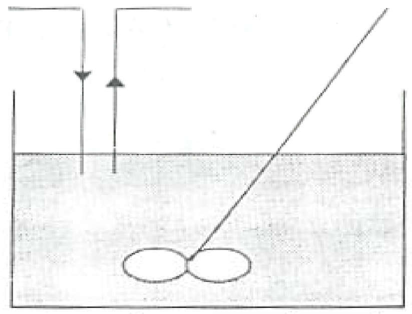

Figure 3. Continuous reactor (Type 2 of bioreactor).

Figure 4. Up-flow reactor (Type 3 of bioreactor).

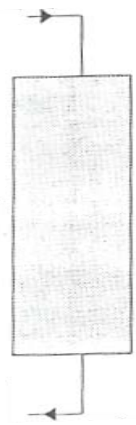

Figure 5. Down-flow reactor (Type 4 of bioreactor).

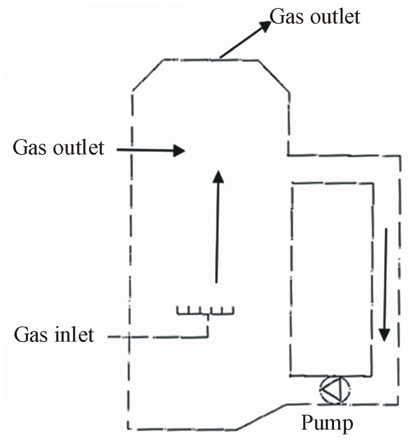

Figure 6. Pumped tower loop reactor (PTLR).

The PTLR reactor for batch production of Xanthan has specially been developed and it eliminates the posed problems in treatment by high viscosity and plastically behavior of polysaccharide.

These achievements by helping a specially designed-pump are afforded that this pump for keeping the liquid in kinetic movement and shorter time of fermentation and more concentration is applied. The LILR bioreactor for some instances among applications for biocatalyst in organic solvents is developed. This bioreactor consists of two parallel tubes connected at the top and bottom.

The bioreactors which have newly been developed are illustrated as **Figures 6-12** [9].

In the LILR bioreactor the organic solvent which has low density into a continuous non organic fluid with high density from bottom is distributed and through difference between densities, the fluid with continuous phase is circulated. The MTB bioreactor uses of the air lift principle and for cells of sensitive to shear can be used. Both microbe flocculating and microorganisms culturing in three different modes can be performed: 1) bubble column. 2) Bioreactor with inner loop that this loop has relevancy to airlift which by riser pipe its activity is performed. 3) Bioreactor with inner loop dependent on airlift which by down comer pipe its activity is performed [8]. The advantage of the MTB bioreactor is that in this bioreactor the modular design is causer for preparation of a system based on biological processes requirements. The fluidized bed and packed bed reactors which are as samples of bioreactors, for decrement of related processes fees and prevention of biocatalysts have been developed. In the fluidized bed reactors, the immobilized catalyst floated in water exists freely around airlift source while in the packed bed reactors the catalyst along with oxygen is almost saturated.

These bioreactors including biofilm reactors have either round or flat drum.

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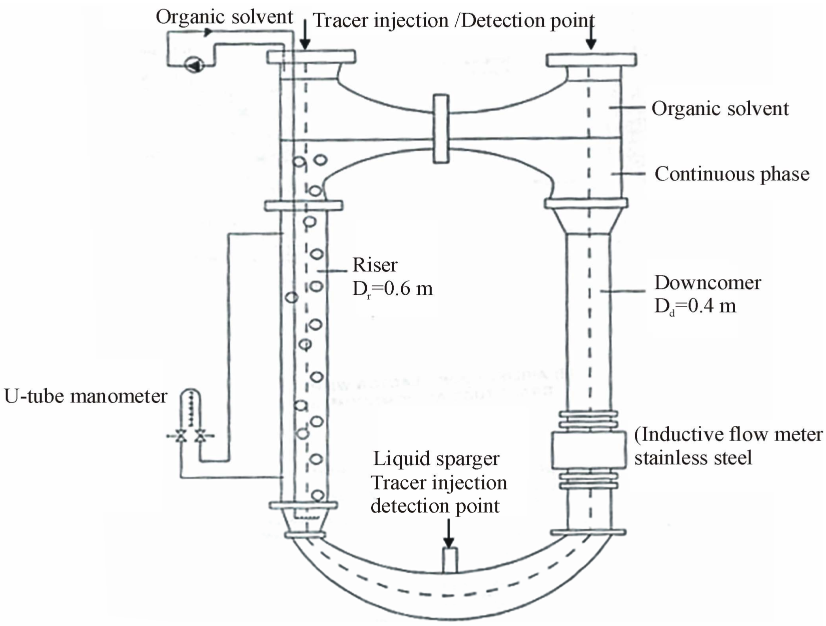

Figure 7. Liquid impelled loop reactor (LILR).

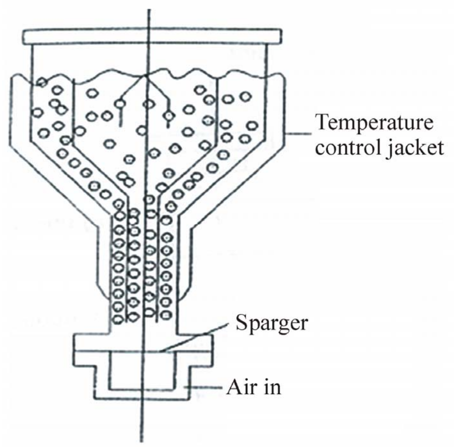

Figure 8. As a bubble column.

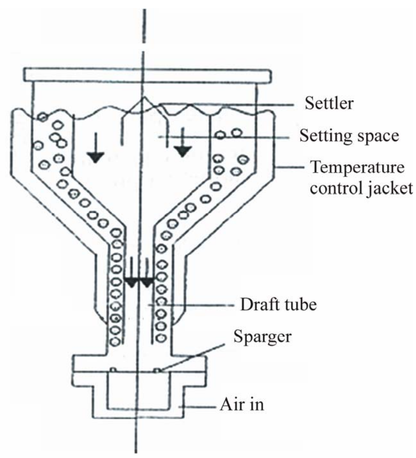

Figure 10. Airlift loop reactor with draft tube as down comer.

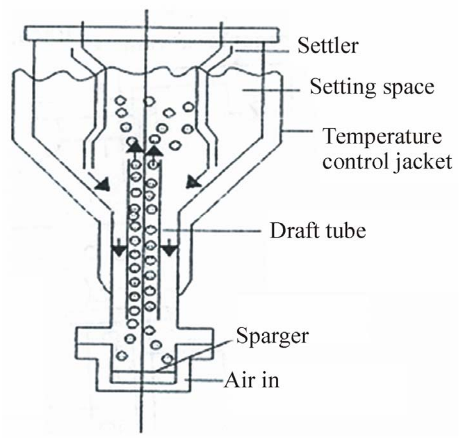

Figure 9. Airlift loop reactor with draft tube as riser.

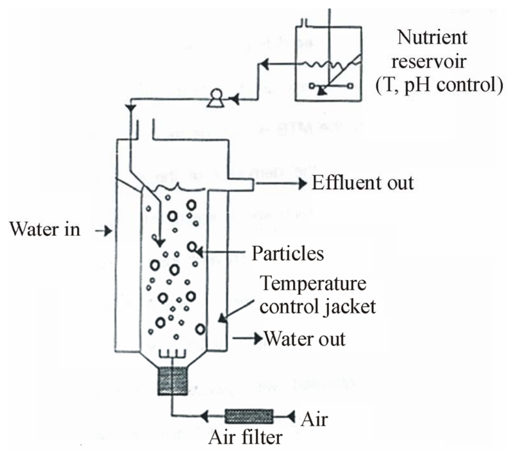

Figure 11. Fluidized bed reactor.

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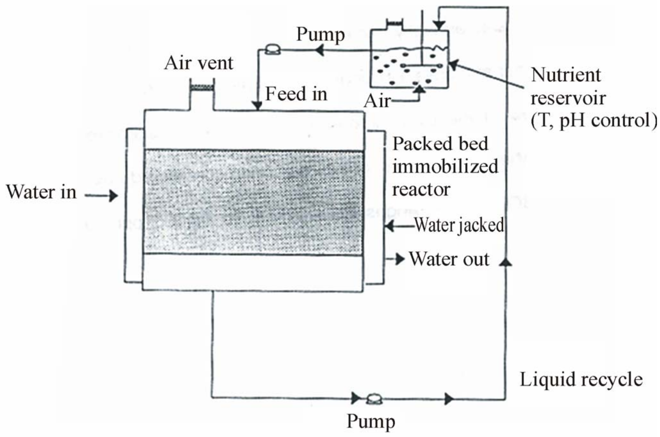

Figure 12. Packed bed reactor.

Dairy industries usually generate a large amount of waste water. According to International Dairy Federation for generation of milk and Milk Products, 10.7 million ton cheese has been used and 88.34 million ton whey is annually generated [10].

Anyway in forthcoming view, pouring the waste water of dairy industries like whey and cheese industries to either rivers or seas is one of the most important problems from the environmental pollution aspects. This problem concerns and must accurately be considered because these waste waters have high BOD with 32,000 ppm - 60,000 ppm that these amounts depend on processes of manufactory of waste water's producer. One of the usage instances of produced waste water in cheese industry is production of organic gases [11].

3. Disscusion

There are several applications of this technology in treatment processes of industrial waste waters according to **Table 2** [1].

The wastewaters due various industries are including a mixture of solids complex and solved particles with high BOD (according to table2). The BOD before disposal in common sewerage may reduce. The various chemical and physical processes like steam stripping, ion exchanging and solvent extraction for separation toxic particles of waste waters can be used. The environmental refinement of waste water might able to use live microorganisms in a free state to either suspended biofilm or fixed forms. In this state a lot of produced sewerage or wastewaters by using the immobilized cell bioreactor technology under aerobic or anaerobic conditions can be refined [12,13]. There is an economical and feasible devised method to treat cheese whey. This method is formulated of 1% glucose, 1% extracted yeast in laboratory.

4. Conclusions

At all two main aims are deduced: 1) preparing a method for practical and economic applications of submerged biofilm reactor in refinement of industrial wastewaters. 2) Developing a batch of processes relating immobilized submerged biofilm reactors for treatment of wastewaters due dairy industries. Cheese whey is compounded of lactose, nitrogenous compounds, vitamins and minerals which by microorganisms to growth can be used. The microorganisms which don't use of lactose can be growth through consuming other components of cheese whey. There is a major problem for usage of cheese whey to growth the yeast and this problem is that some of the yeasts are relatively able to ferment the lactose. There are several methods such as hydrolyze of cheese whey, yeast adaptation and pressure selection which are attempted to overcome on this problem [7,14]. A submerged fixed biofilm reactor by using the culture in

Table 2. Strong effluents from food and beverage industries.

Type of waste	Main pollutants
Abattoir	Suspended solids, protein
Beet sugar	Suspended solids, fat, protein
Cannery (meat)	Suspended solids, carbohydrates, protein
Distillery	Suspended solids, oil-grease
Domestic sewage	Carbohydrates, protein
Dairy	Carbohydrates, fat, protein
Grain washing	Suspended solids, carbohydrates
Fermentation industry	Suspended solids, carbohydrates, protein
Starch reduction of flour	Suspended solids, carbohydrates, protein

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laboratory can be applied to treat cheese whey and all dairy effluents for reducing BOD. At all one of the fastest environment to growth the microorganisms are both slimy and effluent where the various types of extracted wastewaters exist**.**

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