In The Name Of ALLAH, swt

Razi University

Faculty of Chemistry
Department of Applaied Chemistry

M.Sc.Thesis

Title of the Thesis:
High-rate biological treatment of Faraman estate industrial wastewater in an up-flow aerobic/anoxic sludge bed bioreactor

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I am very grateful to God for his guidance and protection during the writing up of the thesis as well as during my studies and every things that I have done,

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Abstract

Simultaneous removal of carbon and nutrients (CNP) in a single bioreactor is of high significance in terms of reactor volume and energy consumption. In this study, an up-flow aerobic/anoxic sludge bed (UAASB) bioreactor under two feeding regimes, continuous-fed and batch-fed, was evaluated for the treatment of an industrial estate wastewater with low BOD_5/COD ratio. The batch wise operation of the UAASB is known as sequencing batch reactor (SBR).The process performance in the two regimes was compared. Two numerical variables (retention time and aeration time) were selected to analyze, model and optimize the process. The region of exploration for the process was taken as the area enclosed by retention time (12-36 h) and aeration time (40-60 min/h) boundaries. The experiments were conducted based on a central composite design (CCD) and analyzed using response surface methodology (RSM). In order to analyze the process, twelve dependent parameters as the process responses were studied.

As a result, retention time showed a decreasing impact on the responses in the both hydraulic regimes, UAASB and SBR. The UAASB shows better performance in removal of TCOD, sbCOD, TN and TKN. Total phosphorus (TP) removal was higher where the UAASB was fed in batch wise (SBR). This study showed that the BOD_5/COD ratio was a key factor affecting the systems performance removing the nutrients. Therefore, the performance of the UAASB bioreactor was evaluated under three different BOD_5/COD ratios (1, 0.3 and 0.11).96, 91 and 76 %, respectively for TCOD, TN, and TP removal efficiency could be achieved at BOD_5/COD equals to 1.

Kinetic analysis of the process in the UAASB bioreactor using the experimental results obtained under different HRT (4 and 8 h) and aeration time (40 and 60 min/h) was carried out. Y value was the lowest value (0.161) relative to the values reported in the literature,

implying low biodegradability of the wastewater. K_d, was similar to the values given by the other works (0.039 day^{-1}). K_1 in the first order model was 4.56 day^{-1} .

The constant values in the stover-kincanoon were obtained 9.82 g/l and 8.47 g/l.d, respectively for K_B and U_{max}.

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Chapter 1

Introduction

1-1-Wastewater

Waste water is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources. If untreated, and discharged directly to the environment, the receiving waters would become polluted and water-borne diseases would be widely distributed.

Figure 1-1. Discharge of untreated industrial wastewater to a river

1-2- Characteristics of wastewater

1-2-1- Physical characteristics

The principal physical characteristics of wastewater are summarized in Figure 1-2. The total solids in a wastewater consist of the insoluble or suspended solids and the soluble compounds dissolved in water. Between 40 and 65 % of the solids in an average wastewater are suspended. Solids may be classified in another way as well: those that are volatilized at a high temperature (600 °C) and those that are not. The former are known as volatile solids, the latter as fixed solids. Usually, volatile solids are organic [1].

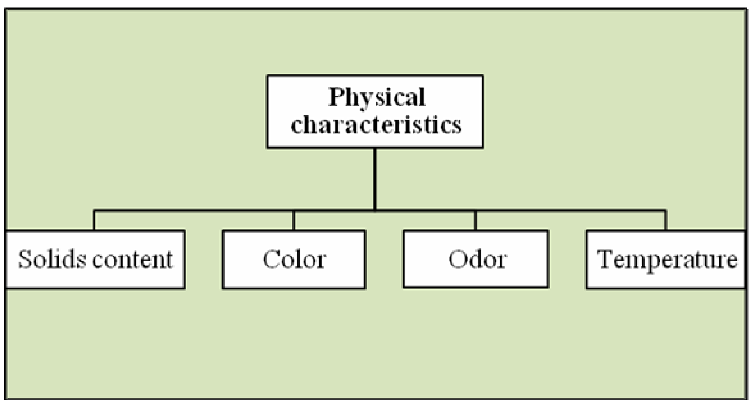

Figure 1-2. Fractionation of physical characteristics of wastewater

1-2-2- Chemical characteristics:

Over the years, a number of different tests have been developed to determine the organic content of wastewaters. Laboratory methods commonly used today to measure gross amounts of organic matter in wastewater include (1) biochemical oxygen demand (BOD), (2) chemical oxygen demand (COD) and (3) total organic carbon (TOC). Fractionation of COD in wastewater based on biodegradability is shown in Figure1-3.

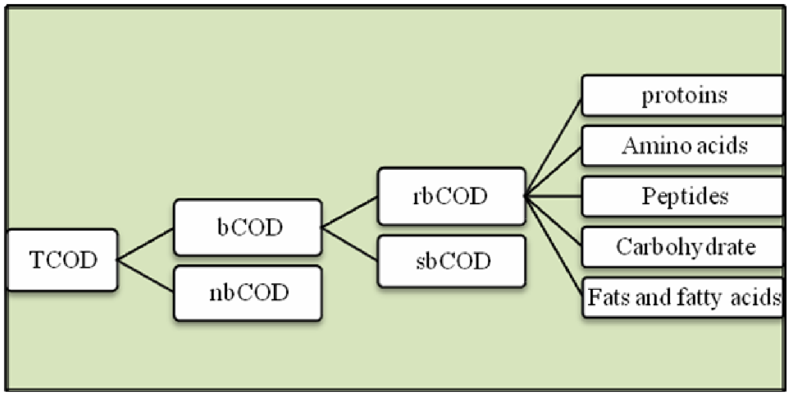

Figure 1-3. Fractionation of COD in Wastewater

The principal chemical tests include free ammonia, organic nitrogen, nitrites, nitrates, organic phosphorus and inorganic phosphorus [1]. Nitrogen and phosphorus are important because these two nutrients are responsible for the growth of aquatic plants. The excessive accumulation of nutrient (N, P) discharge to surface water can pose serious ecological problems that affect the health of aquatic life and consequently that of human and animals[2].

Therefore, Nutrient removal from wastewater is of vital importance as the discharge standards have been more stringent. Nitrogen in raw wastewater is typically comprised of ammonia and organic nitrogen. Generally, there is little or no oxidized nitrogen present (nitrite or nitrate). The combination of ammonia, which is an inorganic form of nitrogen, and the organic nitrogen, is the Total Kejeldahl Nitrogen (TKN). The fractionation of TKN in the wastewater is shown in Figure1-4.

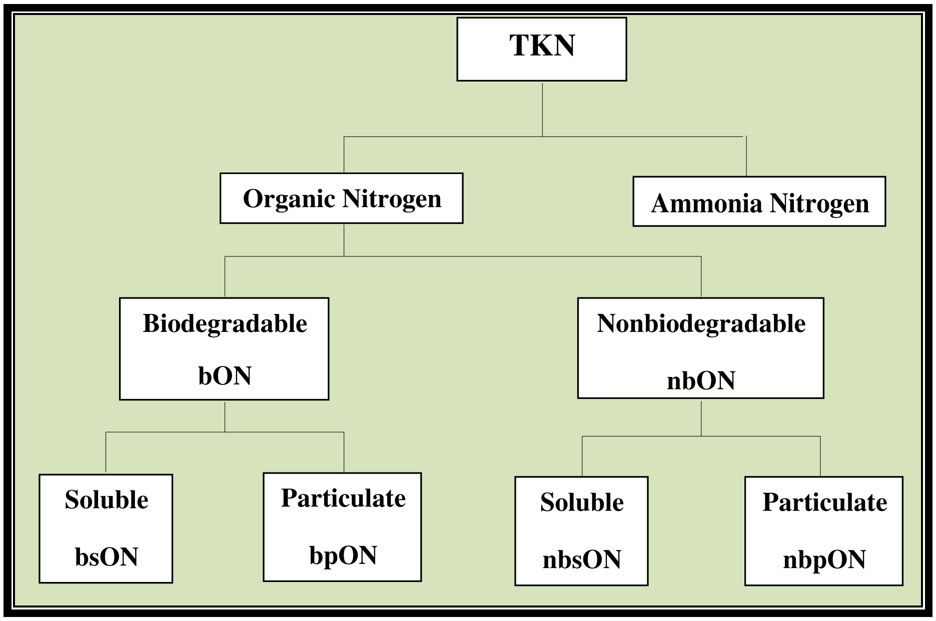

Figure 1-4. Nitrogenous Constituents

The TP concentration is comprised of both inorganic and organic forms. The inorganic forms, which are soluble, include orthophosphate and polyphosphates. The orthophosphate form (PO_4^{3-}) is the simplest form of phosphorus and accounts for 70 to 90% of the TP. Organic phosphorus is also contributed by a variety of industrial and commercial sources.

Other tests, such as chloride, sulphate, pH and alkalinity, are performed to assess the suitability of reusing treated wastewater and in controlling the various treatment processes. Trace elements, which include some heavy metals, are not determined routinely, but trace elements may be a factor in the biological treatment of wastewater. All living organisms require varying amounts of some trace elements, such as iron, copper, zinc and cobalt, for proper growth [1].

1-3- Composition of industrial wastewater

As industries have been rapidly developing, various kinds of wastewater discharged from the plants include high concentration organics and nutrients. The composition of industrial effluents is characterized by the high structural diversity of constituents and their high concentration level. Industrial wastewaters may be a severe hazard to receiving waters and their plants and fauna. In Table 1-1 a list of wastewater characteristics for typical industries is presented. The major problem associated with the biological treatment of industrial wastewater is non and slowly biodegradable fraction of COD which inhibits the treatment performance of the bioreactors. BOD_5/COD ratio constitutes a good measure of the biodegradability of a wastewater and contaminants with a ratio of $BOD_5/COD \geq 0.4$ are generally accepted as biodegradable [3]. From a review, the BOD_5/COD ratio for industrial estate wastewaters is varied from 0.17 to 0.74 [4].

1-4- Needs for treatment industrial wastewaters

Industry views wastewater treatment as an imposed necessity which it employs when it is compelled to, especially when wastewater's effect on the receiving watercourse is readily visible or when public approval and claim will be gained for the expenditure and effort.

Industry should attempt to treat its wastewater at the lowest cost that will yield a satisfactory effluent for the particular receiving stream, which may necessitate considerable study, research, and pilot investigations. Planning ahead will provide time to make appropriate decisions. Conversely, lack of planning on minimizing wastewater treatment costs may mean that a sudden demand for an immediate solution will cause industry to decide to cease production. To prevent any health hazards caused by discharging wastewater to water streams, the wastewater must be treated before discharge. Such treatment should comply with the terms of the legislation defining the characteristics of the effluent discharging in water streams. The concept of planning and development should be based on the criteria to protect land, water resources, aquatic life in streams and rivers and marine life from pollution and to safeguard public health as a high priority. The environmental inspection on wastewater treatment plants aims to support and strengthen the protection of both the environment and the public health, since the pollution generated from the industrial establishments has a negative impact not only on the environment, but also on the health of the individuals. Therefore, it is noted that most of the procedures that could be implemented by industrial establishments to reduce the negative environmental impacts, will also lead to reducing the effects that present a threat to the health of workers within the plants and the public living in regions affected by the various emissions from the plants.

In this respect, the effectiveness of the inspection on industrial wastewater treatment plants will lead to the protection of the environment and the protection of workers and public health.

1-5- Environmental regulations of effluent discharge

The highly pollution loading on the water resources from various sources (municipal, industrial and agricultural) has been led to the increasingly stringent environmental regulations. The permitting variable effluent standards are applied based on the demands of prevailing environmental circumstances. The effluent discharge standards ordinarily applicable to effluent wastewater are presented in Table 1-2.

Table 1-1Wastewater characteristics for typical industries (Kiely,1996) [5]

Industry	Principal pollutants	BOD_5 mg/l
Dairy, milk processing	Carbohydrates, fats, proteins	1000 –2500
Meat processing	SS, protein	200 –250
Poultry processing	SS, protein	100 –2400
Bacon processing	SS, protein	900 –1800
Sugar refining	SS, Carbohydrates	200 –1700
Breweries	Carbohydrates, protein	500 –1300
Canning fruit etc	SS, Carbohydrates	500 –1200
Tanning	SS, protein, sulphide	250 –1700
Electroplating	heavy metals	minimal
Laundry	SS, Carbohydrates, soaps, oils	800 –1200
Chemical plant	SS, acidity, alkalinity	250 - 1500

Table 1-2 Effluent discharge standards for treated wastewater (Iran)

No.	Pollutant material	Discharge to surface water(mg/l)	Discharge to well (mg/l)	Agriculture Uses (mg/l)
5	COD	60	60	200
6	BOD_5	30	30	100
7	TSS	40	-	100
8	TDS	10	10	-
1	NH_4	2.5	1	-
2	NO_2	10	10	-
3	NO_3	50	10	-
4	P	6	6	-
9	pH	6.5-8.5	5-9	6-8.5
10	Turbidity(NTU)	50	-	50

1-6- Problem statement

Due to increasing consciousness about the environment and more severe environmental regulations, treatment of industrial wastewater has been a key aspect of research. The composition of industrial effluents is characterized by diverse in constituents with high concentration level [6]. The complex composition of the industrial wastewater accounts for, in some cases, unpredictable toxicological and ecotoxicological effects[7]. Also, slowly biodegradable chemical oxygen demand (sbCOD) and nutrients content are two problems associated with industrial wastewaters which are not typically considered in conventional treatment processes design.