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THE EFFECTS OF TEMPERATURE ON BIOLOGICAL PHOSPHORUS REMOVAL IN ANAEROBIC/ANOXIC SEQUENCING BATCH REACTOR

ABSTRACT

In this study, it was investigated to effects of temperature on biological phosphorus removal (BPR) in two anaerobic/anoxic sequencing batch reactor fed with acetate and glucose. In both reactors, sludge retention time was 10 days and hydraulic retention time was 12 hours. The studies were made at 20°C, 25°C, 30°C and 35°C, respectively. The optimum temperature for biological phosphorus removal in both acetate and glucose-fed anaerobic/anoxic sequencing batch reactor was 20°C.

Keywords: Biological Phosphorus Removal, Temperature Effect, Sequencing Batch Reactor, Phosphorus Release, COD Uptake

ANAEROBİK/ANOKSİK ARDIŞIK KESİKLİ REAKTÖRDE BİYOLOJİK FOSFOR GİDERIMINE SICAKLIĞIN ETKİSİ

ÖZET

Bu çalışmada, asetat ve glikozla beslenen iki anaerobik/anoksik ardışık kesikli reaktörde biyolojik fosfor giderimine (BFG) sıcaklığın etkisi araştırılmıştır. Her iki reaktörde, çamur bekleme zamanı 10 gün ve hidrolik bekleme zamanı 12 gündür. Çalışmalar, 20°C, 25°C, 30°C ve 35°C'de yapılmıştır. Hem asetat hem de glikozla beslenen anaerobik/anoksik ardışık kesikli reaktörde biyolojik fosfor giderimi için optimum sıcaklık 20°C olarak bulunmuştur.

Anahtar Kelimeler: Biyolojik Fosfor Giderimi, Sıcaklık Etkisi, Ardışık Kesikli Reaktör, Fosfor Salınımı, KOİ Bağlanması

1. INTRODUCTION (GİRİŞ)

The primary characterisric of BPR system is the alternate condition of anaerobic and aerobic environments to stimulate the growth of phosphorus accumulating organisms (PAOs). In the anaerobic phase, carbon substrates such as acetate are taken up and converted to polyhydroxyalkanoic acids (PHA). Concurrently, internally stored polyphosphate is degraded to provide required adenosine triphosphate (ATP), which results in an increase of orthophosphate concentration in bulk solution. In the subsequent aerobic phase, where no external carbon source is present, the internally stored PHA is oxidized and used for cell growth, polyphosphate production from orthophosphate. Several operational parameters are found to affect the performance of BPR system such as pH [1 and 2], carbon source [3], and temperature [4, 5 and 6]. In many cases, glycogen accumulating organisms (GAOs) are observed in BPR system [7, 8 and 9]. During the anaerobic uptake and storage of acetate, GAOs degrade only cellular glycogen through glycolysis to supply ATP required for converting acetate to PHA, but do not degrade polyphosphate for PHA synthesis. Therefore, the uptake and release of phosphate do not occur and eventually the BPR fails.

The biological reaction rates in biological treatment process are dependent on temperature [10]. Many studies on the effects of temperature on the efficiency of the BPR process have been conducted, however, the results are inconsistent. The efficiency of biological phosphorus removal was observed to improve at higher temperatures (20-37°C) [11, 12, 13 and 14]. In contrast, good or even comparatively better phosphorus removal efficiency was reported at lower temperature (5-15 °C) [15, 16, 17, 18 and 19].

Denitrifying phosphorus accumulating organisms (DPAOs) can be easily accumulated by replacing the aerobic phase in a conventional anaerobic—aerobic phosphorus removal system by an anoxic phase [20, 21 and 22]. These bacteria use nitrate instead of oxygen by electron acceptor. DPAOs have metabolic characteristics similar to those PAOs based on the metabolic transformations responsible for EBR [23]. Denitrifying glycogen accumulating organisms (DGAOs) which metabolism similar to GAOs were also enriched in anaerobic/anoxic sequencing batch reactor [24]. The operating condition is the main factor which controls and determinetes the predominant species in the BPR system. Thus, the pattern and treatment efficiency of the denitrifying phosphorus removal system under different temperatures has now been of principal concern.

In this study, it was investigated to effect of temperature to biological phosphorus removal in anaerobic/anoxic sequencing batch reactor fed with acetate and glucose.

2. RESEARCH SIGNIFIANCE (ÇALIŞMANIN ÖNEMİ)

BPR plant will perform exceptionally if the conditions are favorable the growth of the PAOs. However, some of these conditions get out of control. Temperature factor seems to be the most uncontrollable, particularly in field practice. Plant operators need to modify their operating conditions to relieve the adverse impacts from those uncontrollable factors in order to maintain the BPR performance. Therefore, there is strong need to evaluate the impact of temperature variation on the BPR process. This study investigates the effect of temperature on BPR in anaerobic/anoxic sequencing batch reactor.

3. MATERIALS AND METHODS (MATERYAL VE METOT)

This study was made in two lab-scale anaerobic/anoxic sequencing batch reactor fed with acetate and glucose. The cycle time of both

reactors was 6 hours. A cycle consistred of: filling (15 min), anaerobic (105 min), anoxic (180 min), settling (30 min), decanting (15 min), idle (15 min). Both reactors were fed with synthetic wastewater of 0.9 L in filling phase. Nitrate solution of 0.1 L was fed into the reactors during the first 120 minutes of the anoxic phases. Nitrate concentration was 60 mmol in reactor fed with acetate, while 40 mmol in reactor fed with glucose. In decanting phase, 1.0 L supernatant was discharged. The hydraulic retention time was 12 hours and the sludge retention time was 10 days. The pH was not controlled in both reactors.

Both reactors was fed with composition of the same synthetic wastewater except for carbon source. As carbon source, one of reactors was feed with acetate, other was feed with glucose. The medium contained per liter: 850 mg $NaAc.3H_2O$ (412.5 mg $C_6H_{12}O_6.H_2O$), 75,5 mg $NaH_2PO_4.2H_2O$, 107 mg NH_4Cl, 90 mg $MgSO_4.7H_2O$, 36 mg KCl, 14 mg $CaCl_2.2H_2O$, 0.3 ml nutrient solution. One-liter nutrient solution contained: 1500 mg $FeCl_3.\ 6H_2O$, 150 mg H_3BO_3, 30 mg $CuSO_4.5H_2O$, 180 mg KI, 120 mg $MnCl_2.\ 2H_2O$, 60 mg $Na_2MoO_4.2H_2O$, 120 mg $ZnSO_4.7H_2O$, 150 mg $CoCl_2.\ 6H_2O$.

Seeding sludge was taken from a municipal treatment plant designed for nitrogen and phosphorus removal. It was started to experimental studies when stable conditions supplied in reactors.

COD, phosphate concentrations were measured by Standard Methods [25]. MLSS and MLVSS concentrations were determineted using Whatman GF/C filter. Nitrate concentration was measured by Standard Kit (Merck Specquorant).

4. RESULTS AND DISCUSSION (BULGULAR VE TARTIŞMA)

The COD profile in acetate and glucose-fed reactor are given in Figure 1 and 2, respectively. The efficiency of COD removal was approximately 90 % for all temperature. Most of COD removal occurred in anaerobic phase. However, COD removal in anaerobic phase decreased while COD removal in anoxic phase increased at temperature of 35 °C.

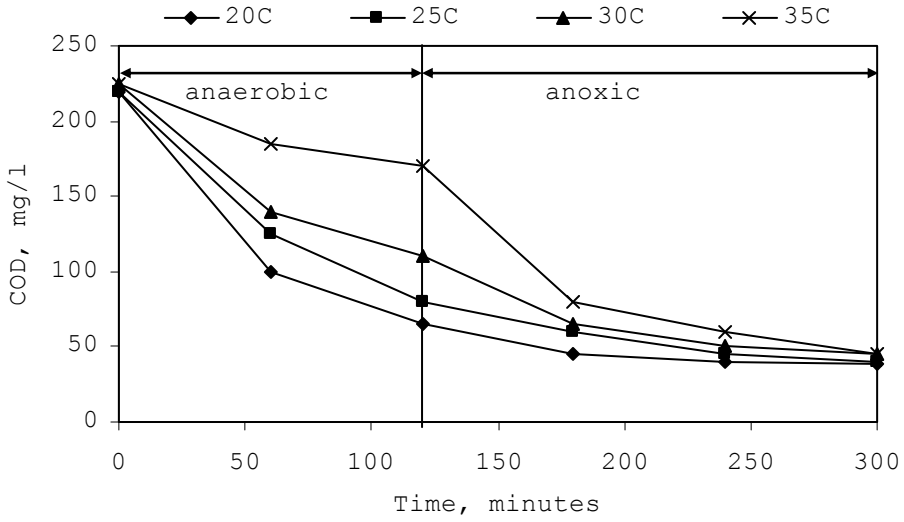

Figure 1. COD profile in acetate-fed reactor
(Şekil 1. Asetatla beslenen reaktörde KOİ profili)

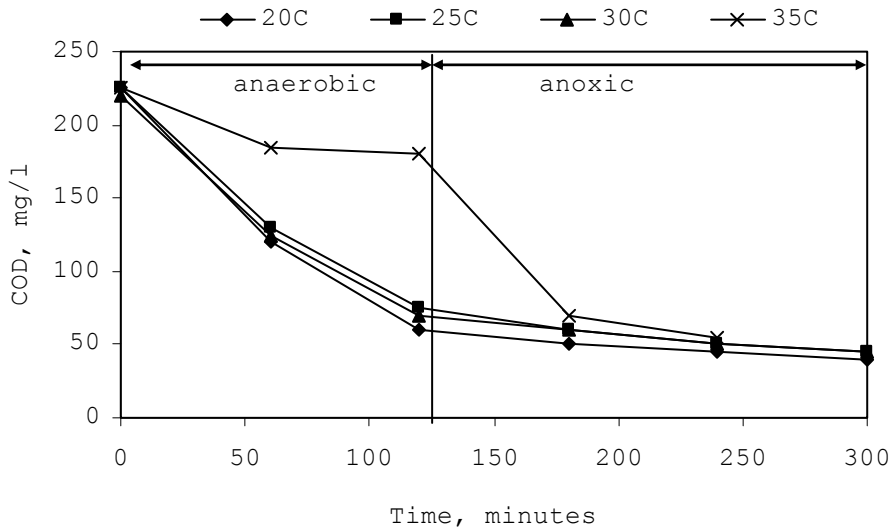

Figure 2. COD profile in glucose-fed reactor
(Şekil 2. Glikozla beslenen reaktörde KOİ profili)

The phosphorus profile in acetate and glucose-fed reactor are given in Figure 3 and 4, respectively. The efficiency of phosphorus removal at both reactors was affected from the temperature. The phosphorus removal in acetate-fed reactor decreased from 13 mg/L at 20°C to 9.60 mg/L and 4.80 mg/L and 2.70 mg/L at 25°C, 30°C and 35°C, respectively. The corresponding phosphorus removal efficiency in acetate-fed reactor decreased from 87% at 20°C to 64%, 32% and 18% at 25°C, 30°C and 35°C, respectively. The phosphorus removal in glucose-fed reactor decreased from 7.70 mg/L at 20 °C to 5.75 mg/L and 1.40 mg/L and 1.20 mg/L at 25°C, 30°C and 35°C, respectively. The corresponding phosphorus removal efficiency in glucose-fed reactor decreased from 51% at 20°C to 38% and 9% and 8% at 25°C, 30°C and 35°C, respectively. The phosphorus release and subsequent uptake in both reactor decreased as temperature increased from 20 °C to 35°C.

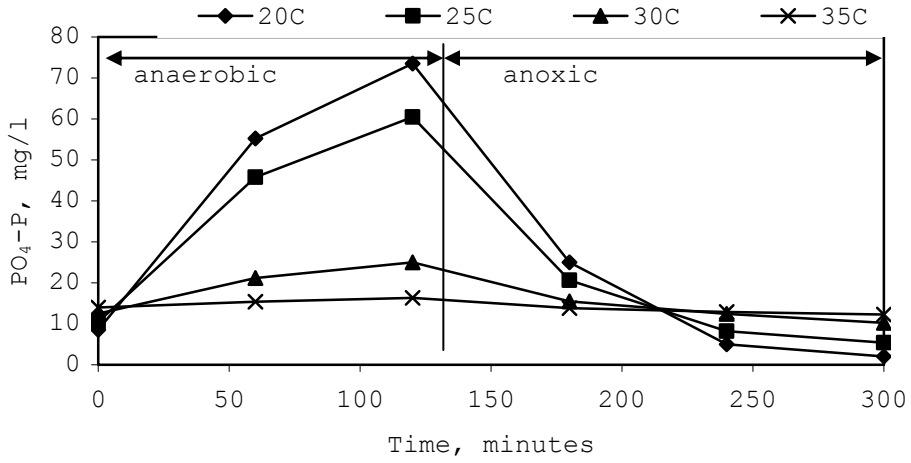

Figure 3. Phosphorus profile in acetate-fed reactor
(Şekil 3. Asetatla beslenen reaktörde fosfor profili)

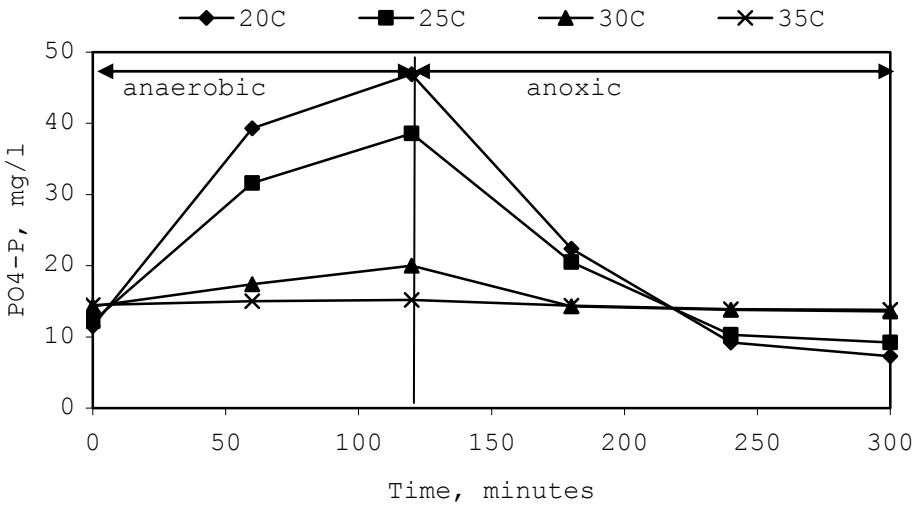

Figure 4. Phosphorus profile in glucose-fed reactor
(Şekil 4. Glikozla beslenen reaktörde fosfor profili)

The COD uptake in anaerobic phase of both reactors was observed, but phosphorus release and subsequent phosphorus uptake decreased at 30°C. The COD uptake in anaerobic phase, phosphorus release and subsequent phosphorus uptake almost ceased at 35°C. These results indicated to be dominant of different microorganism at 30°C and 35°C. These results are consistent with Whang et.al. [26] and Panswad et.al. [27].

Furthermore, parallel experiment results indicated that the phosphorus release induced by acetate was greater than that of glucose. Meanwhile, DPAOs were able to release sufficient phosphorus if abundant readily degradable organic substrate was supplied to the anaerobic phase, and this favored the improvement the phosphorus removal efficiency.

The ratio of MLVSS/MLSS in both reactor increased as temperature increased from 20°C to 35°C (Table 1 and 2). The phosphorus percent of MLSS decreased with raising temperature. These results indicated that DPAO was washout in both reactor. In higher temperature, less MLVSS was present in both reactor operated with the same SRT. This result was correlated that energy requirements for maintenance was greater at higher temperature as reported by Brdjanovic et.al. [16].

Table 1. Values of MLSS, MLVSS, MLVSS/MLSS and % P/MLSS in acetate-fed reactor
(Tablo 1. Asetatla beslenen reaktörde TAKM, TUAKM, TUAKM/TAKM ve %P/TAKM değerleri)

	20°C	25°C	30°C	35°C
MLSS (mg/l)	2060	1860	1600	1350
MLVSS (mg/l)	1385	1320	1220	1140
MLVSS/MLSS	0.672	0.709	0.762	0.844
% P/MLSS	12.1	9.8	4.5	2.8

Table 2. Values of MLSS, MLVSS, MLVSS/MLSS and % P/MLSS in glucose-fed reactor.
(Tablo 2. Glikozla beslenen reaktörde TAKM, TUAKM, TUAKM/TAKM ve %P/TAKM değerleri)

	20°C	25°C	30°C	35°C
MLSS (mg/l)	2070	1900	1740	1600
MLVSS (mg/l)	1650	1570	1500	1420
MLVSS/MLSS	0.797	0.826	0.862	0.887
% P/MLSS	7.1	5.2	3.2	2.2

5. CONCLUSIONS (SONUÇLAR)

The efficiency of COD removal in both reactors was approximately the same at all temperature. The efficiency of phosphorus removal decreased with raising temperature. The results likely indicated to be dominant of different microorganisms at different temperature. It was found that optimum temperature for biological phosphorus removal in both acetate and glucose-fed anaerobic/anoxic sequencing batch reactor was 20°C.

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