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EFFECT OF pH CONTROL ON ANAEROBIC PHOSPHORUS RELEASE IN ANAEROBIC/ANOXIC SEQUENCING BATCH REACTOR

ABSTRACT

In this study, it was investigated to effect of uncontrolled and controlled pH values (6.5, 7.0, 7.5 and 8.0) on anaerobic phosphorus release in two anaerobic/anoxic sequencing batch reactor (SBR) fed with acetate and glucose. It was observed that anaerobic phosphorus release increased with increasing of pH which showed a similar behavior the conventional anaerobic/aerobic sludge. At uncontrolled pH, the anaerobic phosphorus release in acetate and glucose was higher than at pH 7.5 and 7.0, respectively. Obtained results suggest that uncontrolled pH will be more favourable.

Keywords: Phosphorus Release, Ph, Sequencing Batch Reactor, Acetate, Glucose

ANAEROBİK/ANOKSİK ARDIŞIK KESİKLİ REAKTÖRDE ANAEROBİK FOSFOR SALINIMINA pH KONTROLÜNÜN ETKİSİ

ÖZET

Bu çalışmada, asetat ve glikozla beslenen iki anaerobik/anoksik ardışık kesikli reaktörde (AKR) anaerobik fosfor salınımına pH'ın kontrol edilmesinin (6.5, 7.0, 7.5 ve 8.0) ve kontrol edilmemesinin etkisi araştırılmıştır. Anaerobik fosfor salınımı, klasik anaerobik/aerobik çamurdakine benzer bir davranış göstererek pH'ın artmasıyla artmıştır. pH kontrol edilmediğinde, asetat ve glikozla elde adilen anaerobik fosfor salınımı sırasıyla pH 7.5 ve 7.0'den daha çoktur. Elde edilen sonuçlar, pH'ın kontrol edilmemesinin daha uygun olacağını göstermektedir.

Anahtar Kelimeler: Fosfor Salınımı, Ph, Ardışık Kesikli Reaktör, Asetat, Glikoz.

1. INTRODUCTION (GİRİŞ)

Phosphorus pollutants in sewage and industrial wastewater are responsible for increasing the eutrophication in surface waters, which results in a great financial loss and potentially ill effects on health. Enhanced biological phosphorus removal (EBPR) is considered as an economical and sustainable method to remove phosphorus from wastewater.

The enhanced biological phosphorus removal has been obtained with exposed to an anaerobic phase followed by aerobic phase of polyphosphate accumulating organisms (PAOs). In last years, it was observed that enhanced biological phosphorus removal was obtained with exposed to an anaerobic phase followed by anoxic phase of a fraction of PAOs, so-called denitrifying polyphosphate accumulating organisms (DPAOs), which are cabaple of using nitrate as an electron acceptor instead oxygen [1-4].

The phosphorus release in the anaerobic phase was strongly influenced by the pH in anaerobic/aerobic SBR fed with acetate [5]. They determineted that the phosphorus release showed a variation of 0.25-0.75 P-mol/C-mol in a range of pH 5.5-8.2. Besides, they found that less energy is required for the uptake of acetate in low pH. The stoichiometry and kinetics of acetate uptake by enriched cultures of PAOs and glycogen accumulating organisms (GAOs) was studied as a function of pH, respectively [6-7]. They observed that rate of acetate uptake with increasing of pH of the medium for GAOs was significiantly decreased, but the uptake rate for PAOs was independent in a range of pH 6.5-8.0. The effect of pH to the anaerobic metabolisms of PAOs and GAOs was compared using models for the kinetics of acetate uptake [8]. They revealed that rate of acetate uptake for GAO is faster than PAOs when pH is less than 7.25 while rate of acetate uptake for PAO is faster than GAO when pH is greater than 7.5.

In all previous studies on the effect of pH on enhanced biological phosphorus removal, it was used acetate as the carbon source and pH was maintained constant. The objective of this study is to investigate the effect of uncontrolled pH and controlled pH (6.5, 7.0, 7.5 and 8.0) on anaerobic phosphorus release in two anaerobic/anoxic SBR fed with acetate and glucose.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

It is difficult to control a stable pH in a real wastewater plant. So, it is therefore necessary to find a suitable pH control strategy to promote the efficiency of enhanced biological phosphorus removal. This study investigates the effect of pH control on anaerobic phosphorus release in anaerobic/anoxic sequencing batch reactor.

3. MATERIALS AND METHODS (MATERYAL VE METOT)

3.1. Sequencing Batch Reactor Operation (Ardışık Kesikli Reaktör İşletimi)

This study was made in two lab-scale anaerobic/anoxic sequencing batch reactors (SBR). The temperature of reactors was 20±2 °C. The cycle time of each reactor was 6 hours. A cycle consisted of six phases: i) filling (15 minutes), ii) anaerobic (105 minutes), iii) anoxic (180 minutes), iv) settling (30 minutes), v) decanting (15 minutes), vi) idle (15 minutes). The reactors were fed with synthetic wastewater of 0,9 L in filling phases. The 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.

3.2. Syntetic Wastewater and Seeding Sludge (Sentetik Atıksu ve Aşılama Çamuru)

Each reactor was fed with composition of the same synthetic wastewater except for carbon source (Table 1). As carbon source, one of reactors was fed with acetate, other was fed with glucose.

Table 1. Synthetic wastewater composition
(Tablo 1. Sentetik atıksu kompozisyonu)

Chemical compounds	Dose (mg/L)
$NaCH_3COO.\ 3H_2O$ (Carbon source)	850
$C_6H_{12}O_6.H_2O$ (Carbon source)	412,5
$NaH_2PO_4.\ 2H_2O$ (Phosphorus source)	75,5
Main compounds	
NH_4Cl	107
$MgSO_4.7H2O$	90
KCl	36
$CaCl_2.2H2O$	14
Trace minerals	0,3 ml/L
Trace minerals	
$FeCl_3.\ 6H_2O$	1500
H_3BO_3	150
$CuSO_4.5H_2O$	30
KI	180
$MnCl_2.\ 2H_2O$	120
$Na_2MoO_4.2H_2O$	60
$ZnSO_4.7H_2O$	120
$CoCl_2.\ 6H_2O$	150

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

3.3. Analytical Methods (Analitik Yöntemler)

Chemical oxygen demand (COD), phosphate concentration was measured by Standart Methods [9]. Mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS) concentrations were determined using Whatman GF/C filter paper.

4. RESULTS AND DISCUSSION (BULGULAR VE TARTIŞMA)

The reactors were fed with constant COD (400 mg/L) and phosphate (15 mg/L) concentration. MLSS and MLVSS concentrations were 2090, 1400 mg/L and 2110, 1690 mg/L; the ratio of MLVSS/MLSS was 0.67 and 0.80 and phosphorus percent in the sludge was 12.1 and 7.1, respectively as average in reactors fed with acetate and glucose. The reactors were operated without pH control. But, to obtain a direct comparison with the uncontrolled pH and to examine the influence of pH on anaerobic phosphate release in acetate and glucose, the reactors were also operated at different pH values (6.5, 7.0, 7.5, 8.0, 8.5).

Figure 1 shows the effect of pH values on anaerobic phosphorus release. The effect of pH on anaerobic phosphorus release in anaerobic/anoxic sludge showed a similar behavior the conventional anaerobic/aerobic sludge. From Fig. 1, it can be seen that phosphate release increased as the pH raised from 6.5 to 8.0 which coincided well with previous investigations [5,6 and 10]. An explanation for pH effect was due to a higher energy demand for active uptake of acetate at a higher pH, which caused more polyphosphate hydrolysis and phosphorus release [5]. A high pH could lead to chemical precipation

of phosphate and disturb the results of biological phosphorus release experiments [11]. It was observed that phosphorus release at pH 8.0 decreased due to phosphate precipates [12], which contradicted our observation.

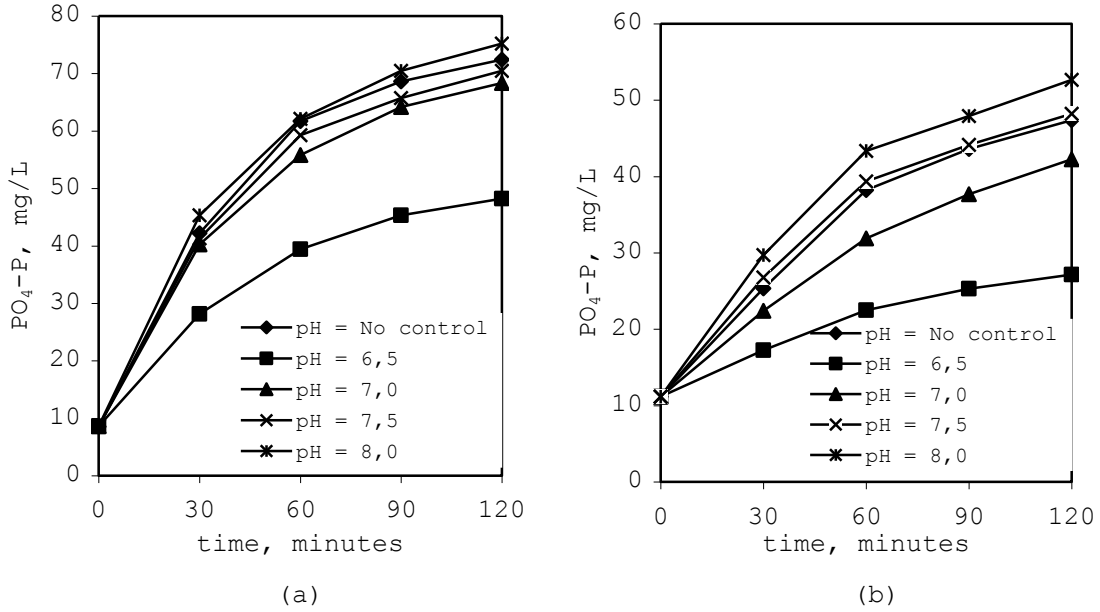

Figure 1. Variations of phosphorus release with pH during anaerobic phase
a) acetate,
b) glucose.
(Şekil 1. Anaerobik fazda pH ile fosfor salınımının değişimleri
a) asetat,
b) glikoz)

At uncontrolled pH, phosphorus release in acetate and glucose was between those at pH 7.5-8.0 and 7.0-7.5, respectively. Control of hydrogen ion concentration (pH) is difficult due to operating trouble and cost. From experiments results, uncontrolled pH strategy compared with controlled pH is suggested to use in practice of wastewater treatment plant.

The uptake rates of acetate and glucose were independent of pH in the range pH 6.5-8.0 and in uncontrolled pH. The influence of pH on acetate uptake has been reported in the literature. Liu et al. [10] observed that both an acidic and an alkaline pH had a negative effect on the anaerobic acetate uptake, its uptake rate remained at a constant level in the pH range 6.3-8.2. Smolders et al. [5] reported that acetate uptake rate was independent of pH in the range pH 5.8-8.2. The observation of Filipe et al. [6,7] also showed that the acetate uptake rate of PAOs had no relation to pH in a range of pH 6.5-8.0, but acetate uptake rate of GAOs significiantly decreased with the increase of pH.

The type of carbon source had a pronounced effect on anaerobic phosphorus release. The phosphorus release with acetate as carbon source was higher than that with glucose. This was likely correlated to reduced anaerobic accumulation of polyhydroxyalkanoate (PHA) in case of glucose use as carbon source as reported by Wang et al. [13].

It can be seen in Fig. 2 that ratio of phosphorus/carbon (P/C) in acetate and glucose increased respectively from 0,26 to 0,43 and 0,10 to 0,26 with the increase of pH from 6.5 to 8.0. A similar

observation was made by other researchers [5,8 and 14]. It was observed that the P/C ratios obtained for acetate were always higher than those from the glucose at all pH values tested. The relations between P/C and pH are different from each other. It is difficult to explain this difference since anaerobic phosphorus release is influenced by several other factor besides pH, such as influent P/C ratio [15], biomass polyphosphate content [10], the fraction of PAOs in biomass [6 and 7] and volatile fatty acid (VFA) composition [16 and 17].

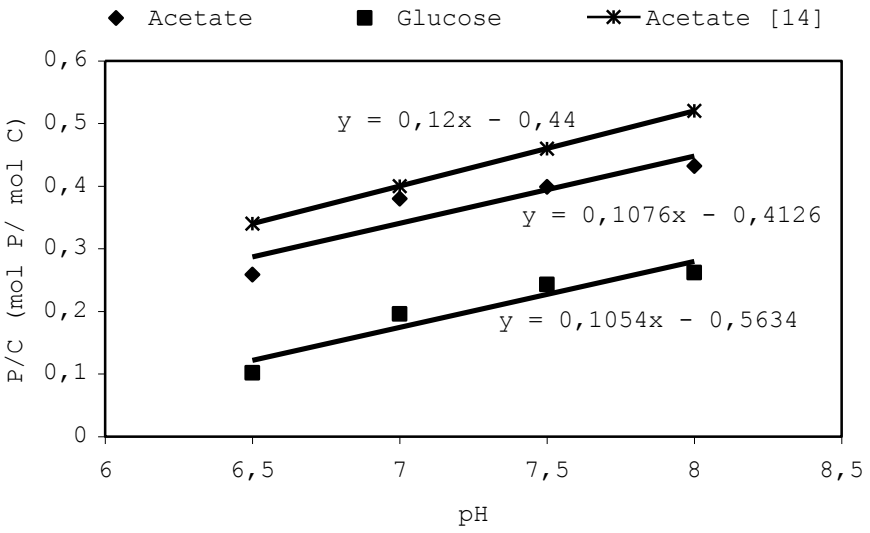

Figure 2. Variation of ratio of P/C with pH.
(Şekil 2. pH ile P/C oranının değişimi)

5. CONCLUSIONS (SONUÇLAR)

The anaerobic phosphorus release in anaerobic/anoxic SBR showed a similar behaviour with anaerobic/aerobic SBR, which indicated that higher anaerobic phosphorus release occured at higher pH. The anaerobic phosphorus release in acetate and glucose at uncontrolled pH was higher than at pH 7.5 and 7.0, respectively. The anaerobic phosphorus release and P/C ratios obtained for acetate were always higher than those from the glucose at all pH values tested. On the other hand, all obtained results showed that uncontrolled pH will be more suitable.

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