Performance evaluation of anaerobic baffled reactor (ABR) for treating alkali-decrement wastewater of polyester fabrics at incremental organic loading rates

Bo Yang, Hui Xu, Junfeng Wang, Dengming Yan, Qijun Zhong and Hexin Yu

ABSTRACT

In this study, an anaerobic baffled reactor (ABR) with four compartments was employed to treat alkali-decrement wastewater of polyester fabrics under different organic loading rates. The stable operation of this reactor was achieved in 70 days at a hydraulic retention time of 36 h and mesophilic temperature of 35 ± 1°C. It is found that the chemical oxygen demand removal and decolorization of this system can be as high as 79.0% and 87.7%, respectively. The different acidogenesis and methanogenesis in four compartments was acclimated by the variation of pH, oxidation reduction potential values and operational conditions in the spatial distribution of the first to fourth compartments of the ABR system. In addition, the dehydrogenase activity (DHA) and coenzyme F_{420} concentrations along the four compartments ranged from 67.8 to 185.21 μgTF/(gVSS·h) (TF: triphenyl formazan; VSS: volatile suspended solids) and 0.123 to 0.411 μmol/g, respectively. These results indicated that the ABR could separate acidogenesis and methanogenesis in longitudinal distribution and treat well the alkali-decrement wastewater.

Key words | alkali-decrement wastewater, anaerobic baffled reactor (ABR), anaerobic granular sludge, coenzyme F_{420}, dehydrogenase activity

INTRODUCTION

The alkali-decrement process is widely used as a pretreatment technology for dyeing and printing, softening polyester fabrics like a real silk (Wen et al. 2006). The discharged wastewater during the alkali-decrement process is characterized by high organic concentration (chemical oxygen demand (COD): 20,000–100,000 mg/L) and high pH (>12.8) due to polyester hydrolysis. Terephthalic acid and ethylene glycol are the key component compounds in this kind of wastewater (Meabe et al. 2011). Incomplete hydrolyzed polyester is also present, resulting in a poor biodegradation efficiency during the conventional biological processes (Spagni et al. 2012); it is toxic and carcinogenic in nature because it has endocrine disrupting ability (Qi et al. 2002). Notably, the chemical treatment process generally would consume a lot of strong acids to reduce the pH, which has demonstrated that COD removal efficiency could achieve 90% (Guo & Zhou 2000). Nevertheless, it is generally accepted that using a biological method might be an attractive option for treating alkali-decrement wastewater due to its cost-effectiveness and energy and resource conservation.

Recently, the use of anaerobic reactors has been successfully applied in the treatment of wastewater with refractory contaminants (Dai et al. 2016). However, little is known about the application of the anaerobic baffled reactor (ABR) for treating alkali-decrement wastewater with an incremental organic loading rate. The ABR, which was developed in the 1980s, is an attractive technology due to its numerous potential advantages over conventional anaerobic reactors such as longer biomass retention time, lower energy consumption, and higher stability for organic and hydraulic shock loadings (Barber & Stuckey 1999; Bell & Buckley 2003; Plumb et al. 2001). This system is described as a series of up-flow anaerobic blanket reactors (Chen et al. 2016), and each compartment is operated as a continuous stirred tank reactor. In addition, the most significant advantage of ABRs is the ability to separate acidogenesis and methanogenesis longitudinally down the reactor (Barber &
In an ABR, acidogenesis predominates in the initial section and methanogenesis dominates in the subsequent sections. In literature, it has been indicated that an increase of the relative abundance of acetoclastic methanogens could improve the contaminant removal performance of anaerobic reactors under an operational condition of low temperature (Bandara et al. 2012). Hence, the ABR should be considered as a promising system for contaminant removal from the industrial wastewater (Hahn & Figueroa 2015), especially the alkali-decrement wastewater.

In this present study, an ABR reactor was employed to evaluate its performance on the treatment of alkali-decrement wastewater under different hydraulic retention time (HRT). Several parameters, namely pH, oxidation reduction potential (ORP), COD, decolorization, and volatile fatty acids (VFAs) concentration, were determined to investigate the performance of the ABR. Effects of microbial activities and scanning electron microscopy (SEM) were also used to study the stabilization of granular sludge.

MATERIAL AND METHODS

Experimental apparatus setup

A laboratory-scale ABR of 800 × 1,000 × 150 mm³ with a total working volume of 80 L for continuous treatment of alkali-decrement wastewater is presented in Figure 1. In this system, a series of vertical baffles was used to divide the ABR into four compartments (20 L) with down-flow and up-flow chambers. The width of the up-flow section was twice the width of the down-flow section. To produce an effective mixing between anaerobic granular sludge and the wastewater, the lower parts of vertical baffles were designed to be angled at 45°. In addition, a sedimentation tank was incorporated with the last compartment to reduce sludge in the effluent. Each compartment was equipped with sampling ports to ensure that liquid, gas and sludge samples could be collected. The temperature was kept constant at 35 ± 1 °C by a heating rod in each compartment. The influent feed was pumped using a variable speed peristaltic pump (Model BT-001, Zhixin, China).

Influent wastewater

The influent wastewater was synthesized in the laboratory based on the main pollutants (terephthalic acid and ethylene glycol). The alkali-decrement wastewater was actually simulated from the hydrolysis process of silk-like polyester textile and contained disperse dyes and textile auxiliaries. The parameters of synthetic alkali-decrement wastewater and influent of ABR are shown in Table 1. COD/N/P ratio of 350/5/1 was kept by adding NH₄Cl, K₂HPO₄ and metal solution (1 mL), which was respectively prepared by dissolving ZnSO₄·7H₂O (0.1 g/L), MnCl₂·4H₂O (5.0 g/L), FeCl₂·4H₂O (6.0 g/L), CoCl₂·4H₂O (0.88 g/L), CuSO₄·5H₂O (0.05 g/L), MgSO₄·7H₂O (5.0 g/L), H₂BO₃ (0.1 g/L) and NiSO₄·8H₂O (1.0 g/L) into a liter of distilled water.

Reactor start-up and operation

The anaerobic system was inoculated with granular sludge taken from an internal circulation reactor for treating paper factory effluents (Zhejiang Province, China). The granular sludge contained moisture content of 90% with average particle size of 3.5 mm, sedimentation velocity of 36.4 ± 0.5 m/h, and volatile suspended solids (VSS)/total suspended solid (TSS) of 0.63. During the inoculation process, the ABR reactor was filled with 35% granular sludge and sealed with lids to keep a strictly anaerobic condition. The ABR system was started with a low organic loading rate (OLR) of 0.85 kg
COD/(m³·d) for maintaining HRT of 36 h. Then, the OLR was gradually increased by increasing the COD concentration of influent. Table 2 shows the reactor operation at different OLRs or HRTs for 250 days. The operation was divided into eight phases, corresponding to the pH, HRT, and OLR condition of each period.

**Analytical methods**

COD, biochemical oxygen demand (BOD), pH, alkalinity, degree of color, ORP; total solid, volatile solid and VFAs were determined by standard methods (APHA et al. 1998). The flow rate, pH and ORP were recorded daily and other parameters such as COD, VFA, and degree of color were determined every 3 days. In addition, the mean and the standard deviation value of experimental data were calculated by triplicate measurements. Coenzyme F₄₂₀ activity was determined by using a UV spectrophotometry method (Ebert et al. 1999). To measure dehydrogenase activity (DHA), 2,3,5-triphenyltetrazoliumchloride (TTC) is used as hydrogen receiver in cell respiration. All sample tubes were mixed thoroughly and extracted for 6 min at 90 °C, then they were centrifuged at 4,000 rpm for 10 min. Notably, the following materials and reagents were added to centrifuge tubes (50 mL): 0.5 mL of 0.4% Na₂SO₃, 0.5 mL of 0.006% CoCl₂, 1.5 mL of tri-buffer (pH, 8), 2 mL of granular sludge, 0.5 mL of 0.4% TTC and 1 mL of synthetic substrate (4 g COD/L adjusted by glucose). The supernatant of each sample was colorimetrically measured at 485 nm. One unit of DHA is defined as the activity catalyzing the reduction of 1 μg of triphenyl formazan (TF) per hour.

Sludge samples from each compartment of the reactor were collected at Day 200 and the sludge surface was examined by SEM (Model JSM-5600LV, Shimadzu, Japan). The sludge sample was firstly mixed with 2.5% (weight/volume) glutaraldehyde in 0.1 M phosphate buffer for 4 h at room temperature, and then it was dehydrated through a graded series of ethanol in distilled water (10% to 100%). All samples were brought to equilibrium in each mixture for 10 min and finally dried by the frozen drying method before sputtering coating with gold particles. Also, the fluorescence in situ hybridization (FISH) was conducted according to the methods in a previous study (Lu et al. 2015). The fluorescence labels of the oligonucleotide probes used included (Archaea (red), GTGCTCCCCGCAATTCC; methanogen (green), ACGCAGACTCATCCC CGTG; and hydrogen-producing acetogen (blue), GGCTATT CCTTCCCAGGG).

**RESULTS AND DISCUSSION**

**pH and ORP profile**

Several studies have reported the importance of pH and ORP for the stable operational condition of anaerobic digestion (Mensah & Forster 2003; Zhu et al. 2008). The profile of pH and ORP at different HRTs is given in Figure 2. The variation of these factors affected not only the efficiency of the anaerobic treatment process, but also the microbial activity and distribution. Under different HRT condition, the average pH value of influent and effluent samples varied in the range of 7.94–8.04 and 7.31–7.54, respectively. The pH of the first compartment was lower than other compartments due to the high concentration of VFAs during the biodgradation process (Figure 3(b)); however, pH of other compartments (second, third and fourth) was maintained at a constant level due to the high-efficiency consumption of VFAs. In addition, pH value of this system increased gradually with the decrease of HRT, which might have resulted from the higher activity of methanogenic bacteria. As for ORP level, it reduced from −192.5 mV in the first compartment to −321.5 mV in the last compartment at HRT of 36 h. Generally, the reduction of ORP was in accordance with the increase of OLR during the anaerobic treatment process. There was a clear correlation between ORP and pH: low ORP is corresponding with higher pH level. Notably, the OPR value of the initial compartment was relatively higher than that of subsequent compartments (first > second > third > fourth) at the same HRT condition due to separation of acidogenesis and methanogenesis in

**Table 2** The operational condition of the anaerobic baffled reactor during all experimental processes

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Period I</th>
<th>Period II</th>
<th>Period III</th>
<th>Period IV</th>
<th>Period V</th>
<th>Period VI</th>
<th>Period VII</th>
<th>Period VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRT (h)</td>
<td>36</td>
<td>36</td>
<td>30</td>
<td>24</td>
<td>18</td>
<td>12</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>pH</td>
<td>7.8–8.3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>OLR (kgCOD/(m³·d))</td>
<td>0.85 ± 0.04</td>
<td>2.41 ± 0.08</td>
<td>2.72 ± 0.13</td>
<td>3.40 ± 0.17</td>
<td>4.54 ± 0.22</td>
<td>6.81 ± 0.34</td>
<td>10.20 ± 0.45</td>
<td>13.61 ± 0.51</td>
</tr>
</tbody>
</table>
this system. The profile of pH and ORP indicated that subsequent compartments, especially the last compartment, presented a good condition for converting acetate to methane (Liu et al. 2015; Li et al. 2017).

**COD removal and VFA production**

During the inoculation phase (Period I and II), the COD removal efficiency was only 21.8% with an influent COD concentration of 513 mg/L and HRT of 36 h (Figure 3(a)). However, the metabolic activity of microorganisms was recovered quickly at an optimal condition of the ABR system. When the COD concentration of wastewater increased to about 1,950 mg/L and OLR increased from 0.85 to 2.24 kg COD/(m³·d), the COD removal efficiencies of the ABR system increased with the increase of OLR. Meanwhile, the concentration of VFAs in each compartment increased with time as shown in Figure 3(b). After a continuous operation of about 70 days, COD removal efficiencies increased up to 75% at HRT of 36 h. However, the concentration of VFAs in each compartment accumulated at significant differences in the four compartments because the VFAs were used to produce hydrogen in the initial compartment and generate methane in the subsequent compartment. The granular sludge was collected from an internal circulation reactor; hence the microorganisms of this kind of sludge showed a high metabolic activity.

![Figure 2](https://iwaponline.com/wst/article-pdf/77/10/2445/234844/wst077102445.pdf)  
**Figure 2** | Variation of average pH (a) and ORP (b) in the influent, effluent and compartment samples during all experimental processes.

![Figure 3](https://iwaponline.com/wst/article-pdf/77/10/2445/234844/wst077102445.pdf)  
**Figure 3** | The profile of COD removal (a) and VFA production (b) in each compartment during all experimental processes.
during the start-up period. In this study, the stable COD removal performance was observed at the end of Period II; therefore start-up period of the ABR system was considered to be completed in about 70 days.

As shown in Figure 3(a), the COD removal efficiency varied with the changes of OLR after inoculation. During the process of HRT decrease from 36 h to 6 h, OLR ranged from 2.41 to 13.61 kg COD/(m³·d), the average COD removal efficiency of the ABR system increased to 78% at HRT of 12 h and then decreased with the enhancement of OLR. The reason for this phenomenon is that a poor mass transfer rate resulting from a higher liquid upflow was used during the operation of this system (Yang et al. 2017). Notably, the variation of HRT was followed by a temporary increase in COD concentration of effluents, and then the system gradually recovered its removal capacity. However, the concentration of VFAs in each compartment varied more complicatedly during the operational condition. It was observed that the VFAs were produced mainly in the first and second compartments and then converted to acetate; finally these acetic acids were converted to methane under the metabolic activity of methanogens in the third and fourth compartments (Damasceno et al. 2007). In addition, the concentration of VFAs in the first and second compartments were found to increase up to 150 mg/L with HRTs below 18 h. The accumulation of VFAs over 150 mg/L was a sign of an instability condition of the ABR system (Langenhoff & Stuckey 2000). These results indicated that the acidity and methane degradation was achieved at a low HRT in the ABR system for wastewater treatment, and the ABR was selected for biological phase separation.

Decolorization performance

Since the alkali-decrement wastewater showed a characteristic of high degree of color, the decolorization of this kind of wastewater is an important parameter for treating dyeing–printing wastewater. In the influent wastewater, the colourity was mainly caused by disperse dyes, which owned the characteristics of non-ionic composition and insusibility. In this study, the efficiency of decolorization in each compartment is given in Table 3. It was obtained that the concentration of DHA and coenzyme F420 down the four compartments ranged from 67.8 to 185.21 μgTF/(gVSS·h) and 1.25×10⁻¹ to 4.11×10⁻¹ μmol/g, respectively. The HDA concentration of the first compartment ranged from 102.56 to 185.21 μgTF/(gVSS·h), which was significantly higher than that of the subsequent compartments under the same operational HRT condition in correspondence with its stronger capability of VFAs production. Furthermore, the concentration of HDA reduced from the second to fourth compartment due to the lack of ample substrate. Hence, the dehydrogenation reaction was mainly produced in the initial compartment so that most of the substrate was hydrolyzed into VFAs. In addition, the enhancement of DHA in each compartment was a response to the decrease of HRT and the increase of OLR.

The use of coenzyme F420, the major intracellular electron carrier in methanogenic metabolism, is based on the advantage of methanogenesis to contribute the anaerobic degradation of substrate in the final process (De Poorter & Keltjens 2001), so the content of coenzyme F420 in the sludge can be used for the evaluation of methanogenic activity (Xie et al. 2009). The profiles of coenzyme F420 are also detailed in Table 3, and the high concentration of coenzyme F420 ranged from 0.253 to 0.411 μmol·g⁻¹ in the fourth compartment and increased with the decrease of HRT.
An inverse correlation between the concentration of DHA and coenzyme F$_{420}$ was presented in the four compartments. In literature, a high coenzyme F$_{420}$ resulted in a low concentration of DHA in the sample of anaerobic sludge. These results indicated that the function of the initial compartments was the process of dehydrogenation and the subsequent compartment was the process of methane production.

### Scanning electron microscopy and FISH analysis

The SEM micrographs of granular sludge are shown in Figure 4. After 70 days’ operation, the spherical granules showed compact structure and cavities naturally occurred on the surface. According to the dissected granules (Figure 4(b)–4(d)), it was clear that the granule consisted of an outer sphere and inside nuclei. Influent has relatively abundant calcium and magnesium, which would contribute to the formation of crystals. The crystals can be used as nuclei during the formation of spherical granular sludge, as illustrated in Figure 4(c) and 4(d) (Liu et al. 2010). The biomass of the inside nuclei was less compact than the biomass of the outer sphere (Figure 4(b)). However, a large amount of microorganisms mainly gathered on the outer surface due to the easier acquisition of nutrient. And the sectioned granules indicated that the bacteria in the deep center of the granules were morphologically different from those of the outer surface.

The bacteria in granular sludge from the first to fourth compartment are shown in Figures 4 and 5, respectively. The first compartment had various microorganisms, predo- minated by short rod-shaped and filamentous bacteria (Figures 4(e), 5(a) and 5(e)). The second compartment had abundant filamentous bacteria, as illustrated in Figures 4(f), 5(b) and 5(f). Based on their appearance, Methanococcus and Methanobacterium became dominant presumably in the subsequent compartmental granules of the reactor as shown in Figures 4(g)–(h), 5(c)–(d) and 5(g)–(h). In the fourth compartment of the reactor, the dominant bacteria were short rod-shaped bacteria characterized by

### Table 3 | Variation of COD removal, decolorization, DHA and coenzyme F$_{420}$ in each compartment at different HRTs

<table>
<thead>
<tr>
<th>HRT (h)</th>
<th>36 h</th>
<th>30 h</th>
<th>24 h</th>
<th>18 h</th>
<th>12 h</th>
<th>8 h</th>
<th>6 h</th>
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<tbody>
<tr>
<td><strong>1st Compartment</strong></td>
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<tr>
<td>COD removal (%)</td>
<td>70.2 ± 3.5</td>
<td>69.0 ± 3.5</td>
<td>70.3 ± 3.5</td>
<td>63.9 ± 3.1</td>
<td>63.3 ± 3.1</td>
<td>59.0 ± 3.0</td>
<td>57.0 ± 2.9</td>
</tr>
<tr>
<td>Decolorization ratio (%)</td>
<td>41.2 ± 2.1</td>
<td>41.9 ± 2.1</td>
<td>39.7 ± 2.0</td>
<td>36.2 ± 1.8</td>
<td>33.7 ± 1.6</td>
<td>28.4 ± 1.2</td>
<td>27.6 ± 1.1</td>
</tr>
<tr>
<td>DHA (μgTF/(gVSS-h))</td>
<td>102.6 ± 5.1</td>
<td>108.5 ± 5.4</td>
<td>123.6 ± 6.2</td>
<td>144.5 ± 7.2</td>
<td>154.3 ± 7.8</td>
<td>164.6 ± 8.2</td>
<td>185.2 ± 9.3</td>
</tr>
<tr>
<td>F$_{420}$ (μmol/g)</td>
<td>0.12 ± 0.006</td>
<td>0.15 ± 0.007</td>
<td>0.13 ± 0.009</td>
<td>0.13 ± 0.009</td>
<td>0.15 ± 0.009</td>
<td>0.14 ± 0.011</td>
<td>0.14 ± 0.009</td>
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<tr>
<td><strong>2nd Compartment</strong></td>
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<td>COD removal (%)</td>
<td>6.40 ± 0.3</td>
<td>8.0 ± 0.4</td>
<td>5.7 ± 0.3</td>
<td>7.1 ± 0.4</td>
<td>7.2 ± 0.4</td>
<td>12.3 ± 0.7</td>
<td>10.72 ± 0.6</td>
</tr>
<tr>
<td>Decolorization ratio (%)</td>
<td>28.5 ± 1.4</td>
<td>21.1 ± 1.1</td>
<td>25.9 ± 1.3</td>
<td>23.6 ± 1.2</td>
<td>25.1 ± 1.3</td>
<td>29.9 ± 1.5</td>
<td>23.2 ± 1.2</td>
</tr>
<tr>
<td>DHA (μgTF/(gVSS-h))</td>
<td>92.5 ± 4.6</td>
<td>98.4 ± 4.7</td>
<td>103.4 ± 5.2</td>
<td>111.4 ± 5.4</td>
<td>131.4 ± 6.5</td>
<td>143.4 ± 7.2</td>
<td>149.8 ± 7.3</td>
</tr>
<tr>
<td>F$_{420}$ (μmol/g)</td>
<td>0.19 ± 0.010</td>
<td>0.20 ± 0.011</td>
<td>0.21 ± 0.013</td>
<td>0.21 ± 0.014</td>
<td>0.22 ± 0.016</td>
<td>0.23 ± 0.017</td>
<td>0.22 ± 0.016</td>
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<td><strong>3rd Compartment</strong></td>
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<tr>
<td>COD removal (%)</td>
<td>7.0 ± 0.4</td>
<td>10.1 ± 0.5</td>
<td>14.5 ± 0.7</td>
<td>19.7 ± 1.0</td>
<td>21.6 ± 1.1</td>
<td>14.1 ± 0.7</td>
<td>13.9 ± 0.7</td>
</tr>
<tr>
<td>Decolorization ratio (%)</td>
<td>42.3 ± 2.1</td>
<td>41.2 ± 2.1</td>
<td>35.9 ± 1.8</td>
<td>42.6 ± 2.13</td>
<td>39.8 ± 1.99</td>
<td>29.1 ± 1.46</td>
<td>28.1 ± 1.4</td>
</tr>
<tr>
<td>DHA (μgTF/(gVSS-h))</td>
<td>87.3 ± 4.4</td>
<td>85.6 ± 4.3</td>
<td>86.7 ± 4.3</td>
<td>89.2 ± 4.5</td>
<td>97.6 ± 4.9</td>
<td>102.8 ± 5.1</td>
<td>113.6 ± 5.7</td>
</tr>
<tr>
<td>F$_{420}$ (μmol/g)</td>
<td>0.21 ± 0.011</td>
<td>0.22 ± 0.011</td>
<td>0.22 ± 0.011</td>
<td>0.24 ± 0.012</td>
<td>0.25 ± 0.012</td>
<td>0.25 ± 0.012</td>
<td>0.25 ± 0.013</td>
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<tr>
<td><strong>4th Compartment</strong></td>
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<tr>
<td>COD removal (%)</td>
<td>0.4 ± 0.2</td>
<td>7.1 ± 0.4</td>
<td>12.3 ± 0.6</td>
<td>19.9 ± 1.0</td>
<td>14.0 ± 0.7</td>
<td>12.53 ± 0.6</td>
<td>8.5 ± 0.4</td>
</tr>
<tr>
<td>Decolorization ratio (%)</td>
<td>49.4 ± 2.5</td>
<td>45.4 ± 2.3</td>
<td>37.4 ± 1.9</td>
<td>27.7 ± 1.4</td>
<td>30.6 ± 1.5</td>
<td>35.8 ± 1.8</td>
<td>34.2 ± 1.7</td>
</tr>
<tr>
<td>DHA (μgTF/(gVSS-h))</td>
<td>67.9 ± 3.4</td>
<td>68.7 ± 3.4</td>
<td>67.8 ± 3.4</td>
<td>69.9 ± 3.5</td>
<td>73.4 ± 3.7</td>
<td>78.9 ± 4.0</td>
<td>88.24 ± 4.4</td>
</tr>
<tr>
<td>F$_{420}$ (μmol/g)</td>
<td>0.25 ± 0.013</td>
<td>0.27 ± 0.013</td>
<td>0.28 ± 0.014</td>
<td>0.30 ± 0.015</td>
<td>0.33 ± 0.017</td>
<td>0.40 ± 0.020</td>
<td>0.41 ± 0.021</td>
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<tr>
<td><strong>The ABR system</strong></td>
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<tr>
<td>COD removal (%)</td>
<td>75.1 ± 3.8</td>
<td>76.2 ± 3.8</td>
<td>79.0 ± 4.0</td>
<td>78.4 ± 3.9</td>
<td>76.4 ± 3.8</td>
<td>73.0 ± 3.7</td>
<td>69.8 ± 3.5</td>
</tr>
<tr>
<td>Decolorization ratio (%)</td>
<td>87.7 ± 4.4</td>
<td>85.3 ± 4.3</td>
<td>82.1 ± 4.1</td>
<td>79.8 ± 4.0</td>
<td>79.0 ± 4.0</td>
<td>77.2 ± 3.9</td>
<td>73.7 ± 3.7</td>
</tr>
</tbody>
</table>
Methanobacterium. These results indicated that different distributions of microbes thrived in the inside of the first to fourth compartment of the ABR system.

CONCLUSION

An ABR reactor with four compartments was used for treating alkali-decrement wastewater. The highest COD removal and decolorization efficiency was 79.0% and 87.7%, respectively. In the first compartment, DHA ranged from 102.56 to 185.21 μgTF/(gVSS·h) with decrease of HRT. In addition, a peak concentration of coenzyme F₄₂₀ (0.411 μmol/g) was obtained in the fourth compartment. The SEM figures and FISH approach showed that different distributions of microbes thrived in the first to fourth compartment of the ABR reactor. These results suggested that the ABR system could separate acidogenesis and methanogenesis in spatial distribution and treat well the alkali-decrement wastewater.
Figure 5 | In situ hybridization diagram of granular sludge. (a) and (e) In situ hybridization composite diagram and dominant bacterium diagram of first compartment; (b) and (f) In situ hybridization composite diagram and dominant bacterium diagram of second compartment; (c) and (g) In situ hybridization composite diagram and dominant bacterium diagram of third compartment; (d) and (h) In situ hybridization composite diagram and dominant bacterium diagram of fourth compartment.
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