Treatment of domestic sewage in a combined UASB/RBC system. Process optimization for irrigation purposes


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Abstract A Rotating Biological Contactor (RBC) was fed with raw domestic wastewater or anaerobic effluents. The experiments were conducted at increasing operational temperatures viz. 11, 20 and 30°C to assess the potential increase in removal efficiencies for the different COD fractions (COD_{total}, COD_{suspended}, COD_{colloidal} and COD_{soluble}), E. coli and in the nitrification rate. The results clearly show that, the RBC at HRT of 2.5 h and OLR of 47 gCOD/m².d provided a very high residual COD_{total} value of 228 mg/l when treating domestic wastewater. This was not the case as compared to the results obtained for the system when operated at the same HRT but at lower OLR’s of 27, 20 and 14.5 g COD/m².d with a UASB effluent at operational temperatures of 11, 20 and 30°C respectively. The residual COD_{total} values amounted to 100, 85 and 72 mg/l in the final effluents. Moreover, a high removal of ammonia and low residual values of E. coli was found for the RBC when treating a UASB effluent at operational temperature of 30°C as compared to the situation for treatment of domestic wastewater and UASB effluent at lower temperatures of 11 and 20°C. It can be concluded that an efficient pre-treatment of sewage implies a substantial reduction of OLR applied to the RBC and consequently improves the residual of COD_{total}, ammonia and E. coli in the final effluent. Therefore, this study supports using a combined system UASB/RBC for treatment of domestic wastewater for reuse in irrigation.

Keywords COD; E. coli; nitrification; post-treatment; RBC; sewage; UASB

Introduction

In view of the rapidly growing shortage of renewable water resources in many parts of the world, there is a growing interest in the reuse of effluent from wastewater treatment plants. Besides possible industrial and urban reuse, treated wastewater can be reused in agriculture depending on local effluent requirements. For instance, Egyptian Environmental legal (law 48/82) required the following (BOD = 60 mg/l, COD = 80 mg/l, TSS = 50 mg/l and NO₃-N = 50 mg/l) for wastewater reuse in restricted irrigation. The often applied complete nitrification/denitrification process, which re-circulates potentially useful nitrogen via atmospheric N₂. This process proceeds at the expense of energy and financial input. This approach appears very inefficient from both an energy and resource utilization point of view. The nutrient rich effluent can be directly used for irrigation purposes especially in developing countries, where agriculture often is limited by water and nutrients. The crop choice and irrigation system to be applied will determine the necessity and extent of nutrient and pathogen removal. Several studies have shown that the crop yield is higher with treated wastewater irrigation as compared to freshwater irrigation (Gijzen and Veenstra, 2001). A major dilemma in this context is how to choose the most appropriate treatment technology to achieve optimal reuse of water and nutrients at minimal energy expense. Anaerobic treatment doesn’t require oxygen and therefore energy input and will yield energy in the form of CH₄ gas. Anaerobic treatment plants have limited space requirement and therefore can be planned at locations within or just outside the city. Besides the generation of energy, anaerobic treatment of wastewater may have additional benefits for re-use
oriented treatment schemes. The anaerobic conditions in the reactor may reduce the level of (toxic) metal compounds in the effluent due to the formation of insoluble metal-sulfides, which precipitate into the anaerobic sludge. As a result the potential danger of accumulating metals into the food chain via agricultural applications of the effluent may be significantly reduced.

Combined with a proper post-treatment, anaerobic treatment provides a sustainable and appropriate method for providing a good quality effluent from domestic sewage, not only for developing countries but also for advanced countries. It is being used successfully in tropical countries (Goncalves et al., 1999), and there are some encouraging results from subtropical and temperate regions (El-Gohary and Naser, 1999).

Effluents from anaerobic reactors cannot be used for restricted irrigation without proper post-treatment. Therefore post-treatment alternatives were researched. Recently, the use of many different biofilm systems for post-treatment have been reported, such as trickling filters (Augusto et al., 2000), fixed media submerged biofilters (Goncalves et al., 1998), granular media biofilters (Goncalves et al., 1999), fluidised bed reactors (Collivignarelli et al., 1990). Each system has its advantages and disadvantages. Based on the results of previous work carried out by Tawfik et al. (2002a) the RBC has been selected for this study. It is a relatively compact system with a sufficiently long biomass retention time, allowing the application of higher volumetric loading rates at low energy cost. Moreover the system is easy to operate at high process stability. Despite their enormous potentials, RBC so far is rarely used especially in developing countries for post-treatment of anaerobically pre-treated wastewater. This paper gives an evaluation of the applicability of a Rotating Biological Contactor (RBC) for post-treatment (polishing) of different anaerobic effluent qualities with emphasis on COD, ammonia and E. coli removal. Optimisation of the process conditions in the two subsequent reactors (UASB/RBC) for complying different reuse standards was evaluated.

**Materials and methods**

Five experiments were carried out by using a RBC system (Figure 1). The system was fed with different wastewaters e.g. raw sewage and effluents of a 6 m³ UASB pilot-plant at different operational temperatures of 11, 20 and 30°C, previously investigated by Grin et al. (1985) for treatment of domestic wastewater.

**UASB effluents**

The main characteristics of the domestic wastewater and UASB reactor effluents, i.e. the feed of the RBC system, are given in Table 1a.

**Pilot-plant**

The schematic diagram of the pilot-plant is shown in Figure 1. The RBC system with a
working capacity of 60 l is equipped with 10 polystyrene foam disks with a total effective surface area of 6.5 m² was used. The disk diameter was 0.6 m with a thickness of 0.02 m and the discs were spaced at 0.02 m distance and operated at 5 rpm. The submerged surface amounted to 40%. The disks were mounted on a steel shaft.

Operational conditions
The RBC system has been operated for 16 month under different conditions as shown in Table 1b. The first 30 days of operation were considered as a start-up period while the periods of 20 days were considered as acclimatisation periods to the new experiment.

Sampling and analytical methods
The performance of the reactor was monitored by analysing 48 hr composite samples (twice per week) of the influent and the effluent. The samples were collected in a fridge at 4°C. Dissolved oxygen; pH and temperature were measured regularly in situ. The COD was analysed using the micro-method as described by Jirka and Carter (1975). Raw samples were used for COD_total, 4.4 µm folded paper filtered (Schleicher and Schuell 595 1/2) samples for COD_filtrate and 0.45 µm membrane filtered (Schleicher and Schuell ME 25) samples for dissolved COD (COD soluble). The COD_suspended and COD_colloidal were calculated by the difference between COD_total and COD_filtrate, COD_filtrate and COD_soluble, respectively. Ammonia, nitrite and nitrate were determined on a stationary auto-analyser (SKALAR SA-9000) total Kjeldahl nitrogen according to the Dutch Standard Normalised Methods (1969) and E. coli according to the method described by Havelaar et al. (1988).

Results and discussion
Performance of an RBC at an OLR of 47 gCOD/m².d at a temperature of 17°C
(Reference experiment no. 1)
Treating raw domestic wastewater in an RBC, at an HRT of 2.5 h and at an OLR of 47 g CO/m².d⁻¹, provides low removal efficiencies, resulting in a relatively high residual COD_total, COD_suspended, COD_colloidal and COD_soluble (Table 2), not complying with any reuse standards. Similar results were achieved for the removal of ammonia and TKN viz. 8

<table>
<thead>
<tr>
<th>Exp. No.</th>
<th>Type of feeding wastewater</th>
<th>Operational period</th>
<th>T °C</th>
<th>HRT (h)</th>
<th>Flow rate (m³/d)</th>
<th>OLR (gCOD/m².d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Raw sewage</td>
<td>4 month</td>
<td>17</td>
<td>2.5</td>
<td>0.576</td>
<td>47</td>
</tr>
<tr>
<td>2nd</td>
<td>UASB effl. at T = 11°C.</td>
<td>3 month</td>
<td>13</td>
<td>2.5</td>
<td>0.576</td>
<td>27</td>
</tr>
<tr>
<td>3rd</td>
<td>UASB effl. at T = 11°C.</td>
<td>3 month</td>
<td>13</td>
<td>5</td>
<td>0.288</td>
<td>13</td>
</tr>
<tr>
<td>4th</td>
<td>UASB effl. at T = 20°C.</td>
<td>3 month</td>
<td>21</td>
<td>2.5</td>
<td>0.576</td>
<td>20</td>
</tr>
<tr>
<td>5th</td>
<td>UASB effl. at T = 30°C.</td>
<td>3 month</td>
<td>30</td>
<td>2.5</td>
<td>0.576</td>
<td>14.5</td>
</tr>
</tbody>
</table>

* The 1st experiment with raw sewage was considered as a reference

Table 1b Operational conditions of a RBC system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Experiment</th>
<th>Time of the year</th>
<th>COD (mg/l)</th>
<th>NH₃-N</th>
<th>TKN</th>
<th>E. coli /100ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sewage</td>
<td>1</td>
<td>4</td>
<td>527 ± 160</td>
<td>287 ± 147</td>
<td>91 ± 58</td>
<td>149 ± 22</td>
</tr>
<tr>
<td>UASB effl. (11°C)</td>
<td>2</td>
<td>6</td>
<td>276 ± 38</td>
<td>117 ± 16</td>
<td>58 ± 34</td>
<td>107 ± 59</td>
</tr>
<tr>
<td>UASB effl. (20°C)</td>
<td>3</td>
<td>4</td>
<td>225 ± 29</td>
<td>77 ± 27</td>
<td>74 ± 28</td>
<td>74 ± 15.3</td>
</tr>
<tr>
<td>UASB effl. (30°C)</td>
<td>4</td>
<td>4</td>
<td>164 ± 21</td>
<td>57 ± 11</td>
<td>28 ± 11</td>
<td>82 ± 22.0</td>
</tr>
</tbody>
</table>
and 16% respectively, mainly for assimilation of biomass. A minor nitrate concentration was produced. Also as expected 69% removal was achieved for *E. coli*. This low removal of *E. coli* is likely mainly due to the low removal of COD_{suspended} and COD_{colloidal} at the applied high loading and short HRT.

Performance of the RBC at an OLR of 27 and 13 gCOD/m².d and operational temperature of 13°C  
(2nd and 3rd experiment)

The RBC system treating 11°C-UASB effluent was investigated at an HRT of 2.5 and 5 h and an OLR of 27 and 13 g COD/m².d. The results in Table 3 show effluent qualities with respect to different COD fractions, at two different loading rates. Decreasing the HRT from 2.5 to 5 hours created the difference in OLR and resulted in a significant decrease in the effluent total COD value. The colloidal COD value hardly changed as a result of the increased HRT, but was low under both conditions.

The results presented also in Table 3 show that by decreasing the OLR from 27 to 13 g COD/m².d and increasing the HRT from 2.5 h to 5 h, the ammonia removal increased from 20 to 30%. However, the nitrification rate was very low, viz. respectively 0.15 and 0.18 g NO₃-N/m².d at the imposed loading rates. The produced nitrite plus nitrate were compared with the ammonia removal. About 31 and 38% of ammonia was nitrified, respectively.

The *E. coli* count was substantially reduced by $1.4 \times 10^5$/100 ml in an RBC by increasing the HRT from 2.5 to 5 h (Table 3). These results demonstrate clearly that the HRT affect seriously the removal of *E. coli* (Polprasert et al., 1983).

Performance of the RBC at an OLR of 20 gCOD/m².d and operational temperature of 21°C  
(4th experiment)

The RBC treating 20°C-UASB effluent was investigated at an HRT of 2.5 h and an OLR of 20 g COD/m².d. The results presented in Table 4 show that the system provided residual COD_{total} COD_{suspended} and COD_{colloidal} values of 85, 14 and 17 mg/l respectively. As the major part of the biodegradable COD_{soluble} was already removed in the UASB reactor at a process temperature of 20°C, as expected, little COD_{soluble} was removed in the RBC reactor.

The results presented in Table 4 show that the RBC achieved a removal efficiency of 18 (± 2.5)% for ammonia and 25% (± 3.9) for TKN. The nitrate produced amounted to only 1.5 mg/l (± 0.5). The achieved nitrification efficiency was very low at imposed OLR of

### Table 2  
Effluent characteristics of the RBC treating raw sewage and operated at an OLR of 47 gCOD/m².d and HRT of 2.5 h

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COD (mg/l)</th>
<th>Nitrogen (mg/l)</th>
<th>TKN /100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>527 ± 160</td>
<td>287 ± 147</td>
<td>91 ± 58</td>
</tr>
<tr>
<td>RBC eff.</td>
<td>228 ± 46</td>
<td>84 ± 34</td>
<td>60 ± 41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COD (mg/l)</th>
<th>Nitrogen (mg/l)</th>
<th><em>E. coli</em> /100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>287 ± 147</td>
<td>91 ± 58</td>
<td>8.5 ± 5.1 x 10⁶</td>
</tr>
<tr>
<td>RBC eff.</td>
<td>84 ± 34</td>
<td>60 ± 41</td>
<td>2.6 ± 1.4 x 10⁶</td>
</tr>
</tbody>
</table>

### Table 3  
Effluent characteristics of the RBC system treating UASB effluent and operated at OLR of 27 and 13 gCOD/m².d and HRT of 2.5 and 5 h

<table>
<thead>
<tr>
<th>Sample</th>
<th>HRT</th>
<th>OLR</th>
<th>COD (mg/l)</th>
<th>Soluble</th>
<th>NH₄</th>
<th>NO₂</th>
<th>NO₃</th>
<th>TKN /100ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>2.5</td>
<td>27</td>
<td>309 ± 46</td>
<td>85 ± 13</td>
<td>81 ± 14</td>
<td>148 ± 27</td>
<td>45 ± 13</td>
<td>50 ± 13</td>
</tr>
<tr>
<td>RBC eff.</td>
<td>2.5</td>
<td>27</td>
<td>100 ± 7</td>
<td>23 ± 8</td>
<td>14 ± 4</td>
<td>62 ± 8</td>
<td>36 ± 12</td>
<td>1.1 ± 1</td>
</tr>
<tr>
<td>Influent</td>
<td>5</td>
<td>13</td>
<td>291 ± 29</td>
<td>64 ± 22</td>
<td>79 ± 18</td>
<td>148 ± 43</td>
<td>48 ± 12</td>
<td>53 ± 7</td>
</tr>
<tr>
<td>RBC eff.</td>
<td>5</td>
<td>13</td>
<td>76 ± 21</td>
<td>16 ± 14</td>
<td>10 ± 5</td>
<td>50 ± 15</td>
<td>34 ± 17</td>
<td>1.5 ± 1</td>
</tr>
</tbody>
</table>

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20 gCOD/m².d, because of the inhibitory effect of heterotrophic cells. The growth of heterotrophs decreases the density of nitrifiers in the aerobic part of the biofilm at high OLR. From the results of the study carried out by Boller et al. (1987), using RBC’s operated at different OLRs, it was concluded that nitrification starts at an organic load of 15 g COD/m².d and was fully developed at about 8 g COD/m².d. According to Boongorsrang et al. (1982) for nitrification in a rotating disc contactor, the COD loading rate should even be less than 2.54 g COD/m².d. Based on these observations no nitrification could be expected for the applied conditions. The latter is confirmed by the results, as shown in Table 4.

The removal efficiency of *E. coli* varied from 58 to 97% with an average value of 81% (± 17.6) as shown in Table 4. The *E. coli* count in the final effluent amounted to $2.5 \times 10^5$/100 ml which is complying with standards for reuse in restricted irrigation. According to the results of the research work of Tawfik et al. (2002b), a 2nd and 3rd stage RBC is undoubtedly needed for complete removal of *E. coli*. In that case unrestricted agricultural reuse is allowed.

**Performance of the RBC at an OLR of 14.5 gCOD/m².d and operational temperature of 30°C**

(5th experiment)

The RBC system treating 30°C-UASB effluent was investigated at an HRT of 2.5 h and an OLR of 14.5 g COD/m².d. The COD\text{total}, COD\text{suspended}, COD\text{colloidal} and COD\text{soluble} removal at these conditions, are presented in Table 5. The results clearly reveal that the system achieved a substantial reduction of COD\text{total} resulting in an average effluent concentration of only 72 mg/l. The high removal efficiency of the UASB reactor at the high temperature implemented (30°C) positively affected the performance of the RBC. The system provided an almost complete removal of COD\text{colloidal} with only 5 ± 2.7 mg/l remaining in the final effluent (Table 5). This excellent performance towards the removal of colloidal matter can be attributed to entrapment or/and adsorption, followed by hydrolysis and degradation on the biofilm. The system achieved only 29% removal for COD\text{soluble} as almost all biodegradable COD\text{soluble} was already eliminated in the UASB reactor.

The RBC system exhibited not only excellent COD removal but also a considerably ammonia removal at temperatures of 26°C. The results presented in Table 5 reveal that about 43% ammonia was eliminated at an HRT of 2.5 h or OLR of 14.5 g COD\text{total}/m².d and temperature of 30°C. Nitrate and nitrite data reveal that 71% of the ammonia removed occurred through nitrification. The remaining portion of ammonia removed (5 mg/l) probably occurred as a result of adsorption. According to Temmink et al. (2001) ammonia

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COD (mg/l)</th>
<th>Nitrogen (mg/l)</th>
<th>E. coli (100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Sus.</td>
<td>Coll.</td>
<td>Sol.</td>
</tr>
<tr>
<td>Influent</td>
<td>225 ± 29</td>
<td>77 ± 27</td>
<td>74 ± 28</td>
</tr>
<tr>
<td>RBC eff.</td>
<td>85 ± 21</td>
<td>14 ± 14</td>
<td>17 ± 23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COD (mg/l)</th>
<th>Nitrogen (mg/l)</th>
<th>E. coli (100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Sus.</td>
<td>Coll.</td>
<td>Sol.</td>
</tr>
<tr>
<td>Influent</td>
<td>164 ± 20</td>
<td>50 ± 13</td>
<td>43 ± 11</td>
</tr>
<tr>
<td>RBC eff.</td>
<td>72 ± 17</td>
<td>16 ± 16</td>
<td>5 ± 3</td>
</tr>
</tbody>
</table>

Table 4  Effluent characteristics of the RBC treating UASB effluent (20°C) and operated at OLR of 20 gCOD/m².d and HRT of 2.5 h

Table 5  Effluent characteristics of the RBC treating UASB effluent (30°C) and operated at OLR of 14.5 gCOD/m².d and HRT of 2.5 h

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can be adsorbed in the biofilm. It is known that the biofilm consists mainly of bacterial cells and extracellular polymeric substances (EPS) which all have a negative surface charge. Consequently various cations, of mono-, di-, and trivalent can be bound, including ammonium.

The results presented in Table 5 show that the RBC achieved a substantial removal of *E. coli*, with values ranging from 89 to 96% (average value of 93.4 ± 2.6%). The *E. coli* count in the final effluent amounted to 1.2 × 10^5/100 ml, which means that according to prevailing WHO-standards (1989) the effluent only can be reused for restricted irrigation purposes. Further treatment is required for reuse in unrestricted irrigation purposes. According to the results of Tawfik *et al.* (2002b) a three stage RBC at an HRT of 10 h provided a residual value of 9.8 × 10^2 for *E. coli* which is complying with WHO (1989) standards (1,000 *E. coli*/100 ml) for reuse in unrestricted irrigation.

**General discussion**

For restricted irrigation in countries suffering from water shortage, like the case in the Middle East and North African region, the COD concentration in the treated wastewater to be reused is an important parameter. Additionally, the crop choice and irrigation system to be applied will determine the necessity and extent of nitrogen and pathogen removal.

The results of the investigation revealed that the RBC system at an HRT of 2.5 h and OLR of 47 gCOD/m^2.d provide a very high residual COD value of 228 mg/l when treating domestic wastewater. This was not the case as compared to the results obtained for the RBC system when operated at the same HRT but at lower OLR’s of 27, 20 and 14.5 gCOD/m^2.d with a UASB effluent at operational temperatures of 11, 20 and 30°C respectively. At OLR of 14.5 g COD/m^2.d, the RBC system provided a residual value of 72 mg/l for COD_{total} which didn’t significantly increase by increasing the OLR (20 gCOD/m^2.d) applied to the RBC system treating UASB effluent (T = 20°C). Whereas, the residual value of COD_{total} was significantly increased to 100 mg/l by increasing the OLR to 27 gCOD/m^2.d, when treating UASB effluent at low operational temperature of 11°C. Such a COD value in the latter case which is not complying for effluent reuse in restricted irrigation (COD<80 mg/l).

In order to improve the effluent quality, the HRT was prolonged to 5 h and OLR was decreased to 13 gCOD/m^2.d. The system achieved a residual value of 76 mg/l for COD_{total}. This indicates that the effect of the anaerobic pre-treatment step, therefore, is quite substantial, i.e. the required HRT of the RBC system treating UASB reactor effluent at operational temperatures of 30 and 20°C is 50% less than that of the system treating UASB reactor effluent at a temperature of 11°C. However, the results obtained by El-mitwalli *et al.* (2000) achieved a high effluent quality in an anaerobic filter followed by anaerobic hybrid at low temperature (13°C). The volume of the RBC as post-treatment can be declined.

The next question is whether or not it would be beneficial to introduce an efficient UASB prior RBC system in case nitrification is needed and high *E. coli* removal efficiency needs to be accomplished. The results obtained revealed that the nitrification rate in the RBC system treating UASB effluent (T = 30 C) at an OLR of 14.5 gCOD/m^2.d is significantly higher than that of the system treating domestic wastewater, anaerobic effluents at operational temperatures of 20 and 11 at OLR of 47, 27 and 20 gCOD/m^2.d, respectively. The nitrification rate amounted to 0.97 gNO_3-N/m^2.d, while it was only 0.2 in the latter cases. This can be attributed to a higher COD particulate concentration (COD_{suspended} and COD_{colloidal}) in the domestic wastewater and UASB effluent (t = 11, 20°C) by 40 and 76% respectively. This negatively affects the nitrification rate due to its entrapment in the biofilm, diluting the fraction of nitrifying organisms in the biofilm and consuming part of the oxygen which otherwise would have been available for the nitrifiers (Temmink *et al.*, 2001). Despite the RBC system treating UASB effluent (t = 11°C) being operated at HRT of
5 h and OLR of 13 gCOD/m².d, the nitrification rate was still lower than that obtained at OLR of 14.5 gCOD/m².d and HRT of 2.5 h by 0.8 gNO₃-N/m².d. This can be due to the higher operational temperatures of the RBC treating UASB effluent (t = 30°C). Boller et al. (1987) found that the nitrification rate increases by about 4.5% per 1°C in the RBC system which can also be shown theoretically from biofilm kinetics (Nowak et al., 1998).

It is not surprising to achieve a high E. coli removal efficiency of 94% in the RBC system treating UASB effluent (30°C) as compared to that obtained for treatment of domestic sewage, and anaerobic effluents at operational temperatures of 20°C and 11°C which amounted to 69, 86 and 81% respectively. Once again this is due to a higher removal of COD particulate in the preceding UASB reactor at high operational temperature.

Conclusions
The use of a combined UASB-RBC system for treatment of domestic wastewater is suitable to achieve the required effluent quality complying for reuse in irrigation for different climate areas i.e.

- For tropical areas, with average sewage temperatures (22–30°C), anaerobic pre-treatment proceeds efficiently, provided the system is well designed. The results obtained in this study with high quality anaerobic effluent using the RBC-system revealed that an RBC is recommended for achieving a low COD<sub>total</sub> (72 mg/l) and for partial ammonia and partial E. coli removal at an imposed OLR of 14.5 gCOD/m².d and HRT of 2.5 h.
- In subtropical areas (average winter time wastewater temperature > 10°C and summer time wastewater temperatures > 20°C with an UASB effluent COD of 200 mg/l, the required HRT for the RBC system should be >2.5 h and the OLR should not exceed 20 g COD<sub>total</sub>/m².d in order to achieve a residual COD value of 85 mg/l.
- In moderate climate areas (average sewage temperature can occasionally (a few days) drop down to values as low as 4°C in winter while they can raise to 20°C in the summer. The performance of conventional UASB reactors will be rather poor during wintertime. The results of our investigations with a poor quality anaerobic effluent revealed that, the required HRT for RBC should be prolonged to 5 h and the imposed OLR reduced to values below 13 gCOD/m².d in order to achieve a residual effluent COD value of 76 mg/l. The RBC can be operated in different ways, i.e. during summer time with temperatures around 20°C and better UASB effluent quality, the RBC can be operated at higher OLR and lower HRT.

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References


