Available online at www.sciencedirect.com
ScienceDirect
Journal of Hazardous Materials 150 (2008) 185–186
Journal of Hazardous Materials
www.elsevier.com/locate/jhazmat

Discussion

Is hydraulic retention time an essential parameter for MBR performance?

Aline F. Viero, Geraldo L. Sant'Anna Jr. *

Chemical Engineering Program, COPPE/Federal University of Rio de Janeiro, P.O. Box 68502, CEP 21941-972, Rio de Janeiro, Brazil

Received 23 August 2007; received in revised form 21 September 2007; accepted 21 September 2007
Available online 29 September 2007

Abstract

The effect of hydraulic retention time (HRT) on membrane bioreactors (MBR) operation is discussed. A brief literature review on this topic indicates that biased conclusions can be drawn if data is obtained under non steady-state conditions.

Another relevant aspect regarding steady-state operation includes activated sludge adaptation to bioreactor running conditions. In addition, wastewater components also have influence on steady-state achievement and MBR performance.

Keywords: Membrane bioreactor; Hydraulic retention time; Steady-state operation; Wastewater treatment

It is widely known that the organic load, expressed as F/M (food to microorganism ratio), is a key parameter for design and operation of the activated sludge process. The hydraulic retention time (HRT) is intrinsically associated with that parameter and is directly related to the reactor volume and the operational costs. In this discussion, we present a brief review of the literature concerning factors affecting membrane bioreactors (MBR) performance, mainly, hydraulic residence time and steady-state operation conditions.

MBR systems are able to completely retain biomass and operate with high volatile suspended solids (VSS) concentrations. Although these systems may operate with a broad range of F/M values, there is a tendency to run such reactors with moderate values, in order to maintain biomass content under tight control. Thus, in this context the relevance of the parameter HRT is even increased.

The treatment of industrial wastewaters in MBR systems may present some challenges, since some pollutants are slowly biodegraded. This fact highlights the relevance of HRT on MBR performance.

Organic matter removal efficiency in MBR is also likely associated with the sludge retention time (SRT). This occurs because the mixed liquor tends to present reductions in its soluble microbial products (SMP) concentrations with the increase of SRT [1,2]. However, long SRT can only be achieved by using low F/M ratios. Regarding industrial wastewater treatment, there is no consensus in the literature concerning the recommended SRT operation range. The choice of SRT is dependent on the nature and recalcitrance of the wastewater compounds.

Best results regarding organic matter removal efficiency are generally obtained in steady-state operation, which means after two or three times the SRT [3]. This statement was made for conventional activated sludge processes, which operate with SRT (7 days) much lower than the ones used for MBR systems.

Another practical criterion to define MBR steady-state operation, when the run is carried out with a high SRT (>50 days), is the stabilization of VSS concentration after a few days of operation under the same conditions. The stabilization of VSS content is a consequence of the selected F/M and HRT.

It is important to notice that HRT must be established as a balance between cost and removal efficiency. If a process requires very long HRT to produce the desired removal efficiency, a completely different treatment process might be proposed.

During the operation of a vertical submerged membrane bioreactor, with SRT of 60 days, Chae et al. [4] suggested that HRT is a key parameter to reduce membrane fouling. The authors reported that reduction of HRT, from 10 to 4 h, promoted a decline in sludge settleability, caused by the increase of extracellular polymeric substances (EPS) and average particle size. Hence, membrane resistance increased. Regarding membrane processes, it is generally observed that the increase of membrane resistance produces a higher retention of solutes and, conse-

* Corresponding author. Tel.: +55 21 2562 8342; fax: +55 21 2562 8300.
E-mail address: lippel@peq.coppe.ufrj.br (G.L. Sant'Anna Jr.).

0304-3894/$ – see front matter
doi:10.1016/j.jhazmat.2007.09.090

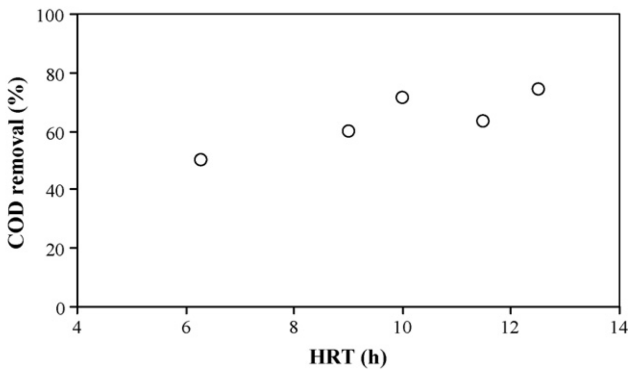

Fig. 1. Effect of HRT on COD removal in a SMBR treating petroleum refinery wastewater. All experiments were performed without sludge withdrawal.

quently, better removal efficiencies can be expected, despite flux reduction.

An important aspect to analyze the effect of operation parameters, mainly HRT, on MBR performance is to assure that the system is being operated under steady-state conditions. It is widely accepted in chemical reaction engineering that data used to calculate the conversion or the reaction yield should be collected after a period higher than three hydraulic retention times. Unfortunately, this experimental procedure has not been considered by some authors, who operated their reactors for short periods of time disregarding this classical recommendation. Rahman and Al-Malack [5] operated a MBR with an industrial wastewater and concluded that COD removal efficiency was not affected by HRT in the range studied (17–34 h). However, such conclusion was based on the results of experiments carried out for periods of time lower than three residence times. As mentioned, it is important to reach the steady-state conditions in order to formulate sound conclusions.

Working with a synthetic wastewater containing easily biodegradable compounds, we observed that HRT did not influence COD removal efficiency, as reported before [6]. When the same MBR system was used to treat a complex industrial wastewater (petroleum refinery), even small variation on HRT affected the removal efficiency, as shown in Fig. 1. In addition, the increase on HRT favored the occurrence of nitrification. Our experience indicates that the treatment of complex wastewaters, containing slowly biodegradable compounds and appreciable ammonia concentration (>100 mg/L), requires high HRT values for MBR operation for obtaining high removal efficiencies of COD and nitrification.

The effect of HRT on the conventional activated sludge treatment (CAS), applied to a synthetic wastewater, containing a highly persistent compound, was investigated by Kargi and Konya [7]. In their experiments, the influence of HRT, ranging from 5 to 30 h, on process performance was evaluated after reaching steady-state conditions, which took about 2–3 weeks per experiment. It is worth notice that SRT was 10 days, in those experiments. Steady-state operation was reached, according to their criteria, after obtaining stable values of effluent COD and pollutant concentrations during 3 days of operation. The authors found that the increase in HRT up to 15 h enhanced COD and pollutant removal efficiencies and that these parameters remained almost constant, while operating with HRT above 15 h. Although this work was conducted with CAS, we think that the authors' conclusions can be extended for MBR applications.

Qin et al. [8] operated a MBR system, with SRT of 25 days, to treat a petrochemical wastewater and investigated the effect of HRT (13, 16, and 19 h) on effluent quality. They observed that the intermediate HRT led to the worst result, which was attributed to the short-term operation under such condition (1 week). In addition, the authors supposed that the seed was acclimated to the wastewater, but sludge adaptation was not performed in the laboratory. Probably, sludge adaptation to the new operation conditions associated to recalcitrance of compounds present in the wastewater affected their conclusions, since one week is a short period to reach steady-state regime.

In the work of Ren et al. [9], the effects of HRT (1–3 h) were evaluated only after 32 days of operation during the treatment of a synthetic domestic sewage in a submerged membrane bioreactor. In these experiments, certainly the results were obtained under steady-state conditions. The influence of HRT was clearly observed when this parameter changed from 2 to 1 h.

Finally, it is important to highlight that, only when MBR are really operated under steady-state conditions, sound conclusions can be drawn about the reactor performance. Achievement of steady-state does not depend only on the extent of the operation time but also on adaptation of sludge to the wastewater components under the assay conditions. Industrial wastewaters generally require higher hydraulic retention times for degradation of complex compounds and, hence, longer biomass adaptation periods are necessary.

References

[1] A. Massé, M. Spérandio, C. Cabassud, Comparison of sludge characteristics and performance of a submerged membrane bioreactor and an activated sludge process with high solids retention time, Water Res. 40 (2006) 2405–2415.

[2] P. Le Clech, V. Chen, T.A.G. Fane, Fouling in membrane bioreactors used in wastewater treatment, J. Membr. Sci. 284 (2006) 17–53.

[3] A. Barrios-Martinez, E. Barbot, B. Marrot, P. Moulin, N. Roche, Degradation of synthetic phenol-containing wastewaters by MBR, J. Membr. Sci. 281 (1–2) (2006) 288–296.

[4] S.-R. Chae, Y.-T. Ahn, S.-T. Kang, H.-S. Shin, Mitigated membrane fouling in a vertical submerged membrane bioreactor (VSMBR), J. Membr. Sci. 280 (2006) 572–581.

[5] M.M. Rahman, M.H. Al-Malack, Performance of a crossflow membrane bioreactor (CF-MBR) when treating refinery wastewater, Desalination 191 (2006) 16–26.

[6] A.F. Viero, G.L. Sant'Anna, R. Nobrega Jr., The use of polyetherimide hollow fibres in a submerged membrane bioreactor operating with air backwashing, J. Membr. Sci. 302 (1–2) (2007) 127–135.

[7] F. Kargi, I. Konya, Para-chlorophenol containing synthetic wastewater treatment in an activated sludge unit: effects of hydraulic resistance time, J. Environ. Manage. 84 (2007) 20–26.

[8] J.-J. Qin, M.H. Oo, G. Tao, K.A. Kekre, Feasibility study on petrochemical wastewater treatment and reuse using submerged MBR, J. Membr. Sci. 293 (2007) 161–166.

[9] N. Ren, Z. Chen, A. Wang, D. Hu, Removal of organic pollutants and analysis of MLSS-COD removal relationship at different HRTs in a submerged membrane bioreactor, Int. Biodeterior. Biodegrad. 55 (2005) 279–284.