Scientific Bulletin. Series F. Biotechnologies, Vol. XX, 2016
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

SHORT TERM EXPERIMENTS ON SYNTHETIC WASTE WATER TREATMENT IN LABORATORY ACTIVATED SLUDGE SEQUENCING BATCH REACTOR

Mirela C. IORDAN[1,2], Ioan I. ARDELEAN[1]

[1]Institute of Biology, Romanian Academy, 296 Splaiul Independenţei, Bucharest, Romania
[2] S.C. RAJA S.A. Călăraşi 22-24 Constanţa, Romania

Corresponding author email: mirela.iordan@yahoo.com; ioan.ardelean@ibiol.com

Abstract

This paper presents the short term (5 hours) evolution of ammonium, nitrite, nitrate, total phosphorus and COD of a synthetic wastewater treated in a laboratory activated sludge sequencing batch reactor. In the experiment with 4.33 g/L activated sludge and the initial raport COD:N:P of 154:5.3:1 in about 4 hours 31% of COD and 83% of ammonium were removed, whereas nitrate shows an increase of 89%. In the experiment with 4.71 g/L activated sludge and the initial raport COD:N:P of 195:3.22:1 in about 4.5 hours 26% of COD and 92% of ammonium were removed, whereas nitrate shows an increase of 85%. In the experiment with 4.34 g/L activated sludge and the initial raport COD:N:P of 103:4.45:1 in about 4.5 hours 30% of COD and 48% of ammonium were removed, whereas nitrate shows an increase of 65%.

***Key words**:synthetic waste water, activated sludge, sequencing batch reactor.*

INTRODUCTION

Wastewater treatment is essentially based on biological treatment using activated sludge, either in suspension or immobilized, containing prokaryotes (archaea and bacteria), eukaryote microorganisms as well some metazoa: nematodes, rotifers, copepods (Ardern and Lockett,1923; Grady and Lim, 1980 Vaicum, 1981;Negulescu, 1985; Arceivala, 1988; Bitton, 1999; Zarnea, 1994; Cheremisino, 2002; Burton and Stensel, 2003; Godeanu 2015). The activated sludge process is based on microorganisms which can use as nutrients organic and inorganic substances that are true contaminants in wastewater. The microorganisms thus growth and multiply, basically converting soluble chemicals (the pollutants) to particulate matter, microbial cells clumping together, thus increasing the biomass of activated sludge. These aggregates of microorganisms are in the form of flocs which can settle to the bottom of the tank, ideally, leaving an outlet water which should be relatively clear liquid free of organic material and suspended solids. .

The Sequencing Batch Reactor (SBR) is an activated sludge process designed to operate under non-steady state conditions. An SBR operates in a true batch mode with aeration and sludge settlement both occurring in the same tank. The major differences between SBR and conventional continuous-flow, activated sludge system is that the SBR tank carries out the functions of equalization aeration and sedimentation in a time sequence rather than in the conventional space sequence of continuous-flow systems (Norcross, 1992; Chambers, 1993; Larrea et al, 2007, Narcis et al., 2014). Furthermore, the SBR system can have the possibility to be functional to treat a wide range of influent volumes whereas the continuous system is based upon a fixed influent input. However, the appropriate function of a SBR deserves that the influent wastewater is admitted into the aeration in a controlled manner, an appropriately designed SBR process being a unique combination of equipment and software and skilled operators (Arora et al., 1985; Norcross, 1992; Chambers, 1993; Narcis et al., 2014). A balanced nutrient ratio is essential if the microorganism are to function at maximum efficiency during wastewater treatment. The most important of these nutrients are carbon, nitrogen and phosphorus. Microorganisms involved in the removal of carbonaceous contaminants from wastewater require nitrogen and phosphorus for growth and multiplication. Microorganisms require nitrogen to form proteins, cell wall components and nucleic acids (Maier, 1999). It is usually stated that the ratio of COD:N:P in the wastewater to be treated should be aproximately 100:5:1 for aerobic treatment and 250:5:1 for anaerobic treatment (Metcalf and Eddy, 1991). Unfavourable nutrient ratio and high concentration of individual substances reduce the degradation efficiency of biological wastewater treatment proceses. Early recognition and continuous monitoring of critical parameters is therefore essential in order to enable plant operators to take rapid corective action when necessary. The aim of this paper is monitor the evolution of ammonium, nitrite, nitrate, total phosphorus and COD of the synthetic wastewater treated in a laboratory activated sludge in sequencing batch reactor.

MATERIALS AND METHODS

The sequencing batch reactor used in this study had an active volume of 2 L. The activated sludge comes from the wastewater treatment plant Constanta Nord. The activated sludge used has been taken from the discharge from the end of the aerobic bioreactor (Vazquez et al., 2003) in each experiment, 2 L of activated sludge was filtered through a filter paper (Filter Discs Grade 388 Munktell – Ahlstrom). The dry mass of activated sludge was measured according to ~~stass~~ SR EN 12880. For the experiment 1 the concentration of activated sludge, dry mass was of 4.33 g/L, for the experiment 2 concentration of activated sludge, dry mass was 4.71 g/L and for the experiment 3 the concentration was 4.34 g/L. In the sequencing batch reactor together with the activated sludge was introduced the synthetic sewage composed of: 1.24 g glucose, 64 mL standardised solution of ammonium 1000 mg/mL NH_4^+ (2,97g NH_4Cl / L H_2O) and 31.5 mL standardised solution of phosphorus 1000 mg/ml (KH_2PO_4 998g/l H_2O). The activated sludge together with the synthetic sewage were the subject of sequences of aeration and mixing both simultaneously and successively. The duration of both aeration and mixing was 60 minutes whereas the mixing time (in the absence of aeration) was 30 minutes. The duration of this experiment was 4.5 h, during which samples were taken as follows: initially – T_0 (after mixing the activated sludge with the synthetic sewage); after 1 hour of aeration and simultaneous mixing – T_1; after 1 hour aeration and mixing, and 30 minutes just mixing – T_2; after 2 hours aeration and mixing and 30 minutes just mixing – T_3; after 2 hours aeration and mixing and 60 minutes just mixing – T_4 ; after 3 hours aeration and mixing and 1 hour just mixing – T_5; after 3 hours aeration and mixing and 1.5 hour just mixing – T_6. For experiments 1 and 2 the samples were filtered through the filter of 0,45 mm type LCW 916, Hach Lange, and were made the following determinations: ammonium, nitrate, total phosphorus, chemical oxygen demand. For the experiment 3 samples were filtered twice - first through the filter type Filter Discs Grade 388 (Munktell - Ahlstrom) then through the filter of 0,45 mm filter type LCW 916, Hach Lange. The determinations were made on the Hach Lange kits: for nitrat was used LCK 339 1-60 mg/L NO_3, for nitrit was used LCK 541 0.005 – 0.10 mg/L NO_2 and LCK 342 2-60 mg/L NO_2, for ammonium was used LCK 303 2,5-60 mg/L NH_4, for total phosphorus LCK 349 0,15 – 4,50 mg/L PO_4 and LCK 350 6-60 mg/L PO_4 , for COD was used LCK 514 100-2000 mg/L O_2.

RESULTS AND DISCUSSIONS

In figure 1 there are presented the time evolution of ammonium, nitrite, nitrate and total phosphorus concentrantions of the synthetic wastewater during the first experiment. In the first experiment with an initial raport to the COD:N:P 154:5.3:1, with about 50% more COD than ideal ratio presented in literature, obtaining an efficiency of 31% for COD removal (figure 4) and 39% for nitrogen, showing the steps of nitrification/ denitrification (aeration/mixing) very well on the parameter to be analyzed - nitrate ($T_{1,3,5}$ times showing stages of aeration). It is observed a reduction of 21.95 mg/L for ammonium within 4 hours, the efficiency of removal of 83% compared with the nitrate which registers an increase of 37.79 mg/L in the range of 4 hours, this fact is due to intense nitrification. In this experiment the concentration of activated sludge used was 4.33 g/L, in which the mineral part represented 33.4% and volatile part represented 66.6%, with a sedimentation of 367 mL, and an Mohlmann index of 85 mg/gf.

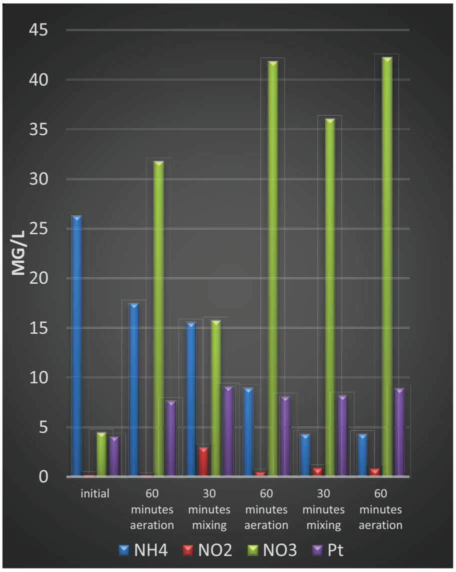

Figure 1 - Time evolution of ammonium, nitrate, nitrit and total phosphorus concentration during the first experiment

In figure 2 there are presented the time evolution of ammonium, nitrite, nitrate and total phosphorus concentrantions of the synthetic wastewater during the second experiment. In the second experiment with an initial raport to the COD:N:P of 195:3.22:1, with about 100% more COD than ideal ratio presented in literature, obtaining an efficiency of 26% for COD removal (figure 4) and 72% for nitrogen, showing the steps of nitrification/ denitrification (aeration/ mixing) very well on the parameter to be analyzed - nitrate ($T_{1,3,5}$ times showing stages of aeration). It is observed a reduction of 23.14 mg/L for ammonium within 4.5 hours, the efficiency of removal of 92% compared with the nitrate which registers an increase of 10.36 mg/L in the range of 4.5 hours, this fact is due to intense nitrification. In this experiment the concentration of activated sludge used was 4.71 g/L, in which the mineral part represented 32.3% and volatile part represented 67.7%, with a sedimentation of 400 mL, and an Mohlmann index of 85 mg / gf.

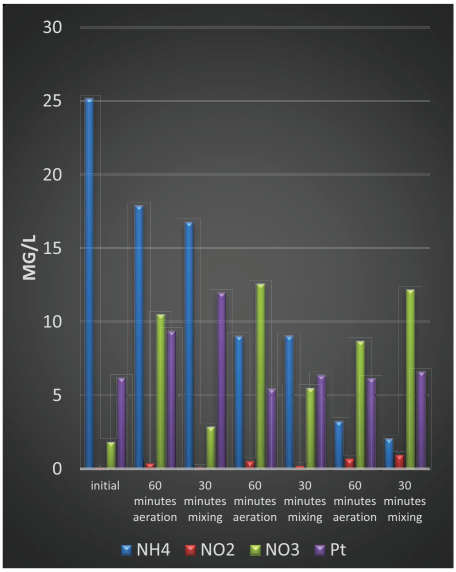

Figure 2 - Time evolution of ammonium, nitrate, nitrit and total phosphorus concentration during the second experiment

In figure 3 there are presented the time evolution of ammonium, nitrite, nitrate, total phosphorus of the synthetic wastewater during the third type of experiment.

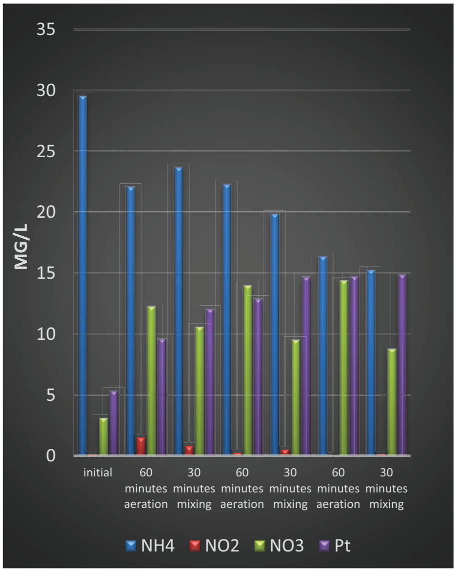

Figure 3 - Time evolution of ammonium, nitrate, nitrit and total phosphorus concentration during the third experiment

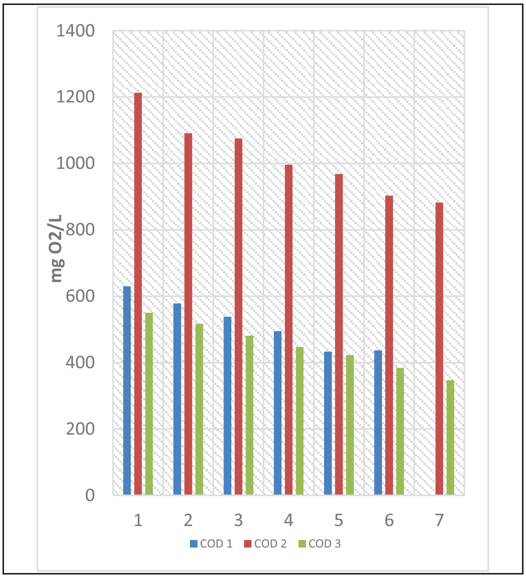

Figure 4 - The decrease in chemical oxygen demand in experiment 1 (COD1), experiment 2 (COD2) and experiment 3 (COD3)

In the third experiment with an initial raport to the COD:N:P of 103:4.45:1, aproximatly ideal ratio presented in literature, obtaining an efficiency of 30% for COD removal (figure 4) and 42% for nitrogen, showing the steps of nitrification/ denitrification (aeration/ mixing) very well on the parameter to be analyzed - nitrate ($T_{1,3,5}$ times showing stages of aeration). It is observed a reduction of 14.30 mg/L for ammonium within 4.5 hours, the efficiency of removal of 48% compared with the nitrate which registers an increase of 5.64 mg/L in the range of 4.5 hours, this fact is due to intense nitrification. In this experiment the concentration of activated sludge used was 4.34 g/L, in which the mineral part represented 31.8% and volatile part represented 68.2%, with a sedimentation of 410 mL, and an Mohlmann index of 95 mg / gf. In figure 4 there are presented the time evolution of COD of the synthetic wastewater during the three experiments.

CONCLUSIONS

a) In the experiment with 4.33 g/L activated sludge and the initial raport COD:N:P of 154:5.3:1 in about 4 hours 31% of COD and 83% of ammonium were removed, whereas nitrate which shows an increase of 89%.

b) In the experiment with 4.71 g/L activated sludge and the initial raport COD:N:P of 195:3.22:1 in about 4.5 hours 26% of COD and 92% of ammonium were removed, whereas nitrate which shows an increase of 85%.

c) In the experiment with 4.34 g/L activated sludge and the initial raport COD:N:P of 103:4.45:1 in about 4.5 hours 30% of COD and 48% of ammonium were removed, whereas nitrate shows an increase of 65%.

PERSPECTIVES

A) The use of immobilized activated sludge for easier physical separation between biological catalysts and (synthetic) waste water as well as for other advantages of immobilization;

B) Deeper caractrization of the activated sludge, mainly with respect to structural (flocs dimentions and structure) and functional traits (the rate of metabolic electron transport such as aerobic respiration, denitrification and resazurine reduction);

C) The selection and improvement of appropriate microbial populations to be used as starter cultures in futher experiments concerning (synthetic) waste water treatment in (laboratory) activated sludge sequencing batch reactor useful for the removal not only of wastes containing C and N but also of P.

AKNOWLEDGEMENTS

Thanks are due to Mr. Felix STROE (General Manager at S.C. RAJA S.A.), Mr. Aurel PRESURA (Deputy General Manager at S.C. RAJA S.A.), Mr. Nicolae JIANU (Head of Wastewater Laboratory at S.C. RAJA S.A.) and Roxana MANEA (Head of Wastewater Department) for kind professional support to MCI. I.I.A work was supported by Romanian Academy (Grant RO1567-IBB05/2015).

REFERENCES

Arceivala J.S., 1988. Wastewater treatment for pollution control, 2nd Ed. Tata McGraw-Hill Publishing Co., New Delhi

Ardern E., Lockett W.T., 1923. Activated Sludge Process. Withington Works. J. Soc. Chem. Ind. 225-230

Arora M.L., Edwin F. Barth and Margaret B., 1985. Umphres Journal (Water Pollution Control Federation), Vol. 57(8), pp. 867-875

Barsan Narcis, Joita Ion, Stanila Marius, Radu Cristian, Dascalu Mihaela, 2014. Modelling wastewater treatment process in a small plant using a sequencing batch reactor (SBR). Environmental Engineering & Management Journal (EEMJ), Vol. 13(7), pp. 1561-1566

Bitton G., 1999. Wastewater Microbiology. Wiley-Liss, New York.

Burton G., Stensel F.L., 2003. Engineering, Treatment, Disposal and Reuse. Tata McGraw-Hill Publishing Company, New Delhi, India

Chambers, B., 1993. Batch Operated Activated Sludge Plant for Production of High Effluent Quality at Small Works. Water Science and Technology, vol. 28(10)

Cheremisino N.P., 2002. Handbook of water and wastewater treatment technologies. Butterworth-Heinemann, Boston

Godeanu S. P., 2015. Biological wastewater treatment. ISBN:978-606-764-002-1, Bucharest

Grady C.P.L., Lim H.C., 1980. Biological Waste Treatment: Theory and Applications

Larrea L, Albizuri J, Irizar I, Hernández JM., 2007 Design and operation of SBR processes for small plants based on simulations.

Maier RM, 1999. Enviromental Microbiology Biochemical Cycling, Chapter 14. In: Maier RM, Pepper IL, Gerba CP (eds.). Academic Press, pp. 319-346

Metcalf & Eddy, Inc., 1991. Wastewater Engineering, Treatment, Disposal and Reuse, third edition, McGraw-Hill, Inc., New York

Negulescu M., 1985. Municipal waste water treatment. Ed.Elsevier, Amsterdam, Oxford, New-York, Tokio

Norcross K.L., 1992. Sequencing Batch Reactors-An Overview. Water Science and Technology, vol. 26(9-11)

Vaicum L.M., 1981. Waste Water Purification with Activated Sludge. Biochemical Bases Publishing House of the Academy of RS Romania (in Romanian)

Vazquez-Rodriguez G., Goma G. and J. L. Rols, 2003. Activated sludge as inoculum for ready biodegradability testing: Effect of source. Environmental Technology, 24(8):979-987

Zarnea G., 1994. Treatise of General microbiology. Romanian Academy Press, Vol. V, pp. 1002-1036 (in Romanian)

SR EN 12880 Determinarea reziduului uscat si a continutului din namoluri.