© 2015 IJSRSET | Volume 1 | Issue 2 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Modeling of Biological Wastewater Treatment Facilities: A Review

Sunil J. Kulkarni[*1], Sonali R. Dhokpande[2], Dr. Jayant P. Kaware[3]
[*1,2]Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India
[3]Bhonsala College of Engineering and Research, Akola, Maharashtra, India

ABSTRACT

Wastewater treatment is major research area in the modern era of industrialization and growing awareness about the sustainable growth. The biological treatment facilities are used in treatment plants for domestic and industrial waste water. Various biological treatments include suspended growth processes like activated sludge process and attached growth techniques like trickling filters. The modeling of these treatment facilities is important. It can be used to relate experimental data for developing the pilot and actual plant. By using the modeling technique, important parameter values can be related for experimental data and can be scaled up. The present review summarizes the modeling for biological treatment facilities.

Keywords: Effluent, parameters, suspended growth, attached growth.

I. INTRODUCTION

Wastewater treatment for removal of various metals, organic matters and other contaminants includes physical, chemical and biological treatment techniques [1, 2, 3]. Adsorption and ion exchange are very important treatment methods. Methods like membrane separation, electro coagulation and flocculation can be used effectively for water treatment for removal of various pollutants [4,5,6]. Biological treatments of wastewater for removal of organic matter are widely studied treatment techniques. Biological wastewater treatments for removal of heavy metals have been reported[7,8,9,10,11]. Modeling of the treatment plants is very important aspect of the treatment methods. The present review aims at summarizing the research on modeling of biological treatment facilities.

II. RESEARCH ON MODELING OF BIOLOGICAL TREATMENT FACILITIES

Carsky and Mbhele carried out kinetic modeling of copper biosorption using marine algae [12].Contact time of 3 hours was enough for equilibrium. According to them copper biosorption was function many parameters like type of biomass (number and kind of biosorption sites), size and form of biomass, physiological state of biomass (active or inactive, free or immobilized), as well as the metal involved in the biosorption system. According to their kinetic modeling, biosorption was divided into two stages: one in which the sorption rate is very high (60% of biomass saturation capacity in a contact time of 25 minutes), followed by a second stage with a much lower sorption rate. Hasan et.al reviewed the design criteria for the design criteria of biological aerated filter (BAF) for COD, ammonia and manganese removal in drinking water treatment [13].They plotted two correlations 1. COD removal efficiencies against the H/D ratio and 2. H/D ratio against BAF height. They observed the expected removal efficiency of COD and ammonia. It was within 80-90%. Masic carried out investigation on a biofilm reactor model with suspended biomass [14]. He presented a one dimensional mathematical model of biofilm and suspended biomass in a continuous stirred tank reactor. The model they referred to was hybrid of chemo-stat like mass balances for the substrate and biomass in the reactor. It was coupled with a free boundary value problem for the substrate in the biofilm. According to the numerical simulations, biofilm dominated over suspended biomass in the long-term reactor performance. He extended this model to two-step nitrification in a moving bed biofilm reactor (MBBR). Eftaxias carried out research on kinetics and reactor modeling on catalytic wet air oxidation of phenol in a trickle bed reactor [15].According to the investigation, the trickle bed model was able to match experimental results obtained in the laboratory reactor. He identified the internal diffusion coefficients and the gas-solid mass transfer coefficient as most influential parameters. He concluded that that for catalytic wet air oxidation of phenol, trickle bed reactor model can be safely used for scale up. Khataee and Kasiri carried out studies on modeling of biological water and wastewater treatment processes using artificial neural networks [16].They studied the applicability of the artificial neural networks (ANNs) to predict the performance of the biological systems. They also reviewed examples of early applications of ANNs in modeling and simulation of biological water and wastewater treatment processes in the presence of various microalgae, bacteria, microbes, yeasts, anaerobic sludge, aerated submerged biofilms, and submerged membrane bioreactors. Wik carried out work aimed at the dynamic modeling of biofilms and fixed biofilm reactors [17].His emphasis was on nitrifying trickling filters (NTFs) for the treatment of wastewater. According to him it was possible to model large number of biofilm reactors by unit called continuously stirred biofilm reactors (CSBR). He carried out simulation of operating parameters which indicated that the nitrifying capacity can be improved by regularly inversing the order of cascaded NTFs and by varying the individual flow through NTFs operating in parallel. Chaudhary et.al. Carried out investigation on biofilter in water and wastewater treatment [18]. According to these studies, the most important parameter which governs this process is the biomass attached to the medium. They also discussed the relative merits of different methods adopted in the measurement of the biomass. According to their conclusion, the mathematical model should incorporate the biofilter parameters estimated for different operating conditions (such as acclimatization filtration rate and initial organic concentration) to verify the adaptability of the model in practice. Chen and Stenstrom presented use of the rotating biological contactor for appropriate technology wastewater treatment[19].They used the mathematical model which included the material balances on both oxygen and substrate in the biofilm and bulk solutions. It resulted in non-Linear, parabolic partial differential equations. Dutta presented a mathematical modeling of the performance of a rotating biological contactor for process optimisation in wastewater treatment [20]. In his work, he tried to frame mathematical models for the process in simple and realistic ways. He used the principles of one-dimensional mass transfer and transport of substances. Oxygen obviously was one of the most influential parameters in the aerobic processes. The model indicated that with the increase of the substrate or hydraulic loading rate, the RBC shows increasing removal rates within an optimal range. Yang et.al. Presented water network optimization with wastewater regeneration models [21]. His work described a unifying approach combining various technologies capable of removing all the major types of contaminants through the use of more realistic models. They carried out some modifications in typical superstructure-based water network models for improving them. They presented a modified Lagrangean based decomposition algorithm in order to solve the resulting non convex mixed-integer nonlinear programming (MINLP) problem efficiently. Drakides and Lay-Son worked on biological treatment of toxic industrial wastewaters[22]. From pilot plant studies they obtained key parameters needed for the degradation of high concentrations of cyanides, thiocyanates and ammonia. The parameters from pilot plant studies were used in kinetic models. They built a conceptual hydraulic model of the biological waste water treatment plant(BWWTP) using a specific software. According to these studies, the models using field data gave a close fit between simulated outlet concentrations and field outlet concentrations with only one significant parameter adjustment.

III. CONCLUSION

The modeling for wastewater treatment facilities is very important area of investigation for design and optimization of the operating parameters for waste water facilities. Simple material balance equation can be used as tool for modeling of the treatment plant. The mass transfer parameters can be included in the models to obtain effect of these parameters and find controlling parameter. The experimental data obtained in batch and continuous operation can be used to verify the model results. It can be concluded that proper and accurate modeling of biological treatment can save time and efforts in design of waste treatment facility.

IV. REFERENCES

[1]. Sunil J. Kulkarni, Suhas V Patil, and Y. P. Bhalerao, “Flyash Adsorption Studies for Organic Matter Removal Accompanying Increase in Dissolved Oxygen”, International Journal of Chemical Engineering and Applications, Vol. 2, No. 6,pp. 434-439, December 2011,.

[2]. S.G. Reznik,I.Katz, C. G. Dosoretz, “Removal of dissolved organic matter by granular-activated carbon adsorption as a pretreatment to reverse osmosis of membrane bioreactor effluents”, Water Research, Vol.42, No..4, pp. 1595-1605, 2008.

[3]. Tapre Ravi W., Kulkarni Sunil J., Patil Suhas V., “Fluidized Bed Activated Carbon Adsorption for Removal of Phenol from Wastewater”, Int. J. Res. Chem. Environ. Vol.2, No.4,pp.101-106, Oct. 2012.

[4]. Sunil J. Kulkarni, Dr. Jayant P. Kaware, “A Review on Research for Cadmium Removal from Effluent”, International Journal of Engineering Science and Innovative Technology (IJESIT),Vol.2, No. 4, pp.465-469, July 2013.

[5]. S.J. Kulkarni, Dr.J.P. Kaware, “Fixed Bed Removal of Heavy Metal- a Review”, International Journal of Research (IJR), vol.1, no.6, pp.861-871,July 2014.

[6]. Sunil J. Kulkarni, Ajaygiri K. Goswami,“ Applications and Advancements in Treatment of Waste Water by Membrane Technology- A Review”, International Journal Of Engineering Sciences & Research Technology,Vol. 3, No.9, pp.446-449,September,2014.

[7]. Sonali R. Dhokpande, Sunil J. Kulkarni, Dr. Jayant P. Kaware, “A Review On Research On Application Of Trickling Filters In Removal Of Various Pollutants From Effluent”, International Journal Of Engineering Sciences & Research Technology, Vol. 3, No.,pp.359-365, July, 2014.

[8]. K.F. Tan, K.H. Chu, M.A. Hashim, “Continuous Packed Bed Biosorption of Copper by Immobilized Seaweed Biomass”, The European Journal of Mineral Processing and Environmental Protection,Vol.2, No.3, pp.246-252, 2002.

[9]. V. Vijayagopal and P. L. Sabarathinam, “Kinetics of biological treatment of phenolic wastewater in a three phase draft tube fluidized bed bioreactor containing biofilm”, African Journal of Biotechnology, Vol. 7 , No.6, pp. 834-837, 18 March, 2008.

[10]. Rangasamy Parthiban, “Biodegradation kinetics during different start up of the anaerobic tapered fluidized bed reactor”, Songklanakarin J. Sci. Technol., Vol.33, No.5,pp. 539-544, Sep. - Oct. 2011.

[11]. Mr. B. C. Meikap, Dr. G. K. Rot, “Removal of Phenolic Compounds From Industrial Waste Water by SemifluidizedBed Bio-Reactor”, Journal of the IPHE, India, No. 3,pp.54-61, 1997.

[12]. M. Carsky and F.N. Mbhele, “Adsorption of heavy metals using marine algae”, South African Journal of Chemical Engineering, Vol. 18, No. 2, pp 40-51,2013.

[13]. Hassimi Abu Hasan, Siti Rozaimah Sheikh Abdullah, Siti Kartom Kamarudin and Noorhisham Tan Kofli, “A Review On The Design Criteria Of Biological Aerated Filter For Cod, Ammonia And Manganese Removal In Drinking Water Treatment”, Journal - The Institution of Engineers, Malaysia,Vol. 70, No.4,pp.35-43, December 2009), 35-43.

[14]. Alma Masic, “Investigation Of A Biofilm Reactor Model With Suspended Biomass”, Doctoral Theses in Mathematical Sciences 2013:1, http://www.maths.lth.se/, 2013.

[15]. Athanasios Eftaxias, “Catalytic Wet Air Oxidation of Phenol in a Trickle Bed Reactor:Kinetics and Reactor Modeling”, Departament d’Enginyeria Qu´ ımica Universitat Rovira i Virgili Tarragona www.tdx.cat/bitstream/handle/10803/8517/eftaxiasthesis.pdf?sequence.. December 2002.

[16]. Ali R. Khataee and Masoud B. Kasiri, “Modeling Of Biological Water And Wastewater Treatment Processes Using Artificial Neural Networks”, Clean – Soil, Air, Water, Vol.39, No. 8, pp.742–749, August 2011.

[17]. Torsten Wik, “On Modeling the Dynamics of Fixed Biofilm Reactors”, Control Engineering Laboratory, Department of Signals and Systems,Chalmers University Of Technology publications.lib.chalmers.se/records/ fulltext/925.pdf Göteborg, Sweden, publications.lib.chalmers.se/records/fulltext/925.pdf.

[18]. Durgananda Singh Chaudhary, Saravanamuthu Vigneswaran, Huu-Hao Ngo,Wang Geun Shim and Hee Moon, “Biofilter in Water and Wastewater Treatment”, Korean J. Chem. Eng.,Vol. 20, No.6, pp.1054-1065,2003.

[19]. Rex Taicheong.Chen, Michael K . Stenstrom, “Use Of The Rotating Biological Contactor For Appropriate Technology Wastewater Treatment”, Uc Appropriate Technology Program University Of California, Davis Research Leaflet Series ,April, 1981, www.seas.ucla.edu/stenstro/r/r7.

[20]. Sanjay Dutta, “Mathematical Modeling of the Performance of a Rotating Biological Contactor for Process Optimisation in Wastewater Treatment “, Zugl.: Karlsruhe, Univ., Diss., 2007,ISBN 978-3-9809383-9-6, digbib.ubka.uni-karlsruhe.de/volltexte/documents/6009.

[21]. Linlin Yang, Raquel Salcedo-Diaz and Ignacio E. Grossmann, “Water Network Optimization with Wastewater Regeneration Models”, http:// egon.cheme.cmu.edu/Papers/Yang_Water%20Treatment_Regeneration%20.pdf.

[22]. Christian Drakides, Meiling Lay-Son,“Model development for biological treatment of toxic industrial wastewaters:an easy tool for linking pilot results and field data”, World Journal of Modeling and Simulation,Vol. 6 , No. 2, pp. 122-133, 2010.