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SEQUENCING BATCH REACTOR (SBR) TECHNOLOGY FOR BIOLOGICAL TREATMENT OF SEWAGE

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SEQUENCING BATCH REACTOR (SBR) TECHNOLOGY FOR BIOLOGICAL TREATMENT OF SEWAGE

By

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SEQUENCING BATCH REACTOR (SBR) TECHNOLOGY FOR BIOLOGICAL TREATMENT OF SEWAGE

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August 2001

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The sequencing batch reactor (SBR) has become popular in recent years since Irvine and Davis (1979) described its operation. The SBR achieves the processes in a framework of space compared to the conventional system, which achieves in terms of space. There are generally 5 operational steps in a SBR cycle namely Fill, React, Settle, Draw and Idle.

A bench scale SBR was studied at 2 different strategies. The study was conducted at different cycle times (6h, 8h and 10h) and different operational mode based on the ratio of anaerobic and aerobic period (1/2.7, 1/1 and 1.7/1). The study was undertaken to investigate the effluent quality, removal efficiency, SVI and kinetic growth coefficient.

Results from strategy A (different cycle time) showed that increases in cycle time led to decrease in the removal of TSS, COD and BOD_5. Best results were obtained for the system with the 6h-cycle time, followed by the 8h-cycle time and lastly was the 10h-cycle time.

Six hours cycle time was chosen for strategy B mainly due to the overall better removal efficiency on TSS, COD and BOD_5. There were 3 operational modes being examined in strategy B, they were 1/2.7 (longest aerobic period), 1/1 and 1.7/1(shortest aerobic periods).

Best results were obtained from the 1/2.7 operational mode with the longest aerobic period (lowest *Li*, which was 1.22 mg/mg.d), followed by 1/1 operational mode and lastly was the 1.7/1 operational mode. The higher removal efficiency was associated with the longer aerobic period, the kinetic growth coefficient and SVI also increased with the increasing of aerobic period. Therefore, the 6h-cycle time and 1/2.7 operational mode appeared to be the most reliable option in this study.

For further studies, more work could be done to have a better understanding of the SBR system. For instance, inclusion of an anoxic period in the React step would enhance denitrification process to achieve better effluent quality. Moreover, kinetic growth model can be further explored by thymidine assay.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

TEKNOLOGI REAKTOR TURUTAN SESEKUMPUL (SBR) UNTUK RAWATAN AIR SISA SECARA BIOLOGIKAL

Oleh

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Reaktor turutan sesekumpul (SBR) semakin popular sejak tahun kebelakangan ini setelah Irvine dan Davis (1979) mengemukakan operasinya. SBR dapat melaksanakan pemprosesannya dalam ukuran masa berbanding sistem pemprosesan tradisional yang memerlukan lapangan atau ruangan. Operasi SBR terdiri daripada lima mod, iaitu Isi, Tindabalas, Mendak, Salur dan Rehat.

Satu kajian SBR berskala makmal telah dijalankan berdasarkan dua strategi yang berlainan. Kajian ini telah dijalankan pada masa putaran yang berlainan (6 jam, 8 jam dan 10 jam) dan pada mod operasi yang berlainan (1/2.7, 1/1 dan 1.7/1). Kajian ini bertujuan untuk menyelidik kualiti sisa kumbahan selepas rawatan, kecekapan pengurangan, SVI dan juga koefisien kinetik pertumbuhan.

Keputusan daripada strategi A (masa putaran yang berlainan) menunjukkan bahawa penambahan masa putaran akan mengurangkan kecekapan pengurangan TSS, COD dan BOD_5. Bagi sistem berdasarkan masa putaran, 6 jam menunjukkan keputusan yang terbaik. Ini diikuti pula dengan 8 jam masa putaran dan akhir sekali 10 jam masa putaran.

Masa putaran 6 jam telah digunakan di dalam strategi B memandangkan kecekapan baik yang dipamerkan dari segi pengurangan TSS, COD dan BOD_5. Terdapat tiga mod operasi yang diselidik dalam strategi B. Mereka adalah 1/2.7 (masa aerobik yang terpanjang), 1/1 dan 1.7/1 (masa aerobik yang terpendek).

Keputusan yang terbaik diperolehi daripada mod operasi, 1/2.7 dengan masa aerobik yang terpanjang tetapi nilai L_I yang terendah iaitu 1.22 mg/mg.d. Ini diikuti oleh mod operasi 1/1 dan seterusnya mod operasi 1.7/1. Di samping kecekapan pengurangan yang tertinggi berkait rapat dengan masa aerobik yang lebih lama, malah nilai koefisien kinetik pertumbuhan dan SVI juga meningkat dengan peningkatan masa aerobik.

Kesimpulannya, sistem SBR beroperasi pada masa putaran 6 jam dan mod operasi 1/2.7 merupakan satu pilihan yang baik dalam penyelidik ini.

Demi kajian lanjutan, banyak penyelidikan boleh diadakan untuk mendapatkan kefahaman yang lebih lanjut tentang sistem SBR. Satu selang anosik boleh diselit pada mod Tindakbalas untuk menggalakkan proses dinitrifikasi supaya menghasilkan air sisa rawatan yang lebih berkualiti. Di samping itu, model kinetik pertumbuhan boleh diselidik dengan menggunakan assay pertumbuhan tymidine.

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I certify that an Examination Committee met on 22nd August 2001 to conduct the final examination of Lim Chin Ming on her Master Science thesis entitled "Sequencing Batch Reactor (SBR) Technology for Biological Treatment of Sewage" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously of concurrently submitted for any degree at UPM or other institutions.

Lim Chin Ming
Date: 28/09/2001

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LIST OF ABBREVIATIONS

μ	-	Specific growth rate
μ_{max}	-	maximum specific growth rate
BOD	-	Biological / Biochemical Oxygen Demand
BOD_5	-	Five days Biological Oxygen Demand
COD	-	Chemical Oxygen Demand
DO	-	dissolved oxygen
EPBR	-	enhanced biological phosphate removal
EQA	-	Environmental Quality Act
F/M	-	food to miroorganism ratio
HDT	-	hydraulic detention time
IWK	-	Indah Water Konsortium
K	-	maximum substrate utilizing rate
k_d	-	endogenous decay rate
Li	-	loading rate
MGD	-	milligallon per day
ML	-	mixed liquor
MLSS	-	mixed liquor suspended solids
MLVSS	-	mixed liquor volatile suspended solids
PAO	-	phosphorus-accumulating organisms
PHB	-	poly-β-hydroxybutyrate
RBCOD	-	readily biodegradable Chemical Oxygen
r_g	-	bacterial growth rate

r_{su}	-	substrate utilization rate
S	-	substrate concentration
S_{bi}	-	biodegradable Chemical Oxygen Demand
S_{bpi}	-	particulate slowly unbiodegradable Chemical Oxygen Demand
SBR	-	Sequencing Batch Reactor
SCFA	-	short chain fatty acid
SS	-	suspended solids
S_{sbi}	-	soluble readily biodegradable Chemical Oxygen Demand
S_{ti}	-	total influent Chemical Oxygen Demand
S_{ui}	-	unbiodegradable Chemical Oxygen Demand
S_{upi}	-	particulate unbiodegradable Chemical Oxygen Demand
SVI	-	Sludge Volume Index
T or t	-	time
TDS	-	total dissolved solids
TKN	-	Total Kjeldahl Nitrogen
TOC	-	total organic carbon
TS	-	total solids
TSS	-	total suspended solids
U	-	specific substrate utilization rate
U.S. EPA	-	United States Environmental Protection Agency

UASB	-	Upflow Anaerobic Sludge Blanket
VFAs	-	volatile fatty acids
X	-	microorganism concentration
Y_x	-	cell growth yield

CHAPTER I

INTRODUCTION

Every community in this world produces both liquid and solid-wastes. Due to the development, the living standard of our nation is increasing. This will consequently cause the increment of the waste generation and the demand of the clean water.

A supply of clean water is an essential requirement for the establishment and maintenance of a healthy community. It acts not only as a source of potable water, but also provides valuable food supplements through supporting the growth of aquatic life and irrigation in agriculture.

As we know, water is universal; water is all around us. It represents the medium of life on earth and one of the four ancient "elements". All body functions depend on water and plants and animals learn to adapt their body functions to humid and dry conditions of their environment.

Hence human and animal life cannot exist without a minimum amount of potable water. However, many biological and chemical contaminants have been known for years to be harmful to human and animal health. New contaminants have been discovered to be harmful in recent years.

Therefore, the immediate and nuisance-free removal of wastewater from its sources of generation, followed by treatment and disposal, is not only desirable but also necessary in an industrialised society. This is because if there is accumulation of untreated wastewater, the decomposition of the organic materials can lead to the production of large quantities of malodorous gases. It usually contains numerous pathogenic, disease-causing microorganisms that dwell in the human intestinal tract. In addition, wastewater also contains nutrients, which can stimulate the growth of aquatic plants and may contain toxic compounds.

Today, not only must a wastewater treatment plant satisfy effluent quality requirements, it must also satisfy many other environmental conditions. The purpose of the wastewater treatment before discharging is to convert the components in raw wastewater (its inherent characteristics) into a relatively harmless final effluent for discharge.

Presently, most of the unit operations and processes used for wastewater treatment are undergoing continual and intensive investigation from the standpoint of implementation and application. In order to meet the increasingly stringent requirements for environmental enhancement of watercourses, many modifications and new operations and processes have been developed and implemented.

Presently, there are many treatment systems such as activated system, anaerobic system, etc. A developing country like, Malaysia; there will be more alternatives to be chosen. One of them is the Sequencing Batch Reactor (SBR).

Meanwhile, SBR has emerged as an innovative technology in the wastewater treatment industry. This is because SBR can accomplish the tasks of primary clarification, biooxidation and secondary clarification within the confines of a single reactor. Furthermore, advances have occurred in sludge bulking control technologies using selector mechanisms.

Therefore, among the alternatives, Sequencing Batch Reactor (SBR) is becoming more and more popular due to the low land requirement and simpler than other activated sludge systems. Beside that, it requires small capital investment and minimum operational skills. It was also found that the biomass in an SBR would be subjected to high substrate tension that provides an effective means for the control of filamentous bacteria and, thus, sludge bulking. In addition, SBR is also effective in the removal of nitrogen and phosphorus.

A properly designed SBR process is a unique combination of equipment and software comprising a complete secondary wastewater treatment facility. There is a widespread belief that periodic processes (like SBR) are a recent development and still in a development stage. It can't be denied that SBR thus has its disadvantages. However, the advantages of its efficiency the in wastewater treatment can't be neglected.