Municipal Wastewater Treatment Using Sequencing Batch Reactor (SBR) Under Tropical Conditions

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Abstract

In this research project a Sequencing Batch Reactor (SBR) plant was tested for performance in terms of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Suspended Solids (SS), under different temporal conditions. In addition, the removal of biological nutrients, namely ammoniacal nitrogen, nitrate nitrogen and phosphorous in the form of phosphate, from the sewage, with anaerobic and aerobic operations using SBR was studied. The performance of the SBR plant was observed under two operating conditions whereby the variable studied was the total cycle time of the SBR process; i.e. 8-hour cycle mode and 6-hour cycle mode. The effluent quality from the plant was compared against standard effluent quality limits to determine the plant's performance in terms of BOD, COD, SS, ammoniacal nitrogen, nitrate nitrogen and phosphate.

The BOD, COD and SS are the commonly accepted parameters by which sewage treatment plants in Malaysia are judged in terms of performance. The BOD, COD and SS levels in the effluent from the SBR plant consistently complied with Standard B effluent limits at all times. The compliance level for ammoniacal nitrogen, nitrate nitrogen and phosphorus was set at 5.0 mg/l, 10.0 mg/l and 2.0 mg/l respectively. For removal of ammoniacal nitrogen, treatment efficiency of over 90% and 100% compliance was recorded using 8-hour cycle mode, compared to a treatment efficiency from 76% to 79% with only 19% compliance using a 6-hour cycle mode. Since ammoniacal nitrogen is known to be consumed during the aerobic phase, the longer

cycle time provides a much longer aeration time which is essential for nitrification to take place. The laboratory results obtained for nitrate nitrogen concentration in the effluent gave a compliance of more 88% at all times. The treatment efficiency recorded was between 73% and 80%. Thus, using a cycle time of 8-hours or 6-hours does not significantly affect the concentration of nitrates in the effluent. The study showed that removal of phosphorous or phosphate content was better using the 8-hour cycle mode (about 98% compliance and 89% removal efficiency) compared with the 6-hour cycle mode (approximately 20% compliance and 69% efficiency). However, the results obtained for the 8-hour cycle mode in November-December 1999 was gave a compliance level of only 10% with a treatment efficiency of 66%. It is believed that this was due to the insufficient period taken (1 to 2 months) to achieve stable conditions, which require at least 3 months.

In conclusion, the SBR plant performed well in terms of BOD, COD and SS removal under both 6-hour and 8-hour cycle modes. If biological nutrient removal to the proposed limits was desired, however, the SBR plant performed better when it was operated under the 8-hour cycle mode.

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Abbreviations

ASCE	:	American Society of Civil Engineers
BNR	:	Biological Nutrient Removal
BPR	:	Bio-phosphorus removal
BOD	:	Biochemical Oxzygen Demand
CAS	:	Conventional Activated Sludge
COD	:	Chemical Oxygen Demand
df	:	degrees of freedom
DGSS	:	Director General of Sewerage Services
DO	:	Dissolved Oxygen
EA	:	Extended Aeration
E. Coli	:	Escherichia Coli
EBPR	:	Enhanced biological phosphorus removal
EPRB	:	Excess phosphorus removal bacteria
F/M	:	Food per Mass
h	:	hour
IAWQ	:	International Association of Water Quality
ID	:	Intermittent Decant
IWK	:	Indah Water Konsortium Sdn Bhd
KLIA	:	Kuala Lumpur International Airport
l/lin.m-min	:	liters per linear meter per minute
m/h	:	meters per hour

m^3/day	:	cubic meter per day
mg/l	:	milligram per liter
MGD	:	million gallons per day
ML/day	:	Million Liters per day
MLSS	:	Mixed Liquor Suspended Solids
MLVSS	:	Mixed Liquor Volatile Suspended Solids
NH_3	:	ammonia
NH_3-N	:	ammoniacal nitrogen
NO_3-N	:	nitrate nitrogen
O&G	:	oil and grease
ORP	:	Oxido-Reduction Potential
PC	:	Personal Computer
PE	:	Population equivalent
PLC	:	Programmable Logic Controller
PO_4-P	:	Phospate
Q	:	Influent flow rate
RAS	:	Return Activated Sludge
SBR	:	Sequential Batch Reactor
SRT	:	Solids Retention Time
SS	:	Suspended Solids
SVI	:	Sludge Volume Index
t	:	t-statistic
t_d	:	time for Draw

t_f	:	time for Fill
t_i	:	time for Idle
t_r	:	time for React
t_s	:	time for Settle
T-N	:	Total Nitrogen
T-P	:	Total Phosphorus
USEPA	:	United States Environmental Protection Agency
US	:	United States
UK	:	United Kingdom
UWWD	:	Urban Waste Water Directive
VFA	:	Volatile Fatty Acids
V_t	:	Total liquid volume of the SBR tank
V_0	:	Volume remaining at the end of Draw
V_f	:	Volume added during Fill
WEF	:	Water Environment Federation
wt/wt	:	weight per weight
ZSV	:	Zone Settling Velocity

Some Useful Definitions

Aerobic processes are biological treatment processes that occur in the presence of oxygen.

Anaerobic processes are biological treatment processes that occur in the absence of oxygen.

Anoxic denitrification is the process by which nitrate nitrogen is converted biologically to nitrogen gas in the absence of oxygen. This process is also known as anaerobic denitrification.

Biological nutrient removal is the term applied to the removal of nitrogen and phosphorous in biological treatment processes.

Facultative processes are biological treatment processes in which the organisms can function in the presence or absence of molecular oxygen.

Carbonaceous BOD removal is the biological conversion of the carbonaceous organic matter in wastewater to cell tissue and various gaseous end products. In the conversion, it is assumed that the nitrogen present in the various compounds is converted to ammonia.

Nitrification is the biological process by which ammonia is converted first to nitrite and then to nitrate.

Denitrification is the biological process by which nitrate is converted to nitrogen and other gaseous end products.