http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 8 (2): 335-337, 2005
ISSN 1028-8880

Wastewater Phosphorus Removal by Intermittent Cycle Extended Aeration System

Farham Karakani and Amir Hossein Mahvi
School of Public Health, Center for Environmental Research,
Tehran University of Medical Sciences, Tehran, Iran

Abstract: The purpose of this study was to determine capability of Intermittent Cycle Extended Aeration System (ICEAS)® (a modification of SBR) to treating contaminants, especially phosphorus. Experiment was carried out in Tehran University of Medical Sciences using a pilot. The used reactor consists of tow zone: pre-react and main react zone. These two zones are separated using a baffle wall. Firstly, wastewater enters to pre-react zone and then through openings in bottom of baffle wall enters to main react zone. The experiment was carried out with three different Hydraulic Retention Times (HRT) and flowrates. Results of different runs showed 38.5, 52.1 and 55.9% of phosphorus removal, which is higher than conventional activated sludge processes. The system is capable to remove phosphorus with nearly similarity with other proprietary phosphorus removal process and with lower cost, whereas is not a proprietary process.

Key words: Wastewater treatment, ICEAS, bio P removal, sewage

INTRODUCTION

Phosphorus compounds are potential pollutant for receiving waters which enter by various wastewaters. Phosphorus is essential for algae and other living organisms, but because of eutrophication in waters and different problems is intense pollutant[1]. In various wastewater treatment methods, pollutants and among them phosphorus will be reduced, nut in some cases this reduction in not sufficient and or because of importance this agent, low level of phosphorus in discharged effluent has high importance[2].

Phosphorus removal is applicable either chemically or biologically. Chemical methods are carried out using addition lime and aluminum and ferric salts. With addition an external chemical, chemical sludge is formed and has related problems and possible impacts on receiving waters and environment. So importance of biological methods is increased[3,4].

Different factors such as entered organics to system and ration of this matters to entering phosphorus, Solids Retention Time (SRT), nitrogen nitrate in anaerobic zone, DO concentration in aeration tank, pH, temperature, organic acid concentration and TSS have effect in phosphorus removal[2].

In recent years Sequencing Batch Reactors (SBRs) are proved as a efficient means to treat wastewater (all required process are occurred in tank base on time sequence). SBR could achieve nutrient removal using alternation of anoxic and aerobic stages[5]. Nitrification and denitrification in a SBR is achieved using these stages, while solids separation is occurred with turning off the aeration or mixing at the end of each process cycle[6]. Because of SBR flexibility, efficiency increasing is carried out with change in phase duration of decreasing tanks in continuous flow systems[7].

SBRs besides many advantages have some disadvantages: 1) require at least two tanks or an equalization tank; 2) when designing one tank, there is not possibility to remove one tank for maintenance purposes; 3) flow and loading changed during day which can cause unequal loading to tanks; 4) control system is based on water level in tank and because of diurnal fluctuations, results in real aeration time for biological reactions; and 5) continuous carbon source is essential in biological nutrient removal systems. In these systems wastewater is used as carbon source, while in SBRs this source is disrupted[7].

Removing these disadvantages, ICEAS® has been presented by SANITAIRE®. This system is a modification of old SBR technology, which allows continuous flow. Influent does not disrupt in any phases.

In conventional SBRs there are five phases: fill, react, settle, decant and idle[8]; but in ICEAS® there are three phases: react, settle and decant. Influent allows that system is controlled based on time (instead of flow) and equal loading reaches to all tanks. Control system based on time allows simple changes to process control program.

Corresponding Author: Dr. Amir Hossein Mahvi, School of Public Health, Center for Environmental Research, Tehran University of Medical Sciences, Tehran, Iran E-mail: ahmahvi@yahoo.com

Reactor is divided by a baffle (pre-react and main-react zone). Pre-react zone acts as a biological selector (enhancing growth of desired microorganisms besides limiting filamentous bacteria), an equalization tank and a grease trap[9].

In SBRs influent is batch and in cases of continuous flow, there should be at least two reactors which increases construction costs. In addition, batch flow causes unequal loading (hydraulically and organically) in basin which has negative effects on biomass. SANITAIRE has presented ICEAS® to remove SBR disadvantages. This investigation was carried out study ICEAS® efficiency to remove pollutants and here we discuss about phosphorus removal in this system.

MATERIALS AND METHODS

ICEAS® reactor: Study was carried out using a pilot plant with capacity of 36 L. Reactor was started up using activated sludge from return line of settling tank in a wastewater treatment plant. An air pump and several diffusers provided required air and mixing. Temperature was 10-24°C. Wastewater flowed to pre-react using a dosing pump and then entered to main react zone through openings in bottom of baffle wall. Analog times operated cycle's sequences.

Wastewater characteristics: In Table 1 typical sewage composition during study is presented.

Experimental: Generally one SBR consists of five phases: fill, react, settle, decant and idle. In presented study there are three phases: react, settle and decant, during them influent does not disrupted. Firstly wastewater enters pre-react zone which has low MLSS concentration. This creates high F/K ratio and prevents filamentous organisms (cause of bulking sludge) growth. After a short (bout 15-20 min) wastewater enters to main-react zone. In react phase diffusers are act to air supply and MLSS mixing in aeration tank. In settling phases, a thick sludge blanket forms. This blanket is so heavy which does not disrupt while entering wastewater. Organics are used by microorganisms during passing of this layer. In decant phase clear supernatant is discharge using decant mechanism. Figure 1 shows flow diagram of the system. Whole effluent was collected and analyzed.

Study was carried out in three runs: 1st run: Q = 1.5 L/h- HRT = 16.7 h, 2nd run: Q = 2 L/h- HRT = 14 h, 3rd run: Q = 2.5 L/h- HRT = 12.4 h.

Duration of cycles is 6 h, include: 3 h aeration, 1.5 h setting and 1.5 h decanting, i.e. aeration phase allocates 50% and settling and decanting allocate 25% of total time of cycle.

Table 1: Sewage composition

Substrate	Concentration (mg L^{-1})
COD	417
BOD	230
TJN	48
TSS	255
Total P	16

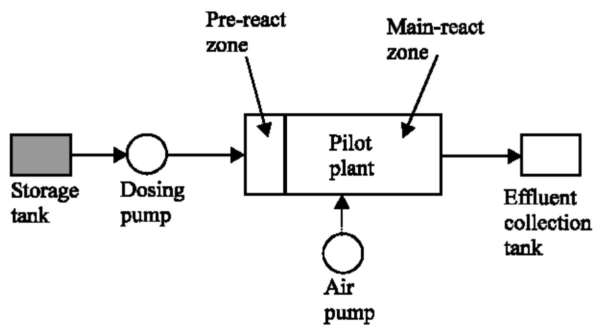

Fig. 1: Flow diagram in investigated system

Pilot runs were with degrited and screened raw sewage. Wastewater characteristics in each run were constant and only treating time (HRT) was varied. In each run, daily sampling and analyzing on effluent samples was carried out after stabilization of system.

RESULTS

Each run lasts about 1 month. Solids Retention Time (SRT) was in range of 12.5 to 24 days, Hydraulic Retention Time (HRT) was in range of 12.4 to 17.6 h, MLSS was in range of 6002 to 6146 mg L^{-1} and temperature was in range of 10 to 24°C (Table 2).

Effluent and influent phosphorus concentration was determined. Influent phosphorus concentration was 16 mg L^{-1}. Phosphorus removal in runs 1 to 3 were 38.5, 52.1 and 55.9%, respectively (Fig. 2).

Table 2: Average operational conditions and influent and effluent concentrations in each run (effluents are in parenthesis)

Run	1	2	3
Cycle time (h)	6	6	6.0
Aeration fraction (%)	50	25	25.0
HRT (h)	16.7	14	12.4
SRT (days)	24	16	12.5
F/M	0.107	0.137	0.133
MLSS (mg L^{-1})	6146	6002	6003.0
MLVSS (mg L^{-1})	3678	3480	3469
Temperature (°C)	20	16	10
COD (mg L^{-1})	417 (21)	417 (25)	417 (29.2)
BOD_5 (mg L^{-1})	230 (5.2)	230 (6.2)	230 (7.3)
TKN (mg/L-N)	48 (7.1)	48 (8.3)	48 (14.6)
NO_3-(mg/L-N)	(6.8)	(6.3)	(5.6)
NO_2-(mg/L-N)	(0.14)	(0.13)	(0.13)
Total Nitrogen (mg L^{-1})	48.7 (14.04)	48.7 (14.73)	48.7 (20.33)
Total Phosphorus (mg/L-P)	16.1 (9.7)	16.1 (7.9)	16.1 (7.3)
pH	7.5	7.3	7.3

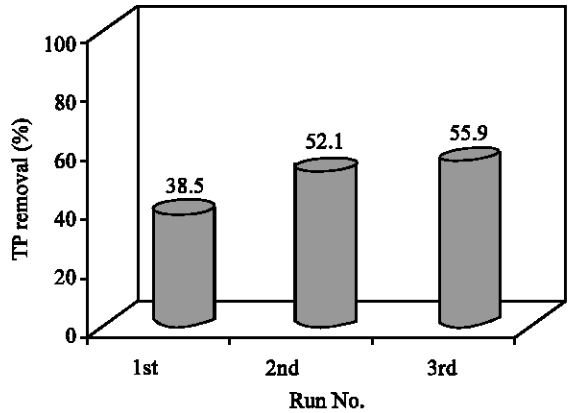

Fig. 2: Efficiency of P removal in different runs

DISCUSSION

As noted efficiency of phosphorus removal in different runs is 38.5, 52.1 and 55.9%, while in conventional activated sludge system, is maximum 10-20%[4]. This shows that even in lowest performance, efficiency is about two times of other systems. But effluent phosphorus content is high because of high influent content. This amount is more than Iran EPA standards for discharge to surface water. Standard value for discharge phosphorus to surface waters is 6 mg L^{-1}.

If more removal is required, chemical precipitation could be an approach, but this remove simple operation, which is one of the system advantages.

From point view of required time for treatment, in proprietary processes such as PhoStrip and Modified Bardenpho required HRT for phosphorus removal is 10 and 11.5-23 h, respectively[1], whereas in this system which is not proprietary, is in range of 12.4 to 17.6 h. This shows that system is capable to phosphorus removal in almost similar time, with difference that has not complexities and alternating aerobic-anaerobic stages related to proprietary processes.

Another important point is cost. As mentioned later, wastewater is received directly from grit chamber and aeration and settling are occurred in same tank. So there are not primary and secondary settling tanks which are a necessity in conventional processes and have high initial investment to construct settling tank, return pumps and also operation and maintenance costs. Also because of absence of primary and secondary settling tanks, eliminates need for land.

ACKNOWLEDGMENTS

The authors would express their thank to Office of Research, Tehran University of Medical Sciences, financial supporter of this study and to Engineer Ali Mohammadi, Supervisor of Environmental Microbiology Laboratories, School of Public Health, Tehran University of Medical Sciences.

REFERENCES

1. Metcalf and Eddy, Inc., 2003. Wastewater Engineering: Treatment and Reuse. McGraw-Hill, New York, pp: 63, 700-703, 814.
2. Najafpoor, A.A., M. Shriat, A.R. Mesdaghinia, S. Nasseri and A.H. Mahvi, 1999. Biological phosphorus removal from sewage using anaerobic-aerobic reactors. J. Man and Environ., 1: 46-53.
3. Bowker, R.P.G. and H.D. Stensel, 1990. Phosphorus Removal from Wastewater. Noyes Data Corporation, New Jersey, pp: 14 -18.
4. Bitton, G., 1999. Wastewater Microbiology. John Willey, New York.
5. Rim, Y.T., H.J. Yang, C.H. Yoon, Y.S. Kim, J.B. Seo, J.K. Ryu and E.B. Shin, 1997. A full-scale test of a biological nutrients removal system using the sequencing batch rector. Wat. Sci. Technol., 35: 241-247.
6. Irvine, R.L. and W.B. Davis, 1971. Use of sequencing batch reactor for wastewater treatment-CPC international, corpus christi, TX. Presented at the 26th Annual Industrial Waste Conference, Purdue, University, West Lafayette, IN.
7. EPA, U.S., 1992. Sequencing Batch Reactors for Nitrification and Nutrient Removal, US Environmental Protection Agency, EPA 832 R-92-002, Washington D.C., pp: 1-5 to 1-7.
8. Crites, R. and G. Tchobanoglous, 1998. Small and Decentralized Wastewater Management Systems. Mc-Graw Hill, New York, pp: 477.
9. Karakni, F., 2004. Feasibility of Uni-Tank Activated Sludge System. M.Sc Thesis, School of Public Health, Tehran University of Medical Sciences, pp: 169, 173-176.