Waste Technology (WasTech)
Journal homepage: http://www.waste.web.id/index.php/wt
An International Journal

CHARACTERISTICS OF CLARIFICATION PROCESS IN NITRIFICATION – DENITRIFICATION SYSTEM FOR WASTE WATER WITH N-NH_3

Ari Setiawan and Bayu Hari Nugroho

Chemical Engineering, Diponegoro University, Jl. Prof. Soedarto, Semarang, Central Java, Indonesia

Abstract - Research on combinations of activated sludge processes - The clarifier is an attempt to improve the performance of the activated sludge process. In this system, the clearing works as a sediment deposition. The treatment process is expected to operate at a high biomass concentration and produce a compact system for optimal deposition speed. Some of the things covered in this research are, to calculate the rate of sludge deposition in the purifier and to measure the level of water purity or turbidity of the activated sludge treatment process. In this research, synthetic wastewater is used. The ventilation tank is made of plexiglass, with a total volume of 150 Liter. The clarifier is made of plexiglass with an inverted prism shape. The results show that the deposition rate and the degree of purity of water are influenced by the concentration of bacteria Mixed Liquor Suspended Solid (MLSS) or bacteria. The results show that the concentration of MLSS or bacteria increased, the deposition rate decreased. This can be seen in the MLSS 130 ppm which shows faster deposition rate than the MLSS 355 ppm. In the case of turbidity, larger MLSS results, increased turbidity, indicate an accurate flux.

Keyword : *activated sludge, ammonia, de-nitrification, nitrification, waste water treatment*

Submission: February 18, 2020 *Correction: March 1, 2020* *Accepted: April 8, 2020*
Doi: http://dx.doi.org/10.14710/wastech.8.1.12-17
[How to cite this article: Ari Setiawan, A. and Bayu Hari Nugroho, B.H. (2020). CHARACTERISTICS OF CLARIFICATION PROCESS IN NITRIFICATION – DENITRIFICATION SYSTEM FOR WASTE WATER WITH N-NH3, 8(1), 12-17. doi: http://dx.doi.org/10.14710/wastech.8.1.12-17]

1. INTRODUCTION

The presence of nitrogen compounds in the final effluent in the activated sludge process can have adverse effects or contamination on the receiving water body. In principle, the nitrogen components in the residue that can cause pollution are ammonium ions ($NH4^+$), nitrite ions ($NO2^-$), and nitrate ions ($NO3^-$). The worst effect if living beings eat water bodies that still contain nitrogen compounds is death. Common problems caused by nitrogen residues include dissolved oxygen depletion, toxicity, eutrophication, and metemoglobinemia. Quality standards set by the government to protect environmental health from waste-caused toxicity, namely pH effluent in the range of 6-9, BOD5 50 mg /liter, COD 100 mg/liter, TSS 200 mg/liter.

To reduce nitrogenous compounds in waste, treatment is needed, one of which is an activated sludge process. At the end of the activated sludge process, the sludge is separated by liquid. Soil separation is called sedimentation process. The deposition process is influenced by feed concentration, sludge residence time, liquid residence time, biomass concentration, organic loading, sludge removal rate, and sedimentation characteristics. Of the many parameters, the most important parameter is biomass concentration

Biomass in the activated sludge process is undergoing an acclimatization process, which is the process of adaptation to the conditions in which the biomass lives. The factors that influence this change are usually temperature and food.

1.1 Problem Formulation

In this report, we will discuss the sludge deposition rate factor in the deposition tank. This sediment deposition speed will affect the water out of the basin (*effluent*).

1.2 Research Purpose

The purpose of this study was to determine the siltation rate and measure the level of effluent clarity in waste treatment with activated sludge process

2. MATERIAL

2.1 Activated Sludge

A widely used and effective sludge process is used to treat soluble solids and soluble organic matter. This is a good technique used for the treatment of organic waste water (Cheremisioff, 1997). An activated sludge process is used to treat liquid residues containing organic chemicals, petroleum filtration residues, textile waste, and municipal waste.

Activated sludge is an organic solid that undergoes biological degradation until the biomass is activated and is able to absorb particles and rehydrate and then forms a mass that easily absorbs and or absorbs as gas. The activated sludge known as Mixed Liquor Suspended Solid is the amount of suspended solids derived from the sedimentation basin. Sludge activity is determined by the concentration of MLSS. Sludge contains many decomposers so it is best to break down new organic matter.

This activated sludge process involves biological processing, as it utilizes the help of microorganisms in the treatment process. In this process there are two important units, the bioreactor tank or the ventilation tank, and the second is the deposition tank (called purifier). The arrangement of these two units is as follows:

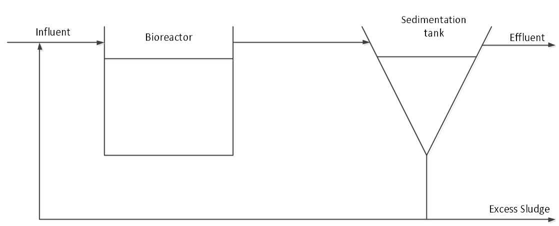

Fig. 1. Activated Sludge Process Scheme

Bacteria that are degraded by bacteria are substrates used to generate carbon and energy. This indicator is indicated by the BOD value. BOD is the amount of dissolved oxygen measured in milligrams per liter required by microorganisms, especially bacteria, to oxidize or reduce residues into simple inorganic components, and multiply bacterial cells.

Under the right operating conditions and adequate ventilation, bacteria can transform substrates into simple products. Table 1 Show some nitrogen-organic compounds such as proteins contain C, H, N, O, P, and S. When proteins are degraded by bacteria, bacteria will gain C for growth, energy for cell activity, and release of inorganic products.

Ammonium ions produced from sewage and ventilation tanks through hydrolysis and desalination processes are substrates for bacteria that oxidize nitrogen in the form of ammonium ions. Oxidation of ammonium ions by bacteria is called nitrification. When ammonium ions are oxidized, the bacteria gain energy and release nitrite ions (NO2-). The nitrite ions produced will be oxidized by bacteria to nitrate ions (NO3-). Oxidation of nitrite ions by bacteria is called a nitrification process. When nitrite ions are oxidized, the bacteria gain energy and release nitrate ions (NO3-). When bacteria oxidize the substrate, the reproduction process takes place or the bakery population increases. Bacteria represent the amount of solid in the ventilation tank. Therefore, as the bacterial population increases during the reproduction process, the volume of solids in the ventilation tank increases. The solid in the air tank is mud. Because air and bacterial sludge become activated during the ventilation process, activated sludge is used to describe the process by which bacterial solids are activated in the treatment of waste in the ventilation tank.

Table 1. in-organic products formed from oxidizing proteins (*Gerardi, 2002*)

Element of Protein	Inorganic products
Carbon (C)	Carbon Dioxide (CO_2)
Hydrogen (H)	Water (H_2O)
Nitrogen (N)	Ion Ammonium (NH_4^+)
Oxygen (O)	Water (H_2O)
Phosphor (P)	Ion Phosphate (PO_4^{3-})
Sulfur (S)	Ion Sulfate (SO_4^{2-})

In the process of activated sludge, microorganisms in the biomass (bacteria and biomass) transform the dissolved organic material into a final product (H2O and CO2) and partially into a new cell (biomass). Therefore, in order to regenerate the organic material optimally the following conditions must be met:

1) The contaminants in the liquid residues must be in contact with the microorganisms.
2) Sufficient supply of oxygen.
3) Adequate nutrients
4) Adequate on Retention time
5) Adequate biomass (amount and type)

The purpose of wastewater treatment with an activated sludge system can be divided into 4 :

1) Allowance for carbon compounds (carbon oxidation).
2) Allowance for nitrogen compounds.
3) Phosphor removal
4) Simultaneous aerobic sludge stabilization

It is hoped that this activated sludge process does not cause sufficient odor and water to be treated. Sludge activated can be used repeatedly if the location is not large enough (*Ginting, 2007*). However, the cost of operation is quite high as it requires mechanical equipment to carry mud and air into the mud. Changes in the quality and quantity of water greatly affect the state of efficiency.

Sludge details and sludge residuals in the reactor should be considered.

Hard mud grains are difficult to absorb so they are difficult to separate from the liquid. Too much of this mud will cover the surface and cause poor growth of microorganisms. This is due to low dissolved oxygen, inadequate nutrients, sludge residue for too long.

Therefore, it is always necessary to know the ratio of volume and weight of mud called mud volume (AVL) or mud content index (SVI) (*Ginting, 2007*). To get good processing it should be consider:

1) It is necessary to determine the air requirements for each cubic meter of treated waste. For that you need to know the amount of power required and its ability to move air at all times
2) It is necessary to determine the maximum hydraulic holding time and mud retention time
3) Air requirements are included with the amount of BOD processed to determine the effectiveness of the treatment
4) To determine the life expectancy of mud using calculations :

$$CRT = \frac{MLSS \ x \ V_{ta}}{W_r \ x \ K_i}$$

Where :

CRT : Cell Retention Time
MLSS : Mixed Liquor Suspended Solid (mg/liter)
Vta : Aeration tank volume (liter)
Wr : Total Effluent (liter/second)
Ki : Total Return of Sludge (mg/liter)

5) Comparison of the amount of food and microorganisms in general is a number: 0.2 - 0.3 calculated by the formula:

$$Fm = \frac{BOD \ x \ V_t}{MLSS \ x \ V_{ta}}$$

Where :

Fm : Comparison of food and microorganisms
BOD : Biochemical Oxygen Demand (kg)
Vl : Sludge volume (m3/days)
MLSS : Mixed Liquor Suspended Solid (kg/m3)
Vta : Aeration tank volume (m3)

6. Mud volume index calculation (MVI) :

$$MVI = \frac{ML}{MLSS} \ x \ 100\%$$

This comparison is expressed from the volume of mud after 30 minutes of settling (ML) compared to the dry weight of the mud

2.2. Nitrification and De-Nitrification

Figure 2. Illustrated for biological process of nitrification and de-nitrification.

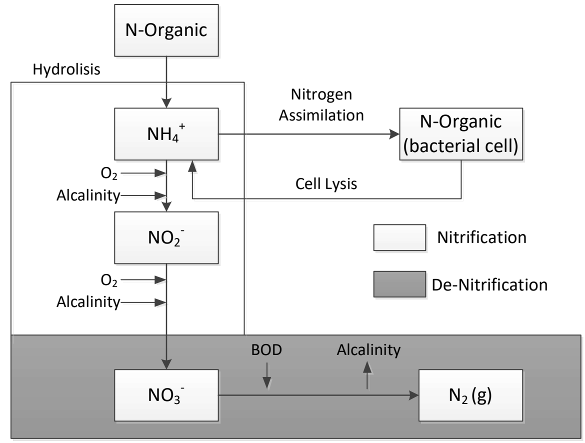

Fig.2 Nitrification – De-nitrification process scheme

The nitrification process requires oxygen and alkalinity, and some nitrogen is used for the synthesis of biomass (activated sludge-sludge). The de-nitrification process occurs under anoxic conditions, consumes BOD and produces alkalinity and new cells.

Biological nitrification is the oxidation of ammonium ions to nitrite ions, and nitrite ions to nitrate ions (*Gerardi, 2002*). During the oxidation process of ammonium ions and nitrite ions, oxygen is added to these ions by nitrifying bacteria. De-nitrification is described as the use of nitrate ions or nitrite ions by denitrifying bacteria (facultative anaerobes) to degrade BODc. Although de-nitrification is often combined with aerobes to eliminate variations in the nitrogen component of the waste, de-nitrification takes place when anoxic conditions (no oxygen). (*Wckenfelder et.al, 1995*)..

2.3. Sedimentation

Sedimentation is the process of separating particles from their fluids (water) which is influenced by gravity or centrifugal force (*Rushton et.al, 1996*). In the sedimentation process only particles heavier than water can be separated, for example mud. The sedimentation basin itself can be placed before the active sludge process or the so-called primary clarifier, sedimentation is placed at the beginning of the process in order to separate the floating components such as oil and fat, and heavy solids that are at the bottom of the clarifier. There is also a sedimentation tank placed after the activated sludge process, in order to separate the mud particles with their clean fluid, so that effluent in the form of clean water can be directly discharged into the environment with a note that the nitrogen content in the effluent meets the standard of water discharge into the environment (*Gerardi, 2002*).

The most important part in planning the sedimentation unit is knowing the settling rate of the particles to be moved (*Siregar, 2005*). According to (*Rushton et al, 1996*), the particle settling treatment is determined by 2 factors, the first is the concentration of the solid particles and the second is the clumping status of the particles themselves. As the concentration of solids increases, settling will be faster, as will the clumping of particles during the sedimentation process. Combining several particles to form a group will increase its mass density, so that it will speed up its deposition. For example in this activated sludge process the output of the biomass suspension is flowed into the sedimentation basin. With a fairly large concentration and the presence of gravity, the biomass or mud will separate from the water

3. METHOD

A. Initial experiments were performed to breed the bacteria to a concentration of 500 mg/liter by feeding it with F/M ratio of 40 starch and ammonia. After reaching the desired concentration, the operation is start continue.

B. Settling rate calculation
   a. take a 0.5 liter sample from aeration tank and put in measuring cup.
   b. For each sample, observe the interface concentration and height measurements (boundaries between solids and clear supernatants) are written as a function of time. Calculate the settling time start from 0.5liter, recording each of 0.05liter decrease until deposit is stable

C. Turbidity calculation
   a. Take a 0.5 liter of activated sludge from aeration tank and put it measuring cup.
   b. Calibration turbidity meter tools and then calculate the turbidity with turbidity meter tools
   c. Check turbidity sample each 5 minutes until constant

After that, we will have clarity level, settling rate, bacterial concentration

4. RESULT

4.1 Settling rate characteristic on some bacterial concentration

Final clarifier is once of the main activated sludge process. The activated sludge process consist of two main process, aeration tank and clarifier tank. Fig. 3 show the settling rate on the some bacterial concentration

Table 2. Settling rate observation

Settling Rate Observation						
bacterial level	MLSS Concentration (ppm)					
(cm)	130	140	200	240	340	355
22.5	0.22	0.38	0.37	0.48	0.97	0.60
20	0.48	0.50	0.57	0.85	1.40	1.00
17.5	0.58	0.67	0.77	1.05	1.87	1.48
15	0.67	0.63	0.93	1.23	2.67	2.18
12.5	0.92	1.17	1.16	1.40	4.28	3.63
10	0.95	1.50	1.35	1.58	7.92	7.00
7.5	1.81	2.05	1.62	1.83	21.75	15.10
5	7.20	9.10	3.97	3.32	26.88	21.75
4.5	7.72	14.63	8.28	5.15	32.75	26.89
4	13.30	20.58	12.03	6.65	64.25	
3.5	26.00	31.10				

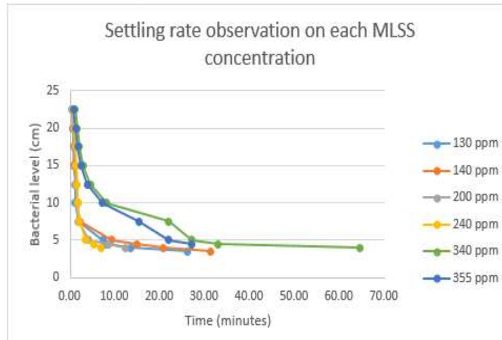

Fig. 3 settling rate observation on each MLSS concentration

Bacterial concentration will given effect of the settling rate. Based on fig. 4. A highest concentration will effect on decreasing of settled. This MLSS concentration given direct effect on sludge loading rate (SLR) in clarifier . Based on the data, bacterial will stopped settled in 3.5 centimeter and maximum settled on 4.5 centimeter for concentration 355ppm

Settling rate on concentration 130ppm and 335ppm have different settled characteristic. MLSS concentration 130ppm will have more time to settled between 335ppm concentration. This case also experienced by *Witzig et al, 2002* which states that high biomass concentrations can cause the separation of biomass from effluent increasingly difficult to do because of high bacterial concentrations so that the speed of bacteria to settle becomes low.

4.2 Turbidity characteristic on each MLSS concentration

Nitrification process is an activated sludge process within oxidized ion ammonium to become ion nitric and then to become ion nitrate (*Gerardi, 2020*). Sometimes, nitrification can make a problem in an activated sludge process. These problems include dispersed growth and filamentous bulking each time the nitrification process experiences an increase in temperature which is also called pinpoint flocs.This pinpoint flocs makes it difficult for bacteria to settle because the size of the bacteria is so small that it just floats in the water. This results in effluent or water produced becomes muddy. Table 3 show the turbidity observation data. The length of time on settling will affect the value of turbidity

Table 3. Turbidity observation data

Turbidity Observation						
Time	MLSS Concentration (ppm)					
(Minutes)	130 ppm	140 ppm	200 ppm	240 ppm	340 ppm	355 ppm
5	33.70	39.50	21.50	20.50	96.20	36.80
10	29.70	23.40	13.10	15.89	74.10	31.10
15	27.40	23.00	12.23	13.56	63.30	26.70
20	24.90	22.70	13.60	12.65	57.80	23.10
25	23.50	22.30	13.03	11.76	57.20	21.30
30	22.70	20.30	12.32	10.17	54.80	19.10
35	20.40	18.20	11.98	10.95	49.80	18.40
40	19.50	17.70	11.84	11.38	48.80	17.60
45	19.40	16.50	11.70	10.82	48.70	16.40
50	19.50	16.30	11.60	10.36	48.00	16.20
55	18.70	16.20	11.36	9.80	48.00	15.10
60		15.80	10.52	9.22	48.20	15.30
65			11.56	9.01		
70				9.21		
75				9.02		

Fig 6 show the effluent condition. In this research, MLSS concentration 200ppm produce enough clean water between MLSS 340ppm, this case indicate having a pinpoint flocs in MLSS concentration 340ppm. So the effluent still muddy

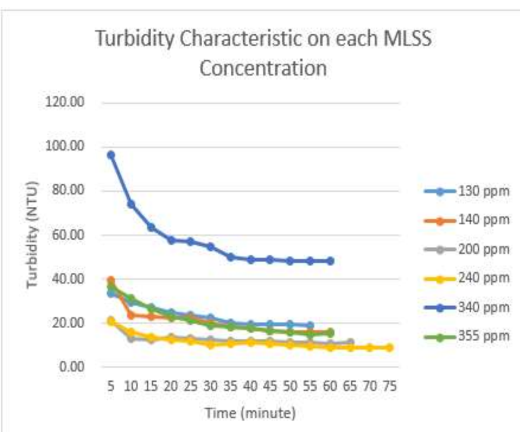

Fig 6. Turbidity characteristic on each MLSS concentraction

5. CONCLUSION

In the active sludge process, the fluctuation of process control causes various microbiological problems including pinpoint flocs, dispersed bacteria that affect the level of effluent clarity. The level of effluent clarity decreases with the increase in MLSS which is indicated by the formation of pinpoint flocs. The performance of the activated sludge process is influenced by the concentration of bacteria. The rate of deposition of bacteria decreased with increasing MLSS at MLSS 355 ppm

REFERENCES

[1] Antileo, Christian and friends**,** *Nitrifying Biomass Acclimation to High Ammonia Concentration*, J. Environmental Eng, 2002, pp. 367-375.

[2] A. Rushton, A.S. Ward, R.G. Holdich**,** *Solid – Liquid Filtration and Separation Technology*. 1st ed., VCH Verlagsgesellschaft mbH, Weinheim, Germany**,** 1996, pp.85.

[3] Departemen Perindustrian**,** *Pengolahan Limbah Industri Pangan,* Direktorat Jenderal Industri Kecil Menengah Departemen Perindustrian, Jakarta, Indonesia, 2007.

[4] Kusumaatmadja, Sarwono**,** *Baku Mutu Limbah Cair Bagi Industri,* Jakarta, Indonesia,1998

[5] Michael H. Gerardi**,** *Nitrification and Denitrification in the Activated Sludge Process*, John Wiley & Sons, inc., 2002

[6] Musterman, Jack L and Eckenfelder, W. Wesley**,** *Activated Sludge Treatment of Industrial Wastewater*, Technomic Publishing AG, Switzerland, 1995, pp. 43.

[7] Nicholas P. Cheremisinoff, Ph.D**,** *Biotechnology for Waste and Wastewater Treatment*. Noyes Publications, Westwood, New Jersey, U.S.A, 1996, pp. 7.

[8] Ginting, perdana, Ir. MS, *System Pengelolaan Lingkungan dan Limbah Industri*. Edisi 1 CV. Yrama Widya, Bandung, Indonesia, 2007, Hal. 122.

[9] Sakti A. Siregar**,** *Instalasi Pengolahan Limbah*. Penerbit Kanisius, Jogjakarta, Indonesia, 2005, Hal. 35.

[10] Thomas E. Wilson, P.E., DEE, Ph.D., *Clarifier Design*, 2nd edition, Mc. Graw – Hill, New York, 2005, Chapter 2 & 4.

[11] Sears, K., J. E. Alleman., J. L. Barnand., J. A. Oleszkiewicz., 2006, *density and Activity Characterization of Activated Sludge Flocs.*

[12] Richard, Michael, Ph.D., Sear-Brown., Fort Collins,Co., 2003, *Activated Sludge Microbiology Problem and Their Control.*

[13] Direktoral Jenderal Usaha Kecil Menengah., 2007, *Pengelolaan Limbah Industri Pangan,* Departemen Perindustrian, Jakarta

[15] Krebs, Peter., Daniel Visher., Willi Gujer., 1995, *Inlet – Structure Design for Final Clarifiers*

[16] E, Orris., Albertson., John P. Wilson., 1997, *Clarifier Concept – Larger is Better*

[17] Li, Yingxia., Sim-Lin., Masoud Kayhanian, M.ASCE., Michael K. Stenstrom, F.ASCE., 2006, *Dynamic Characteristics of Particle Size Distribution in Highway Runoff: Implication for Settling Tank Design*

[18] Budiyono, 1997, *Kombinasi Proses Lumpur Aktif – Membran Untuk Pengolahan Limbah Cair Industri,* Institut Teknologi Bandung.

[19] Svarovsky, Ladislav, Dipl Ing, PhD, Ceng, FlChem E., 2000, *Solid – Liquid Separation*., 4th ed., London, Butterworth-Heinemann Publisher.

[20] T. Valsaraj, Kalliat., 2000, *Element of Enviromental Engineering Thermodinamic and Kinetics*., 2nd ed, Lousiana, Lewis Publisher, 563-586

[21] A. Handayani, Noer., 2010, *Aplikasi Eksternal Hybrid Mixed Matrix Membrane Bioreaktor Untuk Pengurangan Amonium dalam Limbah Cair,* Universitas Diponegoro

[22] M. Stanley, Walas., 1990., *Chemical Process Equipment Selection and Design*., Kansas

[23] Inamori, Ryuhei., Ping Gui., Yasothosi Shimizu., Kaiqin Xu., kenji Kimura., Yuhei Inamori., 2005, *Effect of constructed Wetland Structure on Wastewater Treatment and its Evaluation by Algal Growth Potensiat Test,* Vol 40

[24] Wang, Z., Wu, Z., Yin, X., Tan, L., 2008, *Membran fouling in Submerged Membran Bioreactor (MBR) Under Sub-critical Flux Operation : Membran Foulant and Gel: Layer Characterization.,* Vol 325, 238-244

[25] Hay, F.I., Yamamoto, K., Fukhusi, K., 2005, *Different Fouling of Sunmerged Hollow Fiber and Flat Sheet Membran Induced by High Strength Wastewater with Cocurrent Biofouling.,* Desalination, Vol 180, 89 – 97

[26] Cheng, Jiayang., Bin Liu., 2001, *Nitrification / Denitrification in Intermittent Aeration Proses for Swine Wastewater Treatment*.

[27] Mokhayeri., Yalda., Rumana Riffat., Imre Takacs., Peter Dold., Charles Bott., Jeneva Hinojosa., Walter Bailey., Sudhir Murthy., 2008, *Characterizing Denitrification Kinetics at Cold Temperature Using Various Carbon Sources in Lab-Scale Sequencing Batch Reactors*, Water Science and Tecnology-WST

[28] Parker, Demy., Richard Butler., Richard Finger., Reed Fisher., William Fox., Wendell Kido., Steve Merrill., Gary Newman., Rod Pope., Jeff Slapper., and Eric Wahlberg., 1995, *Design and Operation Experience with Floculator – Clarifier in Large Plants*, Austria

[29] Zeng, Xiangying., Zheng Lin., Hongyan Gui., Wenlan Shao., Guoying Sheng., Jiamo Fu., Zhiqiang Yu., 2008, *Occurrence and Distribution of Polycyclic Aromatic Carbons in Sludges From Wastewater Treatment Plants in Guangdong, China*, Springer Science + Business Media B.V

[30] Albertson Orris E., 2008, *Solids Loading Limitations of Rectangular Secondary Clarifiers*, JOURNAL OF ENVIRONMENTAL ENGINEERING

[31] P, Nicholas Cheremisinoff, Ph. D., 2002, *Handbook Water and Wastewater Treatment Technologies,* Butterworth Heineman