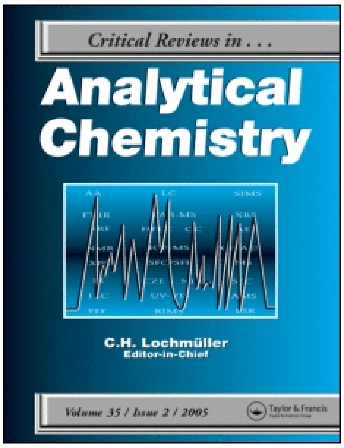
This article was downloaded by:
On: *17 January 2011*
Access details: *Access Details: Free Access*
Publisher *Taylor & Francis*
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Critical Reviews in Analytical Chemistry
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713400837

PROBLEMS AND CHEMICAL ASPECTS OF INDUSTRIAL AND MUNICIPAL WASTEWATER TREATMENT IN ESTONIA

Toomas Tenno; Kaja Orupõld; Aarne Pruks

Online publication date: 03 June 2010

To cite this Article Tenno, Toomas , Orupõld, Kaja and Pruks, Aarne(1998) 'PROBLEMS AND CHEMICAL ASPECTS OF INDUSTRIAL AND MUNICIPAL WASTEWATER TREATMENT IN ESTONIA', Critical Reviews in Analytical Chemistry, 28: 2, 92 — 95

To link to this Article: DOI: 10.1080/10408349891194351

URL: http://dx.doi.org/10.1080/10408349891194351

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Critical Reviews in Analytical Chemistry, 28(2):[SI]92–[SI]95 (1998)

PROBLEMS AND CHEMICAL ASPECTS OF INDUSTRIAL AND MUNICIPAL WASTEWATER TREATMENT IN ESTONIA

TOOMAS TENNO, KAJA ORUPÕLD and AARNE PRUKS
Institute of Physical Chemistry, University of Tartu

Downloaded At: 13:17 17 January 2011

Introduction

In recent years pollution load in Estonia is decreased. From the total discharge of wastewater (1894 millions m^3/year in 1995) 396 millions m^3/year needed treatment. Wastewater from power stations and fish rearing met the requirements for the treated wastewaters and therefore did not need treatment. From 396 millions m^3/year which needed treatment 18 millions m^3/year was not treated and 203 millions m^3/year was treated mechanically, 89 millions m^3/year biologically and 85 millions m^3/year biological-chemically [1]. 4% of biologically treated wastewater were treated by sewage lagoons only.

In Estonia there are more than 1000 wastewater treatment plants, unfortunately not all of them gives effluent of required quality. 29% of biologically treated water are poorly treated. In conventional biological wastewater treatment plants the BOD removal is higher than phosphorus (P) or nitrogen (N) removal and often the effluent P and N content do not meet the requirements. Up to present conventional biotreatment dominates in Estonia.

In modern wastewater treatment plants with enhanced biological phosphorus removal (EBPR) high degrees of biological P removal are achieved and in denitrifying plants high degree of biological N removal is achieved. On the basis of activated sludges and wastewaters we have studied the processes related to nitrogen and phosphorus removal. These processes are nitrification, denitrification, phosphorus uptake and release by activated sludge in aerobic and anaerobic or anoxic conditions.

The P removal in wastewater treatment processes can only be carried out by incorporation into a solid phase, which can be separated from water. During the biological treatment stage, the only way to remove P is the uptake or precipitation by the produced biomass. P removal will thus depend on the quantity of waste sludge produced and the P content [2]. In conventional biological treatment the P content of waste sludges is about 2 % [2,3]. In sewage plants with EBPR the activated sludge or mixed liquor must pass alternately through anaerobic and aerobic stages [4]. In such plants polyphosphate containing bacteria are enriched in the sludge [5]. The activated sludges from EBPR plants have a high P content. In experimental conditions P content can be up to 11 % [6] and even 18 % [7,8].

In the biological sewage plants operating with high energy density (HED) aerators the O_2 concentrations are very different in particular parts of basins. There are zones where the O_2 concentration is zero. This situation is analogical to the main characteristic of the EBPR process - anaerobic/aerobic sequence of both wastewater and sludge. There are some sewage plants in Estonia operating with HED aerators. P removal in such plants in Põlva and Viiratsi was investigated too.

The biological N removal consists of two steps. Ammonium-nitrogen must first be oxidized to nitrate and then subsequently reduced to produce molecular nitrogen. The oxidation of ammonium to nitrate - nitrification - is an aerobic process and consists of two steps: ammonium is oxidized sequentially to nitrite and nitrate by Nitrosomonas and Nitrobacter, respectively. Denitrification is anoxic process. The wide range of nitrification and denitrification rates with varying experiment conditions are reported [9] We have investigated

Copyright© 1998, CRC Press LLC — Files may be downloaded for personal use only. Reproduction of this material without the consent of the publisher is prohibited.

Downloaded At: 13:17 17 January 2011

the influence of preceding anoxic conditions residence time, temperature change and temperature on nitrification rate and the activated sludge oxygen consumption.

In order to achieve the effluent quality to meet treated effluent discharge requirements in wastewater treatment the biological degradation of organic matter by activated sludge in the aeration basins should be sufficient too. To evaluate the biodegradability of wastewaters by certain activated sludge the method based on the activated sludge oxygen uptake measurement has investigated. The method gives a possibility to estimate the content of readily biodegradable organic compounds, that is, short-term biochemical oxygen demand of wastewater, which plays an important role also in biological nitrogen and phosphorus removal.

The kinetic parameters of the biodegradation processes can be determined by monitoring the degradation-associated oxygen consumption in tests with different amounts of wastewaters and simple biokinetic model of sludge respiration. The results can be applied for the estimation of the oxygen requirement in aeration basins and also for the estimation of the efficiency of wastewater treatment processes. On the basis of the results of the activated sludge oxygen uptake measurements is could be possible to operate the plant in proper way.

Results and Discussion

Phosphorus and Nitrogen Removal

The specific nitrification and denitrification rates of the activated sludges from Estonian wastewater treatment plants are not high, up to 2mgN/(gMLSS*h) (MLSS - mixed liquor suspended solids). The determination of the nitrification rates after different anoxic conditions residence times indicates the increase of nitrification rates after short residence times. The maximal nitrification rate was observed after anoxic conditions residence time 2-3 h. The rate increase was ~20%. After 4-5 h the preliminary rate was observed and after 20 h residence in anoxic conditions the nitrification rate was practically zero. Short oxygen starvation increases the nitrification activity, activation of enzyme system can be a reason for such increase. After extensive temperature change the nitrification rate decreased abruptly on the first days, more than twice for three days. It is possible that there are two different kinds of nitrifiers in the activated sludge, one of them is cryophilic and the other mesophilic. Which one of them dominates depends on temperature. In winter the cryophilic nitrifiers are dominant and the higher temperature is unacceptable for these microorganisms. The population of mesophilic microorganisms is not enough numerous and the nitrification rate decreases. After some days the nitrification rate starts to increase as the mesophilic bacteria become dominant. The oxygen consumption rate during the rising of anoxic conditions was constant on the all DO concentrations to the minimal measured values (0.1mg/l), such result is not in accordance with literature. Still, the oxygen consumption can not be only due to nitrification.

In most environments, nitrification and denitrification proceed at suboptimal temperature. To eliminate influence of other factors, we have used relative nitrification and denitrification rates v_t^0/v_{22}^0, where v_t^0 is process rate at investigation temperature and v_{22}^0 rate at 22^0C. The optimal temperature for nitrification was about 30°C. The denitrification rates, as rule, were lower than nitrification rates. The denitrification rate increases with rising of the temperature at least till 40°C.

TABLE 1.

Effect of temperature on the relative nitrification rate v_t^0/v_{22}^0.

Temperature, ^{0}C	15	30	35	40
Relative nitrification rate	0.96	1.62	0.76	0.32

Copyright© 1998, CRC Press LLC — Files may be downloaded for personal use only. Reproduction of this material without the consent of the publisher is prohibited.

TABLE 2.

Effect of temperature on the relative denitrification rate v_t^0/v_{22}^0.

Temperature, ^0C	15	30	35	40
Relative denitrification rate	0.73	1.13	1.35	2.63

In EBPR process good phosphorus removal in the aerobic zone can be obtained only if a sufficient phosphate release in the anaerobic zone is observed. Phosphate release from activated sludge was hindered by nitrate but complete absence of nitrate was not necessary and the start of phosphorus release before complete denitrification of solution was observed. Corresponding nitrate concentration values depend upon activated sludge and wastewater conditions. On the occasion of higher (>7mg/l) nitrate concentrations the phosphorus removal from the solution even in anoxic conditions was observed.

In Põlva wastewater treatment plant, operating with HED aerators, spontaneous EBPR process occurred. In the time of extraordinarily high loading the concentration of dissolved oxygen outside aerators decreased. Concentrations in measuring point were 0.2-0.3 mg O_2/l. The influent P content was very high too, the highest measured P concentrations were more than 18 mg/l. Approximately during a week there was a low O_2 concentration outside aerators. At this time sludge P content was on average 2.1 % and P removal efficiency only less than 10 %. After normalization of oxygen concentration the sludge P content started to rise and after 3 weeks reached 3.9 %. The P removal efficiency was the highest after one week - 88 %, the effluent P concentration was 0.94 mg/l at that time. The rise of sludge P content was a slow process but the P removal efficiency achieved maximum at the beginning of P content rise. The effluent BOD was 5-12 mg/l and the BOD removal efficiency in aeration basin 96-98%.

Downloaded At: 13:17 17 January 2011

Oxygen Uptake Rate Measurements

The use the oxygen uptake rate measurements for the characterization of activated sludge and wastewaters were studied. The developed method was used for the investigation of the organic loads, biodegradability of different influents and activated sludge processes in different wastewater treatment plants in Estonia. This included treatment plants in Põlva, treating municipal and diary wastewaters, in Narva, treating municipal as well as industrial wastewater from textile industry and the Kohtla-Järve regional wastewater treatment plant. The later one is unique because of treating the wastewaters form the oil shale chemistry industry with wastewaters from other nearby industries and municipalities.

The uptake of molecular oxygen by the activated sludge processes caused by the addition of wastewater was followed in the tests. The total oxygen decrease in the batch experiments depends on the rate of the sludge endogenous respiration, i.e., activated sludge characteristics, as well as qualitative and quantitative properties of added wastewater. Oxygen consumption in the tests was characterized with the rate of oxygen uptake reactions.

The measures like biochemical oxygen demand (BOD) and chemical oxygen demand (COD) widely used to express the waste concentrations are often unsufficient for control purposes. The correlation between the short -term biochemical oxygen demands calculated from the oxygen uptake data and BOD_7 values of the wastewaters was studied. The correlation of the dependence of the measured oxygen uptake rates on BOD_7 values of the total influent and municipal wastewater entering to the Põlva wastewater treatment plant was 0.99 and 0.91, respectively. Important is a fact that the test gives a possibility operatively estimate the parameters of the influents. Present method enables to do it within 10-30 minutes.

Copyright© 1998, CRC Press LLC — Files may be downloaded for personal use only. Reproduction of this material without the consent of the publisher is prohibited.

The activated sludge respiration measurements are proposed also for the assessment of the biological treatability of different wastewaters. Different industrial and municipal wastewaters influents to the Kohtla-Järve wastewater treatment plant were analysed and compared on the basis of exogenous oxygen uptake rates of the activated sludge from the same treatment plant [10]. The injection of the different amounts of wastewaters in the tests resulted in oxygen uptake rate curves that can be used in study the biodegradation processes. In this study the kinetic parameters were determined in order to characterize the activated sludge and different wastewaters. The degradative capacity of the sludge is characterized by the maximal reaction rate and its affinity to different influent wastewaters by the half-saturation constant. The introduced half-saturation constant expresses the dependence of the degradation rate on the concentration of organic pollutants in wastewater. The results form the Kohtla-Järve treatment plant showed that the degradation rate for the municipal wastewater was considerably lower than that for other studied wastewaters. The highest degradation rate was achieved for the wastewater sample taken after the equalization. It can be shown that the simple model based interpretation of the data allows a characterization of the sludge as well as a comparison of the biodegradability of different wastewaters.

Conclusions

Estonian wastewater biotreatment plants need reconstruction to achieve higher phosphorus and nitrogen removal. The short-time residence in anoxic conditions increases the rate of following nitrification in aerobic conditions that are favourable for nitrogen removal. After the abrupt temperature change the nitrification rate decreases. It is possible that there are two different kinds of nitrifiers in the activated sludges in Estonia, one of them is cryophilic and the other mesophilic.

Differences in experimentally measured oxygen uptake rates characterize the load to the wastewater treatment plant through short-term biochemical oxygen demand and also give the information about the biodegradability of the certain influents. On the basis of the results obtained from the oxygen uptake rate measurements it is possible to operate the processes in treatment plants in an efficient way.

Acknowledgement

The authors acknowledge the financial support provided by the Estonian Science Foundation.

References

1. Estonian Environment, Tallinn, 1996, 32-36.
2. Meganck, M. T.; Faup, G. M. *Enhanced biological phosphorus removal from waste waters*. In Wise,D.L. (Ed.), Biotreatment Systems, Vol.3, CRC Press, Boca Raton, Florida, 1988; pp 111-203.
3. Harper, D. *Eutrophication of Freshwaters*. Chapman & Hall, London, 1992; pp 221-224.
4. Barnard, J. L. *Water Wastes Eng*., 1974, July, 33, August, 41.
5. Buchan, L. *Wat.Sci.Technol.* **1983**, 15, 87.
6. Appeldoorn, K. J.; Kortsee, G. J. ; Zehnder, A. J. *Wat.Res.* **1992**, 26, 4351-4601.
7. Wentzel, M. C.; Loewenthal, R. E.; Ekama, A.; Marais, G. R. *Wat. Sth. Afr*. **1988**, 14, 81-92.
8. Wentzel, M. C.; Ekama, G.A.; Loewenthal, R. E.; Dold, P. L.; Marais, G.v.R. *Wat. Sth. Afr*. **1989**, 15, 71-88.
9. Focht, D. D; Chang, A. C. *Adv. Applied Microbiol.* **1975**, 19, 153-186.
10. Hellat, K.; Mashirin, A.; Nigu, P.; Orupõld, K.; Tenno, T. *Oil Shale* **1997** (in print).

Downloaded At: 13:17 17 January 2011

Copyright© 1998, CRC Press LLC — Files may be downloaded for personal use only. Reproduction of this material without the consent of the publisher is prohibited.