Polish Journal of Environmental Studies Vol. 13, No. 2 (2004), 219-222

The Influence of Selected Environmental Toxins on the Speed of Decomposition of Organic Compounds in Processes of Oxygen Biodegradation

I. Skoczko, K. Ignatowicz

Department of Technology of Water, Sewage and Sediments,
Białystok University of Technology, ul. Wiejska 45A, 15-351 Białystok, Poland

Received: 21 February, 2003
Accepted: 21 October, 2003

Abstract

Nowadays, when pesticides are commonly available and used in an uncontrolled way, the danger of their infiltration into water and to sewage is very serious. Therefore, it is important to check the influence of chosen environmental toxins on sewage biodegradation effects and on the speed of decomposition of organic compounds. This paper presents the results of research into the changes of reaction rate constants in Eckefelder's and Grau's equations.

Keywords: pesticides, activated sludge, biodegradation

Introduction

Problems with the country and its agriculture and also problems with protecting the environment during food production are the most important in the European Union. These problems that are discussed between Poland and the European Union cause difficulties. Now in West European countries one can see more negative effects in WPR concerning environmental, economic, social and cultural policies.[8] There are conceptions to modernize the country and its agriculture very quickly: to use chemical pesticides to protect plants and to use chemical fertilizers. Thanks to these production has increased. The rules of using pesticides in Poland should be similar to the rules that are obeyed in West European countries. Poland as regards the quantity of used pesticides is at the end. The quantity increases although when we compare it with other countries in the world it is (/gram of an active substance on hectare): Poland 900 , Germany 3000, France 2000, Japan 11000 [1,9,10].

Using pesticides commonly is connected with their going to ground water and also to sewage treatment plants. The pesticides can go to these systems both directly (for instance: by being put into water by accident or on purpose) and indirectly (as a result when water goes from fields or factories that produce and distribute these substances.) It is characteristic of these systems that the pesticides equalize their concentration in containers very quickly. So all living organisms have contact with them. In ground water and biological parts of sewage treatment plants there are special fauna and flora that are adapted to absorb pollution from water solution. The opinions about pesticide biodegradation in biological sewage treatment plants evolve. In previous years it was thought that most of these compounds underwent biodegradation slowly. New research shows that adaptation of bacteria and other microorganisms can help remove pesticides [2,3,4,9,10]. Research in many countries describes the pesticides and their influence in sewage treatment. It is measured by means of $ChZT_{Cr}$, $ChZT_{Mn}$, BZT_5. Thanks to them transformations of nitrogen and phosphorus and transformations of kinetic coefficients in biological sewage treatment are characterized.

Experimental

Research shows the ability of the biological treatment in two-stage system in chambers with active sewage sediment that contain Aminopielik D, Chwastox Extra and Chwastox Trio.

Table 1. Characterisation and composition of synthetic wastewater.

Component	Quantity [g/m^3]	Characterisation of wastewater
		BZT_5 – 280mgO_2/l
Broth meat -(peptone)	300.0	ChZT-Cr - 330mgO_2/l
Soda acetate CH_3COONa	100.0	ChZT-Mn - 100mgO_2/l
Soda acid carbonate $NaHCO_3$	50.0	C_{org}. – 17.8%wag
Phosphate dipotassic K_2HPO_4	50.0	H_{org}. – 2.9%wag
Phosphate diammonium $NH_{4)2}HPO_4$	50.0	N_{org}. – 5.3%wag
Soda chloride NaCl	5.0	N-NH_4 – 31mg/l
Magnesium sulphate $MgSO_4$	5.0	N-NO_3 – śl
		N-NO_2 – śl

Laboratory models of these chambers were cylindrical (30 litres of capacity). They were connected with a cylindrical secondary decanter (15 litres of capacity) thanks to a plastic pipe (2.5 cm in diameter). All these things created one two-stage system of the sewage treatment. Synthetic sewage were the source of carbon. They were prepared according to AKCH in Moscow by Warsaw Polytechnic.

Characteristic features and compositions of sewage are shown in Table 1. Individual components that are reagents were dissolved in municipal water – the quantity was dependent on demand during the day.

Sewage that was purified in the first chamber was going to the next chamber. From there it went to a sewage system. A peristaltic pomp dosed sewage continuously (sewage to the first one and purified sewage to the next one). Purified sewage was going from the secondary decanter through a top valve. Settlings recirculation to the aeration chamber was made through the top valve. Sewage was mixed with activated sludge and next oxidized. Keeping the same quantity of oxygen in the chamber (4 – 5 gO_2/l) everything was made by plate membrane diffusers by ENVICON.

Research for an active settlings in a one-stage system were made using Amienopielik D, Chwastox Extra and Chwastox Trio in one litre of sewage: 5, 10, 20, 30, 50, 75, 100, 150, 200, 300, 400, 600, 800, 1100, 1500mg/l, which amounted to the following amounts of active substances:

- Aminopielik D: 2.0875; 4.175; 8.35; 12.525; 20.875; 31.3125; 41.75; 62.625; 83.5; 125.25; 167.0; 250.0; 334; 459.25; 656.25 mg2,4-D/l.
- Chwastox Trio: 1. 2. 4. 6. 10. 15. 20. 30. 40. 60 .80. 120. 160. 220. 300 mgMCPA/l oraz 1.5. 3. 6. 9. 15. 22.5. 30. 45. 60. 90. 120. 180. 240. 330. 450 mgMCPP/l.
- Chwastox Extra: 1.5. 3. 6. 9. 15. 22.5. 30. 45. 60. 90. 120. 180. 240. 330. 450 mgMCPP/l.

Research for an active sediment in two-stage system were made using only Amienopielik D in one litre of sewage : 5, 10, 20, 30, 50, 75, 100, 200, 300, 500, 750, 1000, 1500, 2000, 3000 mg/l, which amounted to the following amounts of active substances: 2.0875; 4.175; 8.35; 12.525; 20.875; 31.3125; 41.75; 83.5; 125.25; 208.75; 313.125; 417.5; 626.25; 835.0; 1252.5 mg2,4-D/l.

Knowing the parameters in processes that happen in the reactor one can characterize the conditions of the biodegradation: time of retention, quantity of biomass in the reactor, optimal age of settlings, quantity of excessive sediment and many others [4,5,6,11].

The kinetic coefficient method is known and very popular in foreign countries but in Poland it is less popular. This method calculates kinetic coefficients. They characterize the speed of removing the substrate whose initial value is consistent with BZT. The progress in the reaction equals the loss in BZT. The first part of the reaction goes parallel with removing substrate from sewage, the second part of the reaction happens inside the cell (after running out of food). The description of the process was based on Eckenfelder's equation:

$$V = k_1 S_k,$$

k_1 – reaction rate constants in Eckenfelder's equation [m^3/gd],
S_k – substrate concentration in effluent [g/m^3],
V – substrate rate constants [g/gd],

$$V = (S_p – S_k)/(XT)$$

S_p – substrate concentration in inflow [g/m^3],
X – activated sludge concentration [g/m^3],
T – sewage aeration time [d]

and Grau's equation:

$$V = k_2 (S_k/S_p),$$

k_2 - reaction rate constants in Grau's equation [g/gd].

Defining the constant speed of the biochemical decomposition of organic substances in sewage is very important to control the process of treatment. These numbers and k_1 and k_2 refer to using oxygen.

$$k_1 = (S_p – S_k)/(XT)/S_k$$
$$k_2 = S_p(S_p – S_k)/(XT)/S_k$$

The pesticides belong to the group of substances that are toxic for microbiological systems. They make the processes of biodegradation either slow down or come to a stop when there are more toxins in sewage. It is connected with changes of kinetic coefficients that characterize the speed of the decomposition in organic compound (the numbers for individual chambers are shown on graphs 1, 2, 3 and 4).

After using active settlings that were supplied with synthetic sewage, a constant of the speed of the decomposition k_1 (at the beginning of dosing herbicides) was oscillating between 0.0037-0.0048 m^3/gd. During dosing in pesticides system this parameter was decreasing sudden reactions rate constants in Eckenfelder's equation ly at the beginning but later slowly to the value about 0.0001 m^3 /gd (graph 1). A similar relationship was noticed after observing k_2. The highest values were between 11 and 15 g/gd that later were decreasing to 5 – 8 g/gd (graph 2).

Considering the two-stage system it was noticed that for the first stage k_1 changed between 0.0022 m^3/gd and 0.0004 m^3/gd with 2,4 D and was kept to the end of the research (graph 3). The values for the second stage of treatment were constant and fluctuated between 0.0001-0.0007 m^3/gd. A similar relationship was noticed for k_2 (graph 4). For settlings of the first stage the value k_2 was decreasing from 6 to 1.5 g/gd and started to be constant but for settlings of the second stage k_2 was invariable – about 0.1 g/gd.

Results and Discussion

These values during dosing pesticides to systems of the biological treatment were different from the values that are acceptable for town wastes (permissible range is between 0.0007-0.0017 m^3/gd.)[3,4,7] Pesticides made these values increase at the beginning of the research. When there were more toxins flowing with sewage to active settlings equipment k_1 was decreasing and also when SOR dose was increased for the first level settlings and the first level settlings in the two-stage system. For the second level settlings in the two-stage system fluctuation for k_1 was constant and similar to value of town wastes. It was not dependent on quantity of pesticides in the first chamber.

During observation of changes for Grau's constant it was noticed that pesticides in sewage going to the systems made k_2 decrease (correct constants in town wastes are 0.010-0.1 g/gd). Only the values from the second chamber

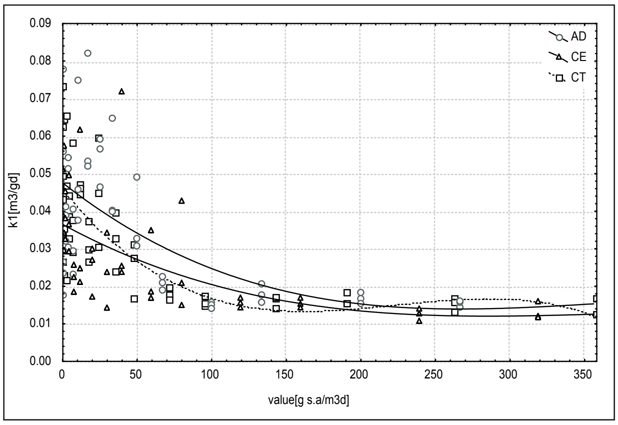

Fig. 1. Influence active sludge loading of pesticides on biochemical-speed-reaction constant k_1 in I-degree system.

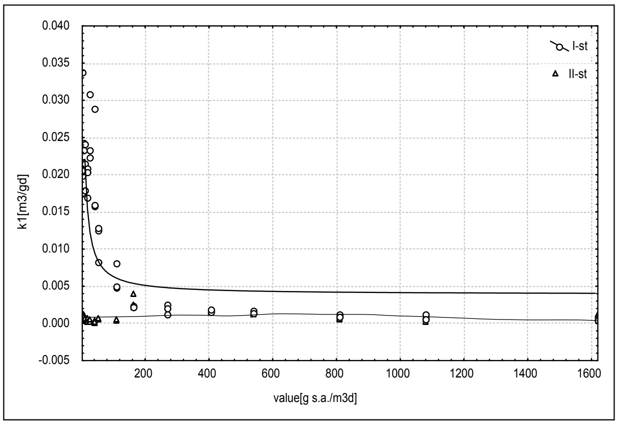

Fig. 3. Influence active sludge loading pesticides on biochemical-speed-reaction constant k_1 in II- degree system.

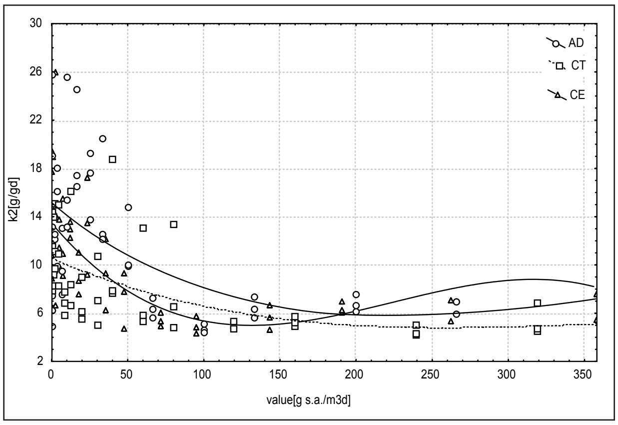

Fig. 2. Influence active sludge loading of pesticides on biochemical-speed-reaction constant k_2 in I- degree system.

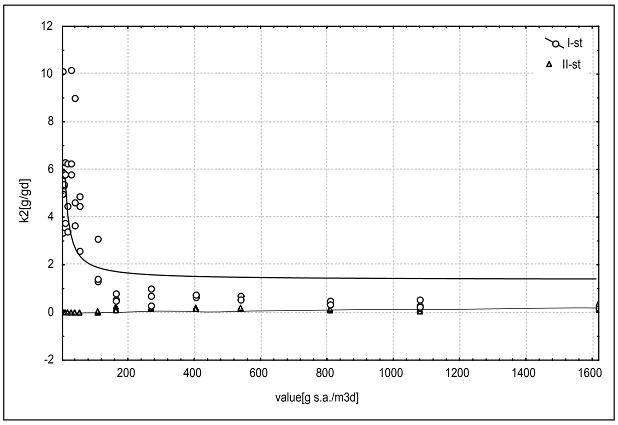

Fig. 4. Influence active sludge loading of pesticides on biochemical-speed-reaction constant k_2 in II- degree system.

of the two-stage system were within this range. For both settlings from the first stage and settlings from the first chamber of the two-stage system permissible range was multiply exceeded when there were minimal quantities of toxins. During research Grau's coefficient decreased but did not exceed permissible range.

Thanks to results it is proved that pesticides chosen for research make Grau's and Eckenfelder's constants increase. The coefficient values were within the range only for the second level in the two-stage system.

On the basis of results one can say that chosen pesticides made Grau's and Eckenfelder's constants increase. The constants were within the range only for the second level of treatment in the two-stage system. They were not dependent on the quantity of pesticides going to the first chamber. It is connected with taking and neutralizing toxins going with sewage to the first level chamber.

References

1. ARNDORFER M., Pesticidendrückstände in Boden- und Grundwasserproben des Bezirkes Gänserdorf, Reports – Umweltbundesamt (Wien), **1989.**
2. BOGACKA T. Kinetyka rozkładu wybranych pestycydów w środowisku wodnym, Roczniki PZH, t. **XXXIII**, **1982.**
3. BOSSELMAN K., LINDAN W., Stoffprüfung im Chemikalienrecht. Kritische Darstellung der gesetzlichen Regelungen über stofbezogene Prüffungen und Angaben, „Schriften des Instituts für Umwltrecht" , **1989**.
4. GRABIŃSKA-SOTA E. Wpływ wybranych pestycydów na pracę osadu czynnego, „Ochrona Środowiska", **77** (2), **2000.**
5. GAŃCZARCZYK J. Oczyszczanie ścieków metodą osadu czynnego, Arkady, Warszawa **1969.**
6. KOŚMICKI E. Główne problemy rozwoju i ekologizacji rolnictwa polskiego w integracji z Unią Europejską, „Ekonomia i Środowisko", **17** (2), **2000.**
7. SKOCZKO I., WIERZBICKI T., Próby określenia przydatności metod biologicznych do detoksykacji ścieków przemysłowych zawierających pestycydy. mat. konf. X Międzynar. Konf. N-T. nt. „Ochrona zasobów i jakości wód powierzchniowych i podziemnych" Augustów, **1999.**
8. WHO, Env. Health Criteria, **9**, **1979.**
9. WINKLER R., MÜLLER R., Wasserwirtschaft, „Wassertechnik", **29**, **1979.**
10. ZDYBIEWSKA W., KWIATKOWSKA K., Badania nad wpływem wybranych pestycydów na proces biochemicznego oczyszczania ścieków, mat. konf. XIX Kurso-Konferencji N-T nt. „Postęp techniczny w dziedzinie oczyszczania ścieków", Katowice, **1976.**
11. ŻELECHOWSKA R., MAKOWSKI Z., , Monitoring pestycydów w wodach powierzchniowych, Biblioteka Monitoringu Środowiska, Warszawa, **1993.**