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THE EFFECT OF MAGNETIC FIELD ON WASTEWATER TREATMENT WITH ACTIVATED SLUDGE METHOD

The effect of magnetic field on the removal of organic compounds, transformation of nitrogen compounds and the rate of oxygen uptake by nitrifying microorganisms in wastewater treated with activated sludge is presented. It was observed that the nitrification rate in the activated sludge system exposed to magnetic field was higher compared to the system without that effect. The rate of oxygen uptake by the nitrifiers of the second phase of nitrification in the system exposed to magnetic field effect was almost twice as high as in the control system.

1. INTRODUCTION

Scarce information is available on the effect of magnetic field (MF) on biodegradation of organic substrates in wastewater, especially on the transformations of nitrogen compounds. The strength of MF which should be used for improving biological process of wastewater treatment is a crucial problem, which has not been solved. JUNG and SOFER [1] showed that application of MF at the induction of 150 and 350 mT improved phenol biodegradation by immobilized activated sludge. The authors mentioned used a unipolar south MF. In their earlier studies, JUNG et at. [2] showed that MF had a positive effect on phenol biodegradation but at the induction of 490 mT. YAVUZ and ÇELEBI [3] demonstrated that MF at the induction of 17.8 mT generated by solenoid direct current supported a glucose biodegradation by activated sludge. ŁEBKOWSKA [4] reported that static MF at the induction ranging from 5 to 140 mT generated by electromagnet coils enhanced biodegradation of the majority of organic substrates in activated sludge method. RUTKOWSKA-NAROŻNIAK [5] observed that MF at induction of 7 mT generated by permanent magnets improved *p*-nitroaniline biodegradation by the microorganisms of activated sludge.

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The aim of this work was to estimate the efficiency of treatment of synthetic sewage whose composition was similar to that of domestic sewage. In this process, activated sludge periodically recirculated was subjected to MF effect of 40 mT induction by using permanent magnets.

2. MATERIALS AND METHODS

The activated sludge collected from the municipal wastewater treatment plant in Częstochowa, Poland, was tested in this study. It was a synthetic sewage of domestic character, further termed *raw sewage*. Its composition was as follows: 110 mg of peptone, 110 mg of bouillon, 28 mg of K_2HPO_4, 7 mg of NaCl, 4 mg of $CaCl_2 \cdot 2 H_2O$, 2 mg of $MgSO_4 \cdot 7 H_2O$, 20 mg of CH_4N_2O, 20 mg of NH_4Cl, 1 dm^3 of tap water. The proportion of organic components of raw sewage was changed in order to obtain the necessary COD value. The concentrations of mineral substrates were also changed, while the concentration of CH_4N_2O was constant.

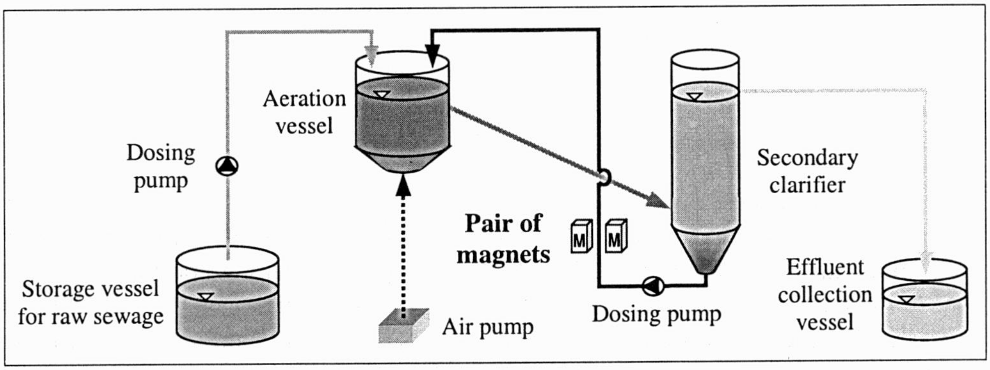

Fig. 1. The scheme of laboratory system

The experiments were performed in two simultaneously operating laboratory systems. Each of the systems consisted of 3.7 dm^3 aeration vessel, a secondary clarifier, the pumps dosing raw sewage and recycling activated sludge, an air pump and storage vessels for raw sewage (influent) and effluent. A total volume of individual laboratory system was equal to 5.8 dm^3. In the first system, a pair of permanent magnets was installed on the pipe used for recycling activated sludge in the secondary clarifier–the aeration vessel system. The permanent magnets were mounted in such a way that MF had a influence only on the activated sludge being recirculated. The test system, where recirculated activated sludge was exposed to MF, was labelled as "M". The second system used as a control was labelled as "C". The scheme of laboratory system with the pair of permanent magnets is given in figure 1. The permanent magnets were located in such way that a maximum induction of MF along the axis of a pipe used for recycling the activated sludge was 40 mT. A glass pipe of 18 mm diameter was centrally located between the magnets. Installation with magnets was calibrated (with measurement accuracy of ±5%) using gaussmeter, model 912 (Magnetic Instrumentation Inc., USA).

The following parameters of raw sewage and effluent from the aeration vessel were determined: COD, total nitrogen (determined according to Kjeldahl method), ammonia nitrogen [6], nitrite and nitrate nitrogen [7]. In activated sludge, suspended solids and dissolved oxygen concentrations were determined [6]. The biodegradation process was controlled based on the rate of oxygen uptake by nitrifying microorganisms [8]. The tests were carried out at the room temperature ranging from 20.7 to 24.4 °C for 20 days. During the experiment the sludge age beneficial for nitrification process was in the range from 15 to 10 days. The dissolved oxygen concentration in the aeration vessel was kept above 2 mg O_2/dm^3. The other process parameters and pollutant concentrations in a raw sewage are given in the table.

Table

The process parameters of wastewater treatment and concentrations of pollutants in a raw sewage

Parameters		Concentration of pollutants	
Hydraulic retention time, *h*	5.2	COD, mg/dm^3	193–845
		Organic nitrogen, mg N_{org}/dm^3	18.1–87.5
Aeration tank loading, g COD/m^3·d	860–3810	Kjeldahl nitrogen, mg N_{Kj}/dm^3	49.5–118
		Ammonia nitrogen, mg N–NH_4^+/dm^3	20.4–47.1
Sludge loading, g COD/g MLSS·d	0.48–1.18	Nitrite nitrogen, mg N–NO_2^-/dm^3	0.02–1.23
		Nitrate nitrogen, mg N–NO_3^-/dm^3	0.08–1.3

3. RESULTS AND DISCUSSION

A periodical exposure of activated sludge to the MF did not improve the removal of organic pollutants. The results obtained show that COD removal from the system where the recycled activated sludge was exposed to MF and from the control system was high ranging from 74 to 91%. The other authors using MF strength in a wide range of induction (from 5 to 460 mT) claimed that MF improved degradation of organic substrate. This statement, however, was true for biodegradation of industrial wastewater [1], [2], [4], [5].

However, the analysis of transformations of nitrogen compounds shows that the most efficient removal of organic nitrogen compounds was observed in the system M (in the system M it ranged from 89 to 99%, and in the system C from 82 to 96%). In each subsequent day of measurements, the organic nitrogen concentration was lower; its value in the system M. was 1.4 to 4.2 times lower compared to the system C (figure 2). A higher rate of the transformation of nitrogen compounds in the system where mag-

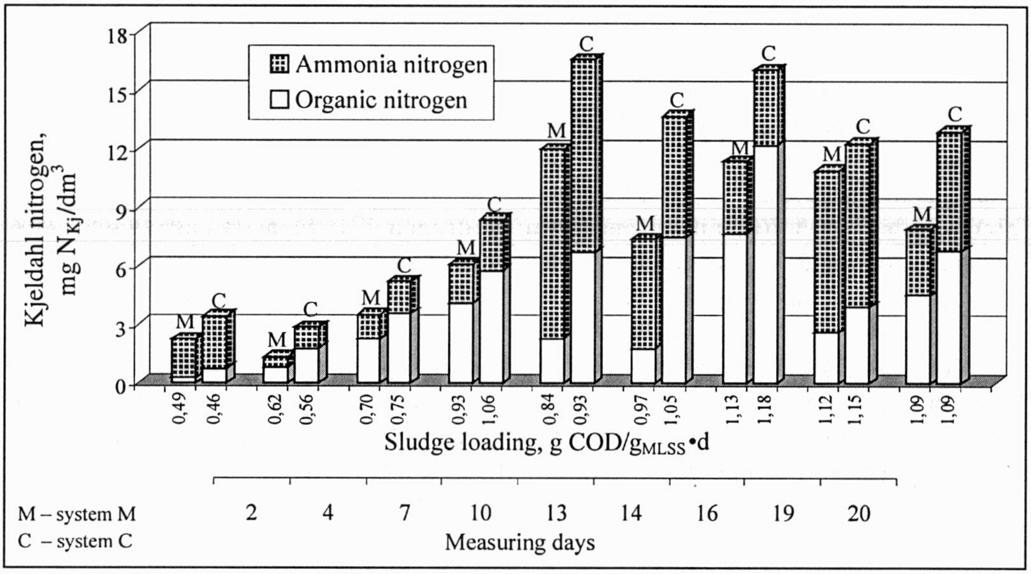

Fig. 2. The concentration of Kjeldahl nitrogen in the effluent versus sludge loading in subsequent days of measurements

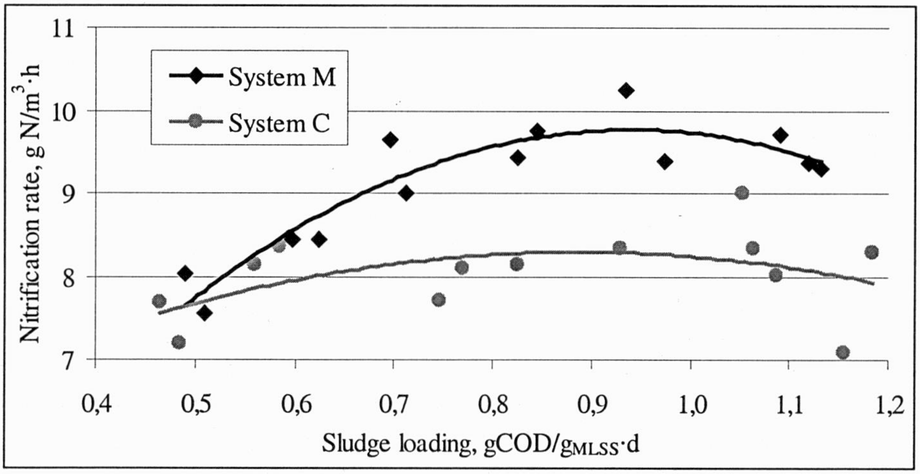

Fig. 3. Nitrification rate versus sludge loading

nets were installed was also corroborated by a higher nitrification rate expressed as a sum of nitrite and nitrate nitrogen produced in the biodegradation process in terms of the time of sludge oxidation. These changes in the nitrification rate in terms of the sludge loading are shown in figure 3. The curve representing this dependence for the system M is above the curve representing the system C. The studies on the rate of

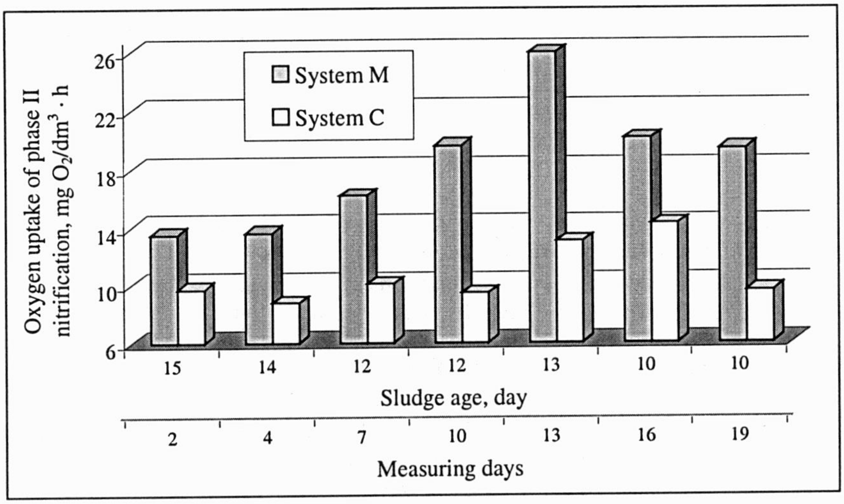

Fig. 4. The oxygen uptake by microorganisms in the second phase of nitrification versus the sludge age in subsequent days of measurements

oxygen uptake by microorganisms of activated sludge showed also that the nitrification process was more effective in the system M. In every day of measurements, the rate of oxygen uptake in the second of phase of nitrification in the system, where recirculated activated sludge was exposed to MF, was 1.4–2.1 times higher than in the system C (figure 4). RUTKOWSKA-NAROŻNIAK [5] also claimed that nitrification was more efficient in the system where MF was applied but at induction of 7 mT. She reported that an increase in nitrate concentration in the sample exposed to the MF effect was 10 times higher than in the control sample [5]. It should be stresses, however, that Rutkowska-Narożniak subjected the microorganisms of activated sludge to a continuous exposure to MF, installing a magnetostatic device directly on the aeration tank. In our studies, the microorganisms of activated sludge were fed through the pipe recycling activated sludge, therefore they were exposed to MF only periodically.

4. CONCLUSIONS

• A periodical exposure of activated sludge to MF at induction of 40 mT produced by permanent magnets did not improve COD removal from sewage whose composition was similar to that of domestic sewage.

• The transformation of nitrogen compounds in the system where activated sludge was periodically exposed to MF at induction of 40 mT was more effective compared to the control system.

• A periodical exposure of activated sludge to MF at induction of 40 mT raised the rate of oxygen uptake by nitrifiers of the second phase.

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WPŁYW POLA MAGNETYCZNEGO NA PROCES OCZYSZCZANIA ŚCIEKÓW METODĄ OSADU CZYNNEGO

Przedstawiono wpływ pola magnetycznego na usuwanie związków organicznych, przemiany związków azotu oraz aktywność oddechową mikroorganizmów nitryfikacyjnych podczas oczyszczania ścieków metodą osadu czynnego. Obserwowano, że szybkość nitryfikacji w układzie wspomaganym polem magnetycznym była większa w porównaniu z układem pozostającym poza jego zasięgiem. Odnotowano również, że aktywność oddechowa niryfikantów II fazy w układach wspomaganych polem magnetycznym była prawie 2 razy większa w porównaniu z układem kontrolnym.