Research about impacts of specific pollutants like herbicides upon microbial activity of activated sludge systems in wastewater treatment plants

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Abstract. The impacts of five types of typical specific pollutants like herbicides (including prometon, propazine, acetochlor, metolachlor and bentazone) upon microbial activity of activated sludge systems in wastewater treatment plants were studied by quantitatively feeding specific pollutants into these systems and measuring changes to specific oxygen uptake rate (SOUR) of the systems. The research results suggest that all these five types of specific pollutants significantly inhibit microbial and aerobic metabolisms of the activated sludge systems. The impacts of these herbicides are arranged as follows according to their degrees: bentazone = prometon = propazine = metolachlor < acetochlor. When the concentration of specific pollutants was 20mg/L in the wastewater, bentazone, prometon, propazine and metolachlor decreased the SOUR of the activated sludge by 17.0%, 28.4%, 25.8% and 31.1% respectively. The SOUR declined by 37.1% when the concentration of acetochlor was 10mg/L. Useful lessons may be drawn from this study for controlling concentration of specific pollutants like herbicides in influents of the wastewater treatment plants in pesticide parks.

1. Introduction

With striking features such as low operating costs, wide scope of application and remarkable effects of treatment, aerobic activated sludge treatment process has become the most widespread and leading one for treating industrial wastewater at present [¹]. However, some highly toxic specific pollutants of influents often have significant impacts upon microbial activity of the activated sludge systems when the aerobic activated sludge treatment process is used. As a result, the degradation efficiency of the activated sludge systems is decreased and the effects of wastewater treatment are affected.

In this study, a wastewater treatment plant of an industrial pesticide park in Binzhou of Shandong Province was exemplified. It mainly receives pretreated wastewater from manufacturers of pesticides like herbicides. Owing to frequent fluctuations in wastewater discharge of pesticide manufacturers, biochemical system of the wastewater treatment plant was impacted in the industrial park. To specify the impacts of specific pollutants in discharged wastewater of pesticide enterprises upon microorganisms of the activated sludge system in the wastewater treatment plant of the industrial park, five types of typical specific pollutants like herbicides were determined based on preliminary research, including prometon, propazine, acetochlor, metolachlor and bentazone, in order to explore their effects.
on these microorganisms and thereby provide references for controlling specific pollutants of the influents for the wastewater treatment plant of this park.

2. Experimental Materials
The activated sledge was taken from the aeration basin of the wastewater treatment plant in an industrial pesticide park of Binzhou.

The raw water of the wastewater was taken from the equalization basin of the wastewater treatment plant of an industrial pesticide park in Binzhou.

Prometon, propazine, acetochlor, metolachlor and bentazone are purchased from a pesticide shop of Jinan.

3. Experimental Methods
SOUR was one of the important parameters which characterize microbial activity of activated sludge systems for wastewater treatment, it reflects physiological state, mechanisms and metabolic state of microorganisms in activated sludge from the perspective of the respiration rate \(^2\)-\(^3\). As a parameter for detecting microbial activity of activated sludge, SOUR has been generally recognized and widely used by scholars home and abroad for analyzing, evaluating and predicting operating conditions and treatment capacity of the systems \(^4\)-\(^7\).

The experimental methods were introduced as follows: 5L activated sludge was settled for 15min and 2L supernatant was taken out by siphonage. Then, 2L raw water of wastewater was added into it. After stirring and mixing, specific pollutants, including prometon, propazine, acetochlor, metolachlor and bentazone, were added at the prescribed doses. Sgitator was started to keep mixing the muddy water, and the air pump was turned on for aeration. The dissolved oxygen of the sludge treatment system was measured online, and the aeration was suspended when the concentration of the dissolved oxygen was approximately 6.0 mg/L. Subsequently, initial and final numerical values of dissolved oxygen (DO) and time were recorded with a dissolved oxygen meter and a timer. Next, the concentration of mixed liquor volatile suspended solids (MLVSS) was measured for the activated sludge, and the SOUR of the sludge was calculated according to the following formula.

$$\text{SOUR} = (\text{DO}_{\text{initial}} - \text{DO}_{\text{final}}) \frac{(\text{mg/L})}{(\text{t}_{\text{initial}} - \text{t}_{\text{final}}) \text{(h)}} \times \text{MLVSS (g/L)}$$

4. Results and Discussions

4.1. Impacts of Prometon upon SOUR of the Activated Sludge System
The tested system of SOUR was shown in Fig 1 as follows when no prometon was fed and it was fed at different dosages, including 5mg/L, 10mg/L and 20mg/L.

![Figure 1. Impacts of Prometon upon SOUR of the Activated Sludge System](image)

From Fig 1, it has been discovered that without prometon, the SOUR of the activated sludge system was about 2.5mg- O\(_2\)/g-vss.h. When prometon was fed at 5mg/L, 10mg/L and 20mg/L, the SOUR got to decline drastically at the 4\(^{th}\) minute and generally kept stable thereafter. On average, it was declined
by 7.62%, 11.3% and 25.8% respectively at these doses. This suggests that the metabolic activity of microorganisms would be inhibited in the activated sludge system if prometon exists in the wastewater.

4.2. Impacts of Propazine upon SOUR of Activated Sludge System
The tested system of SOUR was respectively measured when propazine was fed at 5mg/L, 10mg/L and 20mg/L, as shown in Fig 2 as follows.

![Figure 2. Impacts of Propazine upon SOUR of the Activated Sludge System](image1)

It has been observed from Fig 2 that when propazine was fed at 5mg/L, the SOUR of the activated sludge system has been slightly impacted and declined by about 3.7%. As it was fed at 10mg/L and 20mg/L respectively, it could decrease by 12.3% and 31.1% respectively. This indicates that the metabolic activity of microorganisms would be inhibited in the activated sludge system when there was propazine in the wastewater.

4.3. Impacts of Metolachlor upon SOUR of Activated Sludge System
The tested system of SOUR was respectively measured when the metolachlor was fed at 5mg/L, 10mg/L and 20mg/L, as shown in Fig 3 as follows.

![Figure 3. Impacts of Metolachlor upon SOUR of Activated Sludge System](image2)

It has been discovered from Fig 3 that SOUR of the activated sludge system was affected a little and declines by about 4.2% when metolachlor was fed at 5mg/L. It dropped by 10mg/L and 20mg/L respectively when the metolachlor was fed at 10mg/L and 20mg/L respectively. This reveals that the metabolic activity of microorganisms would be inhibited in the activated sludge system when metolachlor exist in the wastewater.
4.4. Impacts of Acetochlor upon SOUR of Activated Sludge System

The SOUR was respectively measured when the acetochlor was fed at 3mg/L, 5mg/L and 10mg/L, as shown in Fig 4 as follows.

![Figure 4. Impacts of Acetochlor upon SOUR of Activated Sludge System](image)

It has been observed from Fig 4 that the SOUR of the activated sludge system declined significantly by 7.4%, 14.8% and 37.1% respectively when acetochlor was fed at 3mg/L, 5mg/L and 10mg/L. The metabolic activity of microorganisms was even inhibited to a great extent in the activated sludge system when acetochlor was fed at a low dose. Thus, it was significantly much more effective for inhibiting toxicity of microorganisms in the activated sludge system than prometon, propazine and metolachlor.

4.5. Impacts of Bentazone upon SOUR of Activated Sludge System

The tested system of SOUR was respectively measured when the bentazone was fed at 5mg/L, 10mg/L and 20mg/L, as shown in Fig 5 as follows.

![Figure 5. Impacts of Bentazone upon SOUR of Activated Sludge System](image)

It has been observed from Fig 5 that SOUR of the activated sludge system declined by 4.8%, 10.1% and 17.0% on average respectively when the bentazone was fed at 5mg/L, 10mg/L and 20mg/L. Bentazone was effective for inhibiting metabolic activity of microorganisms in the activated sludge system. However, it was less effective for inhibiting such activity than prometon, propazine, acetochlor and metolachlor in case of the same dose.

5. Conclusions

- Specific pollutants like herbicides, including prometon, propazine, acetochlor, metolachlor and bentazone, may significantly inhibit microbial activity of microorganisms in activated
sludge systems of wastewater treatment plants, and become increasingly more effective for inhibiting the activity with the increase of their concentration.

- All five types of specific pollutants inhibit anaerobic metabolism of microorganisms in the activated sludge system and their impacts are arranged as follows in view of their degree: bentazone\(\approx\)prometon\(\approx\)propazine\(\approx\)metolachlor\(\approx\)acetochlor. In case that the concentration of specific pollutants was 20mg/L in the wastewater, bentazone, prometon, propazine and acetochlor contribute to a decline of SOUR by 17.0%, 28.4%, 25.8% and 31.1% respectively in the activated sludge system. When the concentration of acetochlor was up to 10mg/L, the SOUR of the activated sludge system would decrease by 37.1%. Useful lessons may be drawn from this study for controlling the concentration of specific pollutants like herbicides in the influents of wastewater treatment plants of pesticide parks.

References

[1] WANG Zhi-hai, WEI Hong-bin, JIA Zhi-yu, et al. Activated sludge process for treatment of formaldehyde wastewater[J]. China water & wastewater. 2009,25(1): 86-88.

[2] GAO Chun-di, PENG Yong-zhen, GAO Kai, et al. On-line detection of oxygen uptake rate in SBR process and error analysis[J]. Industrial Water and Wastewater, 2001, 32(2): 4-7.

[3] SUN Yan, LI Ruo-gu, ZHANG Yan-qiu. Determination of the our in wastewater treatment plants with a manometric respiromete[J].Energy Environmental Protection. 2011(01): 19-22.

[4] PAMBRUN V, PAUL E, SPERANDIO M. Control and modelling of partial nitrification of effluents with high ammonia concentrations in sequencing batch reactor[J].Chemical Engineering and Processing: Process Intensification, 2008, 47(3):323-329.

[5] WANG Shu-tao, LI Su-ping, WANG Wei-qing, et al. Impact of ZnO nanoparticles on the activity of the activated sludge in SBR[J].China Environmental Science. 2014,34(10): 2575-2580.

[6] SONG Ying-hao, WANG Kai-jun, NI Wen, et al. Study on measurement of inhibition kinetic constant based on respiration rate in activated sludge process[J].Chinese Journal of Environmental Engineering. 2008,2(04): 493-497.

[7] SONG Ying-hao, WANG Kai-jun, NI Wen, et al. Study on judgment of inhibition type based on respiration rate in activated sludge process[J].Environmental protection Science. 2008,34(05): 7-9.