Research on the Cotreatment of Landfill Leachate with Ozone and Electromagnetic Technology

Z S Wang[1, 2, 3, *], Z Y Jiang[1, 2, 3], M C Chi[3] and T Y He[3]

[1]State Key Laboratory of Biobased Material and Green Papermaking, Qilu University of Technology, Shandong Academy of Sciences, Jinan, 250353
[2]Key Laboratory of Pulp & Paper Science and Technology of Education Ministry of China, Jinan, 250353
[3]College of Paper and Plant Resources Engineering, Qilu University of Technology (Shandong Academy of Sciences), 3501 Daxue Rd, Changqing district, Jinan city, Shandong Province, P.R.China

Corresponding author and e-mail: Z S Wang, wzsylq@aliyun.com

Abstract. The optimum technological conditions were investigated and the removal rates of BOD (BOD_5), COD, SS and AN (Ammonia Nitrogen) were obtained by using the ozone generator and electromagnetic technology to treat municipal landfill leachate. These results showed that the removal rates of BOD, COD, SS and AN reached to 83.7%, 53.1%, 85.4% and 57.8% using ozone generator to treat them for 90 min respectively. Subsequently, the treatment of municipal landfill leachate was continuously treated via graphite electromagnetic device. The result exhibited that the optimal treatment condition was as follows: voltage 9.2 V, current 1.72 A, the number of graphite plates in series 10, plate distance 3.24 mm and the treatment time 25 min. The removal rates of BOD, COD, SS and AN were 89.9%, 76.0%, 89.3% and 78.8%, respectively in this condition.

1. Introduction

Landfill leachate is a kind of high concentration wastewater with high pollution and complex composition. It mainly comes from the water contained in the garbage, the precipitation of the landfill and the moisture were produced by the pollutants in the landfill due to the compaction and microbial decomposition [1]. Landfill leachate has complex composition, usually is dark black with a certain irritating smell. The landfill leachate consists of inorganic pollutants (such as heavy metal ions, inorganic salts, and so on), organic pollutants (such as high concentration organic acids, alcohol and other organic waste liquid, etc.) and microbes (colibacillus and other harmful microorganisms, etc.)[2].

Ozone is a strong oxidant with oxidation potential of 2.07 V. Ozone has the characteristics of quick reaction with organic matter without secondary pollution, local production, easy availability of raw materials and convenient use [3]. Ozone can react with soluble and insoluble pollutants in water to convert complex organic matter into simple organic matter, and changes the polarity, biodegradability and toxicity of pollutants, and greatly reduces COD, BOD, SS and AN (Ammonia Nitrogen, the same below)

Wang, Z., Jiang, Z., Chi, M. and He, T.
Research on the Cotreatment of Landfill Leachate with Ozone and Electromagnetic Technology.
In *Proceedings of the International Workshop on Environmental Management, Science and Engineering (IWEMSE 2018)*, pages 409-415
ISBN: 978-989-758-344-5

in water. Excess ozone can be decomposed into oxygen by itself. Ozone wastewater treatment is an effective, environmental-friendly and energy-saving method [4].

During the treatment of wastewater, the basic principle of electrolysis and electromagnetism is that the harmful substances in the wastewater are enriched on both anode and cathode, subsequently, they are oxidated and reduced, respectively, thereby converting them into harmless substances or separating and concentrating them to achieve the purification and separation of wastewater [5].

Graphite electrode was considered as a good electromagnetic sewage treatment electrode selection with long service life due to its excellent electrical conductivity, high temperature resistance, chemical corrosion resistance, excellent chemical stability [6].

In this paper, the landfill leachate was treated via the ozone and optimized the treatment process. In order to further treat sewage, the electromagnetic technology was firstly proposed to continuously deal with the above sewage, leading to the further reduction of the COD , BOD, SS and AN in waste water and reach to the wastewater discharge standard, thereby realizing the sewage reuse.

2. Experiment

2.1. Experimental instruments and chemicals

Electric drying oven with forced convection (DHG-9140A,Gongyi Yuhua instruments co., Ltd.); BOD detector (LH-BOD601A, Lianhua Technology); Energy saving COD constant temperature heater (JHR-2, Shanghai Yetuo instrument Co., Ltd.); UV-Vis Spectrophotometer (Agilent, USA); Ozone generator (Qingdao ODO environmental technology development Co., Ltd); Slag water separator (self-made). Municipal landfill leachate from the Qihe refuse treatment plant. Potassium dichromate digestion solution (self-made); Potassium sodium tartrate standard solution (self-made); Nessler's reagent (self-made).

2.2. Experimental method

2.2.1. Ozone treatment method. The volume of waste water used in the experiment is 22, 000 mL. The wastewater was treated by ozone and electromagnetic cooperation, and ozone was first used for 1.5 hours. The experimental process of ozone wastewater treatment is shown in Figure 1.

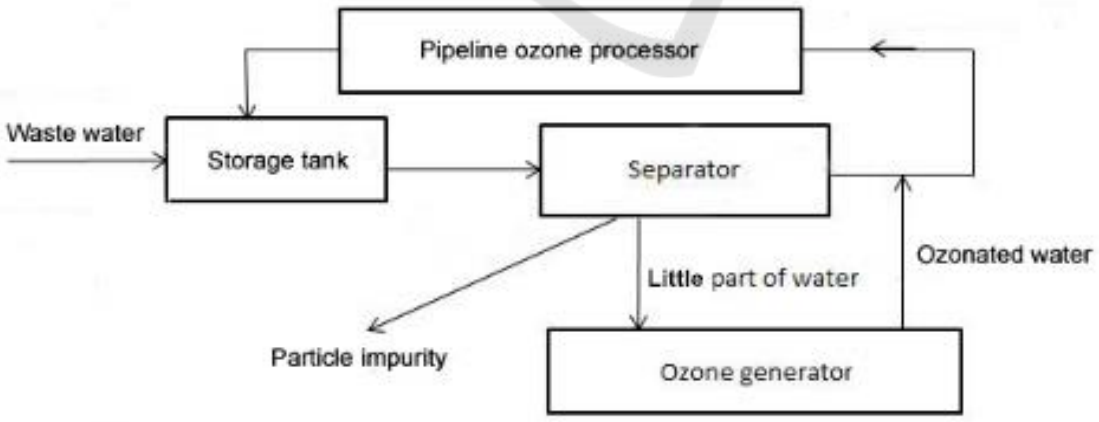

Figure 1. The experimental flow chart of ozone wastewater treatment.

2.2.2. Electromagnetic treatment method. The graphite plate with microporous structure is used as electrode in this experiment, which provides a large specific surface area and a uniform flow channel,

and provides a greater current density and better catalytic reaction effect for wastewater treatment. A special graphite electrode plate is used to recycle the wastewater sample. The experimental device is shown in Figure 2.

By changing the variables such as current and voltage, distance between electrode plates and reaction time, the effects of these factors on the treatment of wastewater by electromagnetic technology were researched, and the optimum technological conditions were obtained.

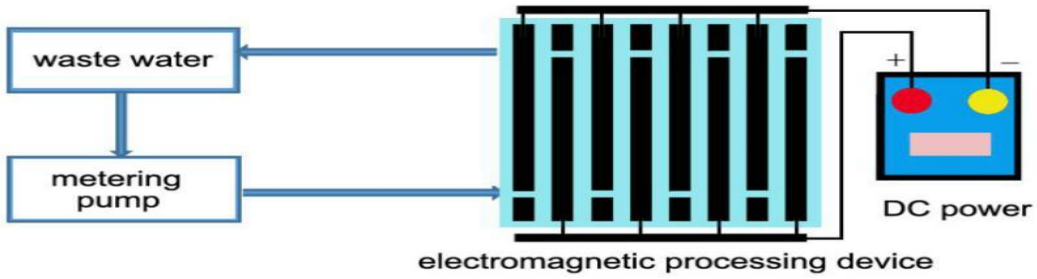

Figure 2. The diagram of the experimental equipment for electromagnetic processing.

3. Results and discussions

3.1. Ozone treatment process

Ozone water was prepared by using the purchased ozone generator. The ozone concentration of ozone water was determined by KI-$Na_2S_2O_3$ method and the value was 14.4 ppm. The waste leachate was treated by ozone generator, and the curves of COD, BOD (BOD_5, the same below), SS and AN with the treatment time were shown in Figure 3.

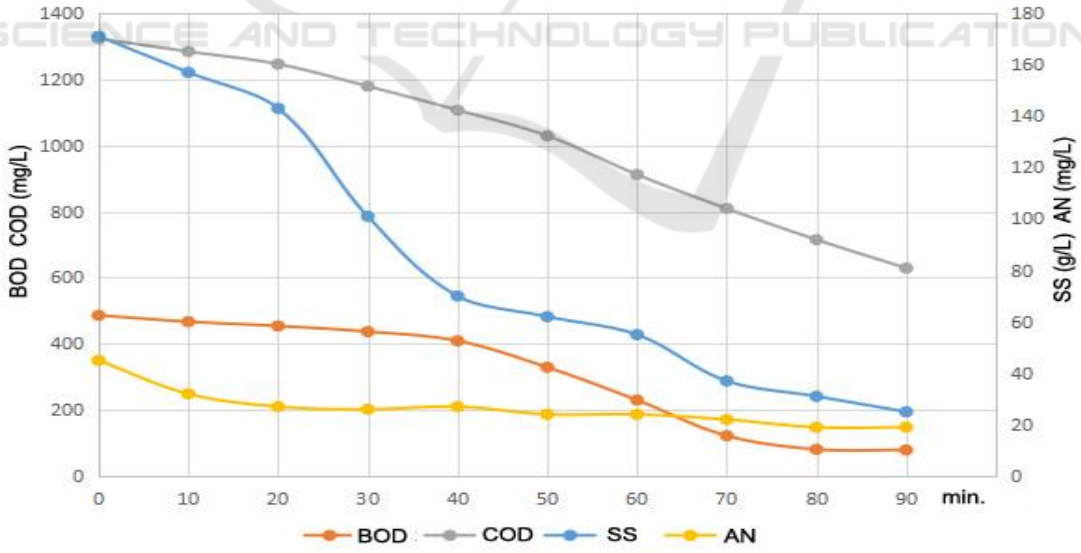

Figure 3. The variation curves of COD, BOD, SS and AN with ozone treatment time.

As shown in Figure 3, the COD, BOD, SS and AN of landfill leachate decreased with the enhancement of ozone treatment time. After 90 min, it was reduced 83.7%, 52.5%, 85.4% and 57.8%

from 486mg/L,1323mg/L,171g/L,45mg/L to 79mg/L, 629mg/L, 25g/L, 19mg/L respectively. Obviously, the reduction of BOD and SS after ozone treatment was much larger than that of 80%, while the decrease of COD and AN was about 50%. The result indicated that ozone treatment has obvious effect on organic pollutants in sewage.

3.2. Electromagnetic treatment process

Further treatment of waste leachate treated by ozone using electromagnetic device:

(1) The control voltage was 5.1 V, the current was 0.74 A, 2 pieces of graphite plate and the distance between the graphite plates was 1.08mm (between the two plates was a layer of insulation net). The curve of the change of the control voltage with the treatment time was shown in Figure 4.

It could be observed in Figure 4, in 0-30 minutes, the COD, BOD, SS and AN of the leachate have a decreasing tendency with the increase of the electromagnetic processing time. Before processed, the amount of BOD, COD, SS, AN was 79 mg/L, 629 mg/L, 25g/L and 19 mg/L, respectively. And after 30 minutes, it went down to 65mg/L, 565 mg/L, 17g/L, 12mg/L, reduced to 17.7%, 10.2, 32.0%, 36.8% respectively. It was obvious that the reduction of BOD and COD was not significant after electromagnetic treatment, while the decrease of SS and AN was more than 30%. It can be found that the more suitable electromagnetic treatment time was 25 min.

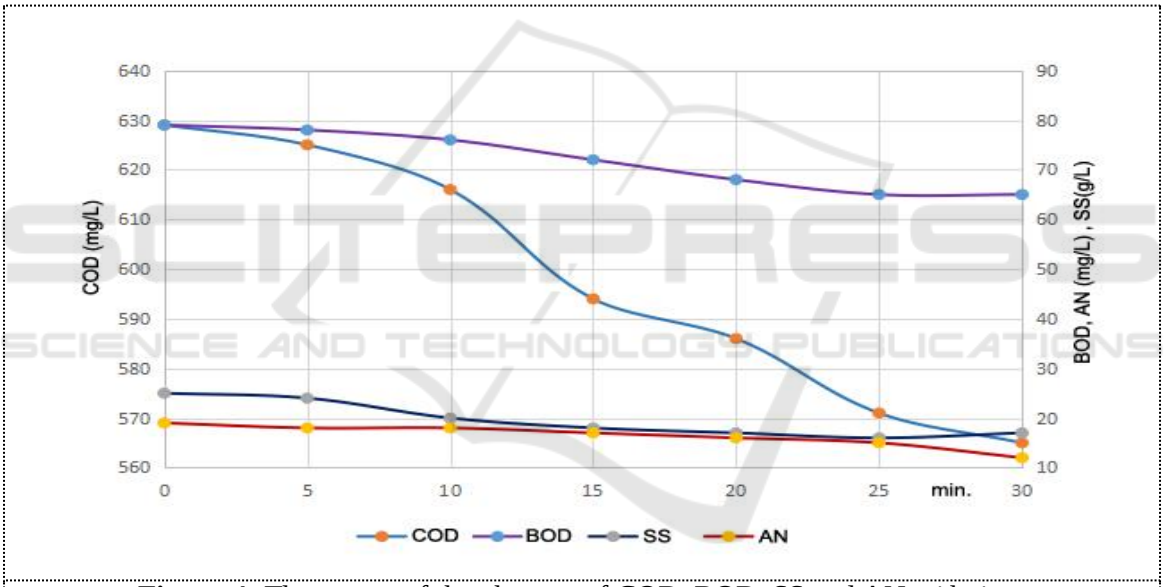

Figure 4. The curves of the changes of COD, BOD, SS and AN with time.

(2) Control voltage 5.1 v, current 0.74 A， 2 graphite plates, treatment time 25 min, change the electrode plate distance. The curves of the changes of COD, BOD, SS and AN with plate distance are shown in Figure 5.

(3) In the Figure 5, it can be seen that with the increase of plate distance, the index value of sewage decreases slowly but the change is very slight. The result suggested that the distance between electrodes has no great effect on the treatment of electromagnetic sewage.

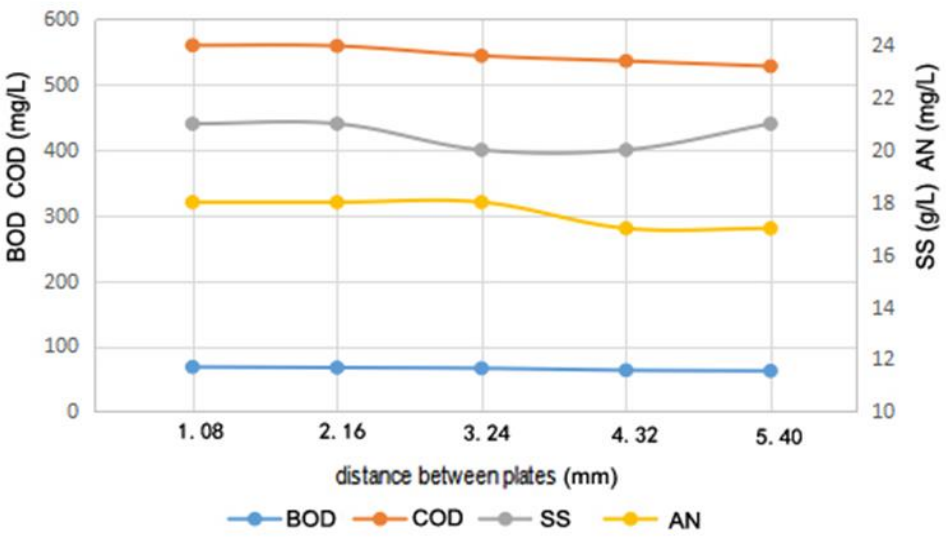

Figure 5. The curves of the changes of BOD，COD，SS and AN with plate distance.

(4) Control voltage 5.1V, current 0.74A, graphite plate distance 3.24 mm, reaction time 25 min. The effect of the number of electrode plates on sewage treatment was also studied, and the result was shown in Table 1.

As shown in table 1, with the increase of the number of graphite electrode plate, sewage BOD, COD, SS, AN were reduced, and the removal effect was most obvious when the number increased to 10. Continuously increasing the number of electrode plates, almost no significant changes have been observed in Table 1. Therefore, the optimum number of electrode plates for electromagnetic treatment under this condition was determined to be 10.

Table 1. The effect of the number of electrode plates on sewage treatment.

The number of electrode plates	2	4	6	8	10	12
BOD	79	60	58	55	51	51
COD	629	519	507	496	480	482
SS	25	20.9	20.5	19.8	18.3	18.3
AN	19	17	16	14	12	12

(5) Controlling the distance of graphite electrode plate to 3.24 mm, the number of graphite plate 10, the processing time 25 min. By adjusting the voltage and current, the variation of each performance index is determined. The curves of the changes of COD, BOD, SS and AN with voltage and current were shown in Figure 6.

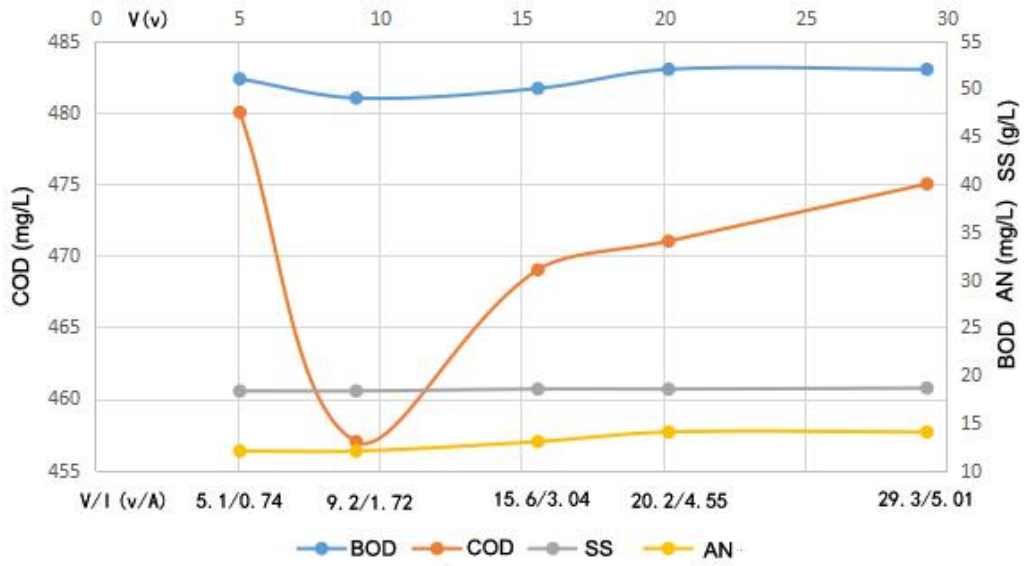

Figure 6. The effect of voltage/current on sewage treatment.

It was clear in Figure 6 that when the voltage varied from 5V to 10V, with the increase of rated voltage and current, the value of BOD and COD of the wastewater decreased from 51mg/L and 480mg/L to 49mg/L and 457 mg/L, which decreased by 3.9% and 4.8% respectively, while SS and AN have no change. When the voltage was between 10 and 30 v, with the increase of rated voltage and current, the BOD, COD, AN and SS of waste water increases, and the voltage of 29.3V is increased by 6.1% , 3.9%, 1.6% and 16.7% respectively, compared with the voltage of 9.2V. This result showed that under the above conditions, the electrified voltage/current of sewage treatment was the best choice at 9.2V/1.72A.

(6) Under the experimental conditions, the landfill leachate was treated with ozone generator for 90 minutes, then control the voltage at 9.2 V, the current at 1.72 A, the number of electrode plates is 10, and the electromagnetic technique is used for 25 minutes.The experimental data of ozonic-electromagnetic treatment of landfill leachate is shown in table 2. As can be seen from table 2, the BOD, COD, SS and AN of landfill leachate decreased to 49mg/L, 317mg/L, 18.3g/L, and 49mg/L from pretreatment 486mg/L, 1323mg/L, 171g/L and 45mg/L, and the removal rates were 89.9%, 76%, 89.3% and 77.8% respectively, and the treatment effect is good.

Table 2. The experimental data of ozonic-electromagnetic treatment of landfill leachate.

	BOD（mg/L）	COD（mg/L）	SS（g/L）	AN（mg/L）
Before treatment	486	1323	171	45
After ozone treatment	79	629	25	19
Reduced %	83.7	52.5	85.4	57.8
After ozonic - electromagnetic treatment	49	317	18.3	10
Reduced %	89.9	76.0	89.3	77.8

4. Conclusions

The composition of landfill leachate was complex and was difficult to deal with them via the conventional biochemical technology. However, good results have been achieved by using ozone-electromagnetic technology. After being treated for 90 min via ozone generator, the experimental results showed that the removal rates of BOD, COD, SS and AN reached to 83.7%, 53.1%, 85.4% and 57.8%, respectively. Subsequently, the municipal sewage was continuously treated by graphite electromagnetic technology. The optimal treatment conditions were as follows: voltage 9.2 V, current 1.72 A, and the number of graphite plates in series 10, the plate distance 3.24 mm, the cycle treatment time for 25 min, the removal rates of BOD, COD, SS and AN reached to 89.9%, 76.0%, 89.3% and 77.8% respectively. This work demonstrated the the cotreatment both ozone treatment and electromagnetic technology may offer an attractive approach for the the purification and separation of wastewater.

Acknowledgement

The project supported by the Foundation (No.ZR201706) of Key Laboratory of Pulp and Paper Science and Technology of Ministry of Education/Shandong Province of China. The authors are grateful for the financial support from the National Key Research and Development Program of China (Grant No. 2017YFB0307900), the National Natural Science Foundation of China (Grant No. 31470602, 31670595, 31770628), the Provincial Key Research and Development Program of Shandong (Grant No. 2016CYJS07A01) and the Taishan Scholars Program.

References

[1] Li H W 2005 *Study on the treatment of black liquor and middle stage water in papermaking wastewater* [D]. Harbin University of Technology p33

[2] Tan Q X 2016 Municipal landfill leachate treatment technology and method *Engineering Technology* 2 No.15: 25-32

[3] Yang B Y 2016 Application of landfill leachate treatment technology *Resource Information and Engineering* 12 31 No.6: 56-62

[4] Zou C W, Xu M S and Huang H 2016 Treatment technology of landfill leachate *Environment and Development* 16 No.3:23-25

[5] Zhang H 2014 *Study on landfill leachate treatment technology D*. Central China Normal University p23

[6] Wang H 2015 *Experimental study on the treatment of landfill leachate reverse osmosis solution* D. Qingdao Technological University p15