

# Effect on Treatment of the Landfill Leachate with the Furrow Irrigation in Onland Planting Reed (*Phragmites*)

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## ABSTRACT

The furrow irrigation tests were done to estimate the efficiency of the HRT (Hydraulic Retention Time) and landfill leachate collected from Dalian Maoyingzi Municipal Solid Waste Landfill, which contained high level of COD (Chemical Oxygen Demand,  $3.8 \times 10^4 \text{ mg}\cdot\text{L}^{-1}$ ), TOC (total carbon,  $4.8 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$ ), TN (total nitrogen,  $2.9 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$ ) and SS (Suspended Solids,  $6.5 \times 10^2 \text{ mg}\cdot\text{L}^{-1}$ ), using the reed (*phragmites*) cultivated onland located in south area of Dalian Jiaotong University. The results showed that: 1) The TN concentration was decreased from  $9.8 \times 10^2 \text{ mg}\cdot\text{L}^{-1}$  in the landfill leachate to  $7.6 \times 10^2 \text{ mg}\cdot\text{L}^{-1}$  in the soil water, and the 22.4% of the removal rate; 2) The TOC concentration was decreased from  $4.8 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$  in the landfill leachate to  $1.0 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$  in the soil water, and the 79.2% of removed rate; 3) The water concentration in the soil was no significant difference of irrigation between the water and the landfill leachate; 4)  $\Delta\text{HRT}$  was 2.1 hours in irrigation 39 L of the water and landfill leachate and 1.3 hours in the 9 L.

**Keywords:** Cultivated Onland; Landfill Leachate; Total Nitrogen (TN); Total Carbon (TOC)

## 1. Introduction

There are many project cases and researches on treating the landfill leachate with constructed wetland around the world. For example, Ithaca Landfill in New York in the USA started to treat the landfill leachate with constructed wetland in 1989 [1]. Chunchula Landfill in the city named Mobile in Alabama in the USA mixed the wastewater and landfill leachate together and treated with constructed wetland, and expelled at the standard [2]. Des Moines area in Aihua Florida in the USA treated the landfill leachate with constructed wetland, and the removal rate was significant [3]. Perdido Landfill in Escambia in Finland is running and treating the landfill leachate with constructed wetland for 13 years in cold temperature. Canada, United Kingdom, Australia and Poland and some other countries applied to the constructed wetland system process for landfill leachate [4]. Laogang Landfill in Shanghai in China has a certain scale and effective application on treating the landfill leachate with constructed wetland by the way of "Facultative anaerobic pond + Facultative anaerobic and aerated ponds + Aeration pond + Constructed Wetland" [5], and the average removal rate of COD was 66% [6]. The city named Monroe in New York in the USA treated the landfill leachate from Northeast-quadrant Solid Waste Facility

after sealing of landfill with constructed wetland, and the average removal rate of COD was 68%. Dragonja Landfill in Slovenia treated the landfill leachate with constructed wetland, and the average removal rate of COD was 68% [7]. Esva Landfill in Norway treated the landfill leachate by the way of "Oxidation pond + constructed wetland", the HRT was 40d, and the average removal rate of COD was 88% [8,9]. But there is little reach on treating the landfill leachate with the method of land fill leachate preferential flow and reflowing tests on undisturbed soil cuboids in cultivated onland.

Cultivated onland treatment of landfill leachate is a relatively new wastewater treatment technology, and was attention and gradually applied in recent decades [10-16]. Landfill leachate has a large concentration of pollutants, black, dark green and chocolate color, and complex components, so it's hard to treat by tradition ways. As investigation that the main treatment of landfill leachate in China is reverse osmosis, and it has good treatment effect, but there are running unstable, expensive, consume large and some other shortcomings [17-22]. In addition, there is no effective disposal traditional way for the production of concentrated solution, and any mistake will cause secondary pollution. Therefore, research on cultivated onland treatment of landfill leachate is of great

significance, the applicable criteria that follow.

## 2. Materials and Methods

### 2.1. Materials

The landfill leachate was collected from Dalian Mao-yingzi Municipal Solid Waste Landfill, which contained high level TN ( $9.8 \times 10^2 \text{ mg}\cdot\text{L}^{-1}$ ) and TOC ( $4.8 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$ ). Its color was dark brown and smelled bad. The cultivated onland located in the South Area of Dalian Jiaotong University. The main onland plant was reed (*Phragmites*) with a spacing of 0.5 m, and the roots extended about 30 cm depth under the onland surface. Preparing instruments and medicines used for analyzing the TN and TOC by international standard methods, and Marriott Bottles, polyethylene plastic films, collecting basins, tape measure, shovel, pickaxe, scraper knife, adhesive tapes, sieve, bezel and some other equipment and tools.

### 2.2. Methods

The schematic diagram of experiment ground can be seen from Figures. Digging the soil in between the reed of 2 ridges with long (1 m), wide (0.34 m) and depth (0.25 m), and became the furrow, and dripping the landfill leachate (**Figure 1**) and the deionized water (**Figure 2**) into the furrow with two times, irrigating the volume



Figure 1. Landfill leachate treatment of furrow irrigation.



Figure 2. Deionized water treatment of the furrow irrigation.

of the water and the landfill leachate was 39 L and 9 L, respectively. The experiment was 4 times of repeats. While the water and the landfill leachate had permeated the ground, having been taken 1 kg of the soil nearby 5 cm of the furrow were 12 samples, and N, C and water concentrations in the samples were measured by semi-micro-Kjeldahl azotometer, external heating potassium dichromate and drying and weighing method.

## 3. Results and Discussion

### 3.1. Total Nitrogen Contents in the Landfill Leachate and the Soil

Total nitrogen in the 48 L of the landfill leachate is 47.14 g, and the soil (volume  $1.00 \times 0.25 \times 0.34 \text{ m}$ , density  $2.65 \text{ g}/\text{cm}^3$  and background value  $0.58 \text{ g}/\text{kg}$ ) is 130.65 g. It is 177.79 g of both in the landfill leachate and the soil. The total nitrogen content in the soil might be  $0.79 \text{ g}/\text{kg}$  as the theory. In 1 day after treatment, the  $0.76 \text{ g}/\text{kg}$  its content was measured (**Figure 3**), The content was very significantly different ( $P < 0.01$ ) from the deionized water ( $0.53 \text{ g}/\text{kg}$ ) and background value ( $0.58 \text{ g}/\text{kg}$ ). The landfill leachate surely increases the nitrogen concentrations in the soil. No significant difference ( $P > 0.05$ ) of the contents was measured between the deionized water and the background value. The TN concentration was decreased from  $9.8 \times 10^2 \text{ mg}\cdot\text{L}^{-1}$  in the landfill leachate to  $7.6 \times 10^2 \text{ mg}\cdot\text{L}^{-1}$  in the soil water, and the 22.4% of the removal rate.

### 3.2. Total Carbon Contents in the Landfill Leachate and the Soil

The total carbon of 48 L of the landfill leachate is 228.77 g, and the soil (volume  $1.00 \times 0.25 \times 0.34 \text{ m}$ , density  $2.65 \text{ g}/\text{cm}^3$  and background value  $4.67 \text{ g}/\text{kg}$ ) is 1051.92 g. It is 1280.69 g of both in the landfill leachate and the soil. The total carbon content might be  $5.69 \text{ g}/\text{kg}$  as the theory. In 1 day after treatment, the  $10.01 \text{ g}/\text{kg}$  of its content was measured (**Figure 4**). The content was very significantly different ( $P < 0.01$ ) from it in the treatment of the deionized water ( $7.81 \text{ g}/\text{kg}$ ) and background value ( $4.67 \text{ g}/\text{kg}$ ); the contents in the treatment of the deionized water was very significantly different ( $P < 0.01$ ) from the background value. Water and landfill leachate surely increase the total carbon contents. The TOC concentration was decreased from  $4.8 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$  in the landfill leachate to  $1.0 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$  in the soil water, and the 79.2% of removed rate.

### 3.3. Water Contents and Hydraulic Retention Time

In the 1 day after the treatments, the average water contents of the background value, the deionized water and

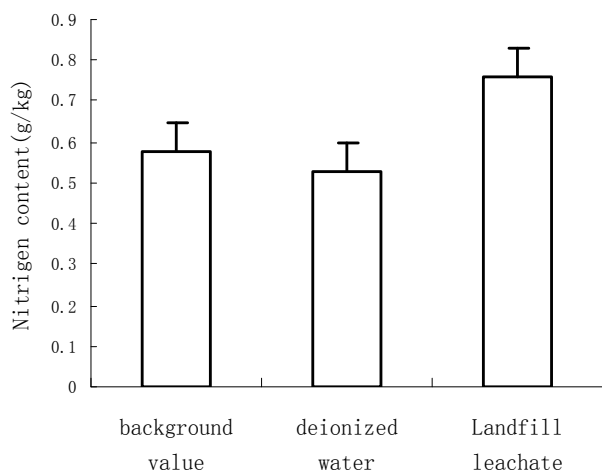


Figure 3. Total nitrogen contents.

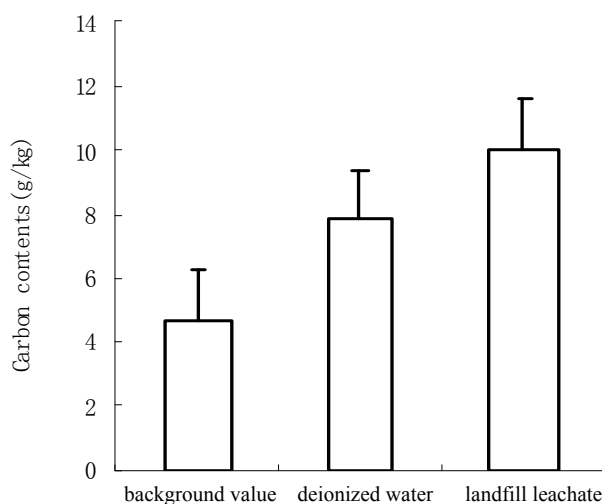


Figure 4. Total carbon contents.

the landfill leachate in the soil were 9.51%, 17.23% and 17.18%, respectively. It ranged from 7.41% to 10.71% in the soil of the background value, from 12.50% to 20.00% in soil of the deionized water and from 15.79% to 18.52% in the soil of the landfill leachate. It was no significant difference ( $P > 0.05$ ) of irrigation between the water and the landfill leachate, and background value. First time, HRT of irrigating 39 L the deionized water was 15 hours and it of the landfill leachate was 12.9 hours; then it of the 9 L of the deionized water was 8.3 hours and the landfill leachate was 7.0 hours.  $\Delta$ HRT was 2.1 hours in irrigation 39 L of the water and landfill leachate and 1.3 hours in the 9 L. To some extent, the landfill leachate increased the leakage of water and solute loss, and reduced the HRT of pollutants in soil. It was in accordance with Chen *et al.* [10]. Hydraulic load of the landfill leachate was  $1.70 \times 10^3 \text{ m}^3/(\text{ha}\cdot\text{d})$  and it of the deionized water was  $1.45 \times 10^3 \text{ m}^3/(\text{ha}\cdot\text{d})$ , it was 16.9% higher than hydraulic load of the deionized water.

## 4. Conclusion

In 1 day after the treatment of furrow irrigation the landfill leachate, total nitrogen and total carbon remove 22.4 and 79.2% of efficiency rate from  $9.8 \times 10^2$  and  $4.8 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$  in the landfill leachate to  $7.6 \times 10^2$  and  $1.0 \times 10^3 \text{ mg}\cdot\text{L}^{-1}$  in the soil water, respectively. Hydraulic load in the landfill leachate of  $1.70 \times 10^3 \text{ m}^3/(\text{ha}\cdot\text{d})$  was 16.9% higher than it in the water of  $1.45 \times 10^3 \text{ m}^3/(\text{ha}\cdot\text{d})$ . As time goes by, the removal efficiency will be very higher than the 1 day. Furrow irrigating the landfill leachate in growing Reed onland may be a better method of treating the landfill leachate, which more and more will have been permeated by city solid waste.

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