

**Manuscript Number:** water-1799138

**Manuscript Title:** The experience and development of the treatment technology of municipal solid waste leachate in China

**Article Type:** Review paper

**Response to Reviewers' comments**

Dear editor and reviewers:

Thanks a lot for perfect work of Prof. Coral Chen and the Reviewers' detailed comments and suggestions. The manuscript has been revised according to reviewers' comments, and questions have been explained point by point. The accurate positions of revised parts are marked in blue font. The specific discussion and revision are addressed as follows.

**Reviewer #2:**

In this review manuscript, the authors presented the development of the treatment technology of leachate and compared the details with other countries around the world. Also, propose a few suggestions for the future.

**Comment (1):** The first 5 pages or almost half of the manuscript deal with the background of the leachate definition, characteristics, and collection. Only in the second half, the topic as stated in the title is presented. I would suggest shortening the earlier part and focusing more on the treatment technology as suggested by the title.

**Response:** Thanks for the reviewer's suggestion. We deleted some parts of Section 1 and Section 2. Please see it in revised manuscript.

**Comment (2):** Section 1: no references are included to support (only 1 reference included)

**Response:** Thanks for the reviewer's suggestion. We rewrote Section 1. Please see it as follows.

The process of development of the leachate treatment industry corresponded to the development of the Chinese waste treatment industry during different periods. Originally, municipal solid waste disposal in China could be dates back to the 1980s, and the disposal method gradually developed from simple stacking of waste to the modern sanitary landfills[1]. Leachate is a high-concentration organic wastewater which is produced in the process of garbage collection, transportation and disposal[2]. Generally, leachate was mainly divided into landfill leachate, incineration plant, transfer station leachate, and also organic waste anaerobic digested slurry.

With the continuous improvement of the landfill leachate collection system and environmental protection regulations in China, landfill leachate had become a key pollutant in sanitary landfills[3]. These regulations had driven the development of Chinese landfill leachate treatment industry. With the rapid development of economy in China, various waste treatment and disposal technologies also developed rapidly. For example, waste incineration power plants gradually replaced sanitary landfills as a new mainstream waste treatment method[4]. In addition, due to the rapid development of urbanization and increase of garbage collection and transportation distance, the application of transfer stations had gradually been promoted. Since the high-concentration wastewater was collected by waste incineration power plants and transfer stations had similar properties to fresh landfill leachate, these three kinds of wastewater are collectively referred to as leachate. In 2010, four ministries and commissions, including the National Development and Reform Commission and the Ministry of Agriculture of China, issued a notice to select qualified cities or municipalities to carry

out pilot work on resource utilization and harmless disposal of kitchen waste. In 2016, China began to generally implement waste classification nationwide[5]. By the end of 2021, almost cities in China with a population of more than one million had built kitchen waste recycling facilities [6]. Household food waste is generated during the waste classification process, and its physical composition is similar to that of restaurant kitchen waste. These two types of waste are collectively referred to as food waste. The mainstream process technology route adopted for food waste is the pretreatment + wet or dry anaerobic fermentation process[7]. The digested slurry had similar properties to landfill leachate, and it was also classified into municipal solid waste leachate[8].

Due to the complexity and uncertainty of landfill leachate, the disposal technology of landfill leachate was very complicated. In order to improve the ecological environment and provide cost-effective treatment options for managers, the objectives of this review are (1) to summarize the historical process of municipal solid waste leachate treatment in China and analyze the characteristics of landfill in different countries, (2) to summarize processes of leachate treatment and discharge standards at different stages in China, (3) and to prospect and advise the technology for leachate treatment and standards establishment for the future.

## References:

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2. Luo, H.; Zeng, Y.; Cheng, Y.; He, D.; Pan, X. Recent advances in municipal landfill leachate: A review focusing on its characteristics, treatment, and toxicity assessment. *Science of the Total Environment* 2020, 703, 135468.

3. Rajoo, K.S.; Karam, D.S.; Ismail, A.; Arifin, A. Evaluating the leachate contamination impact of landfills and open dumpsites from developing countries using the proposed Leachate Pollution Index for Developing Countries (LPIDC). *Environmental Nanotechnology, Monitoring & Management* 2020, 14, 100372.
4. Li, Y.; Zhao, X.; Li, Y.; Li, X. Waste incineration industry and development policies in China. *Waste Management* 2015, 46, 234-241.
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7. Angelonidi, E.; Smith, S.R. A comparison of wet and dry anaerobic digestion processes for the treatment of municipal solid waste and food waste. *Water and environment journal* 2015, 29, 549-557.
8. Jayanth, T.; Mamindlapelli, N.K.; Begum, S.; Arelli, V.; Juntupally, S.; Ahuja, S.; Dugyala, S.K.; Anupaju, G.R. Anaerobic mono and co-digestion of organic fraction of municipal solid waste and landfill leachate at industrial scale: Impact of volatile organic loading rate on reaction kinetics, biogas yield and microbial diversity. *Science of The Total Environment* 2020, 748, 142462.

**Comment (3):** Most of the tables presented lack the source from where the data presented are obtained.

**Response:** Thanks for the reviewer's advice. In this manuscript, data in Chinese landfills were summarized based on typical domestic cases, including Tianjin Dahanzhuang landfill, Hangzhou Tianzhiling landfill, Wuhan Chenjiachong landfill, Chongqing Changshengqiao landfill, Shenzhen Xiaping landfill. We supplemented references of other countries in revised manuscript. Please see it in revised manuscript.

**Comment (4):** Line 96: stated that “in China have basically achieved a “zero landfill”, ..” could be nice if the authors could include how it was achieved.

**Response:** Thanks for the reviewer’s advice. According to the "Implementation Plan for Strengthening Weaknesses in Urban Domestic Waste Classification and Treatment Facilities" jointly issued by Chinese National Development and Reform Commission, the Ministry of Housing and Urban-Rural Development, and the Ministry of Ecology and Environment, the "primary domestic waste" will be basically realized to "Zero Landfill" by 2023. In areas where the daily removal and transportation of domestic waste exceeds 300 tons, it is necessary to speed up the development of incineration-based waste treatment methods, and moderately overdue the construction of incineration treatment facilities commensurate with the removal and transportation of domestic waste.

We added some contents about how to achieve it. Please see it as follows.

To date, the cities with a population of more than one million in China have basically achieved a “zero landfill” by [incineration treatment](#), and landfills previously in service are also in a state of simple closure.

**Comment (5):** Section 2.4: repetition of fact. no new point is discussed in this comparison.

**Response:** Thanks for the reviewer’s advice.

**Comment (6):** Figure 1: repetition of section 1.

**Response:** Thanks for the reviewer’s advice. We deleted the Figure 1 of the manuscript.

**Comment (7):** Throughout the manuscript Table 5 is referred to as Table 6. It would be nice if the authors could include an economic analysis and sustainability analysis of the 5 stages of the Development history of leachate treatment. (3.1-3.5). Now it is just the chronology of the development of the 5 stages without depth analysis.

**Response:** Thanks for the reviewer's advice. We appologized for this mistake. We corrected this error. We added some discussion about economic analysis and sustainability analysis. Please see it as follows.

With the development of science and technology and the gradual stricter discharge stand-ards, the treatment and disposal technology of landfill leachate has been continuously improved. Processing cost of landfill leachate in different stages was also summarized in Table 6. It showed that the cost increased continuously from 4 to 75 RMB/m<sup>3</sup>. As mentioned above, technology of landfill leachate treatment was gradually changed from physical technology to chemical-physical technology. Recently, membrane technology was gradually used in the landfill leachate technol-ogy, which was the main for the increase in treatment cost[28]. Therefore, there is an urgent need to find cost-effective technologies to treat landfill leachate to meet increasingly stringent dis-charge requirements.

Reference:

28. Ahmed, F.N.; Lan, C.Q. Treatment of landfill leachate using membrane bioreactors: A review. *Desalination* **2012**, *287*, 41-54.

**Comment (8):** Section 4.5: this section need to be enhanced with more input and details.

**Response:** Thanks for the reviewer's advice. We summarised treatment technologies of landfill leachate in recent three years. We rewrote this section and added some discussion. Please see it in revised manuscript.

**Comment (9):** Conclusion: this section is lengthy and is just a repetition of facts in previous sections, could avoid repeating points presented earlier.

**Response:** Thanks for the reviewer's advice. We rewrote the conclusion. Please see it as follows.

(1) The characteristics of the leachate are related to the production mechanism, fermentation cycle and waste composition. With the increase in landfill years, the concentration of ammonia nitrogen in the landfill leachate increases, the biodegradability decreases, and the C/N is out of balance, resulting in leachate being more difficult to treat. Compared with other countries, although the quality of landfill leachate was similar in the middle and late stages, the concentration of pollutants in the late stage leachate in China was higher, which was attributed to the differences in eating habits, landfill size and treatment methods. The leachate generated from incineration power plants had high biochemical properties and pollutant concentrations because it originated from fresh leachate. The leachate from food waste anaerobic digestion had the highest salt content due to the source of cooking additives.

(2) The leachate treatment process mainly underwent through five stages. The treatment process and the emission standard has been continuously improved. In recent years, due to the improvement of environmental protection standards and national environmental protection policies, the treatment process of landfill leachate was mainly “secondary

A/O + ultrafiltration + nanofiltration (NF) + reverse osmosis (RO)” or “pretreatment + secondary A/O+MBR+Fenton Advanced Oxidation+BAF”.

(3) The future development of the landfill leachate treatment industry and the entire environmental protection industry need to meet the requirements of the Chinese social economy and urban development. Under the current general conditions, the future development trend of the leachate treatment industry should enact more scientific emission standards and local standards. Under the background of the global " Dual carbon " strategy, the green ecology of the technical route is represented by new high-efficiency denitrification, new advanced catalytic oxidation, evaporation and other fully quantitative process technologies. In addition, the construction and operation of landfills need to be more professional and intelligent, and the government also needs to formulate strict emission standards.