# Investigating of color removal from landfill Leachate by ozone

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Received:21/4/2024 Accepted: 11/7/2024

## Abstract

Leachate landfills are defined as the aqueous effluent generated by rainwater percolation through wastes, biochemical processes in waste cells, and the inherent water content of wastes themselves. Leachates may contain large amounts of organic matter (biodegradable, but also refractory to biodegradation), They contain non-biodegradable organic matter and nitrogenous compounds. There are different methods for the treatment of composting leachate. Parameters dictating which method to choose include the leachate's quantity and quality, required treatment amount, and economic issues. Therefore, posttreatment of composting leachate using ozonation was considered the main objective of this study. In the ozonation process, the amount of ozone for treating the leachate in optimum condition was determined to be 0.65 gr/h. In this process, a maximum color removal of 85% was attained after 60 minutes of ozonation at pH 9.

**Keywords:** Leachates, landfill, Ozone, Color removal.

## Introduction

The growth of industries and the development of technology in the past few decades has increased the production of solid waste materials. Leachate is formed as a result of water infiltration through sedimentation at a landfill site or through processes of waste volume reduction and waste crushing (Alaa and Mokhtarani, 2016). Also, during biodegradation, compounds in the waste dissolve, causing the production of organic acids, thus lowering the pH and increasing the temperature. These processes are accompanied by the release of interstitial water and increasing the concentration of many pollutants such as organic compounds, ammonia, and heavy metals in the filtrate (Czurda and Haus, 2002; Alaa *et al*., 2021; Alaa *et al*., 2018a; Alaa and Mokhtarani, 2016).

Landfill leachate is a very dark-colored liquid formed primarily by the percolation of precipitation through an open landfill or the cap of the completed site. The decomposition of organic matter such as humic acid may cause the water to be yellow, brown or black (Anastasios *et al.*, 2004).

The common methods to treat the leached material are divided into three main categories. The first category is the method of transporting the leached material, which is divided into two parts: returning the leached material to sanitary burial centers and transferring the leached material to the sewage collection network and treatment with municipal sewage water. The second category is biological methods, which are divided into aerobic and anaerobic methods. As for the third category, it belongs to physical and chemical purification methods, which are divided into chemical oxidation, absorption, chemical precipitation, coagulation, flocculation, flotation, and advanced oxidation ( Hamidi *et al* ., 2007; Alaa *et al.*, 2018b; Alaa and Hasan, 2022).

Other leachate treatment methods include advanced oxidation processes (AOPs) such as ozonation. Today, the ozonation process is widely used in water and wastewater treatment due to the high potential of ozone in oxidation and conversion of decomposable hard components into biologically degradable compounds ( Mohammad *et al* ., 2020; Adnan and Soubh, 2024; Alaa, 2020)

In addition to removing organic and inorganic pollutants, ozone has a very high ability to remove color and odor, and unlike other methods, it does not leave residue or sludge. The use of this method also has disadvantages. For example, due to the variable and complex properties of the leachate, high amounts of input ozone are usually needed, as well as a long period to contact the ozone with the solution and carry out the reactions, which makes the process uneconomical and limited the single application of this method ( I Monje and Orta , 2004)

Based on what we said above and considering the special characteristics of ozone, the research purpose is to study the effect of ozone in treating the color problem of leachate.

## Materials and methods

### Materials

Fresh leachate was obtained from Aradkouh's landfill located in Tehran, Iran. This landfill accommodates 8000 tons of solid waste per day ( Alaa *et al.*, 2018b). It is worth noting that the samples have been stored in plastic-tight vessels at a temperature of 4°C to prevent occurrence of possible changes in physical, chemical, and biological properties up to the time of experimenting with transferring leachate to the laboratory. The initial value of leachate color was 8 Gardner. Before releasing ozone, it is passed through a diluted KI solution

### Analytical methods

Color concentration was determined using a UV/ Vis spectrophotometer (HACH, DR 5000). A Metrohm 691 pH meter was used to measure the pH of the solutions.

### Oxidation experiments

The laboratory model used to conduct this study is illustrated in Fig 1. The ozone contact reactor consisted of a Plexiglas column with a 20 mm inner diameter and 800 mm height. An ozone generator (ARDA-COG 5S) with 5 g hr-1 nominal capacity was used. Ozone content was measured with a BMT-964 ozone analyzer. A rotameter was applied to measure the volume of injected gas in the column. A Varian digital gas flow meter (Dfm-05) with a flow range of 1 to 1000 mL $min^{-1}$ was also supplied to calibrate the rotameter. The continuous $O_3$ gas is introduced into the column

through a diffuser at the bottom of the reactor. To prevent the emission of $O_3$ into the environment, off gas from the reactor was passed through a 2% KI solution.

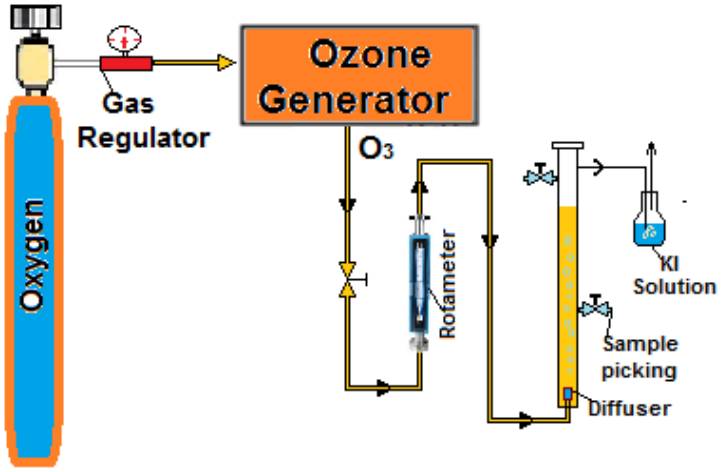


**Fig. 1. Schematic laboratory setup**

In this study, the effects of reaction time (0-120 min), pH (3-9), and $O_3$ mass flow rate (0-1.25 g $hr^{-1}$), on the treatment of leachate landfill were studied (Salem *et al* ., 2013).

## Results and discussion

### Effect of reaction time and Ozone consumption rate

**Fig.2.** Presents the impact of $O_3$ on color removal efficiency, as indicated in **Fig.2.** The improvement in removal effectiveness of color continued until nearly 60 min. After that, no significant change was observed. Thus, the reaction time of 60 min was selected as the optimum reaction time to perform the required experiments.

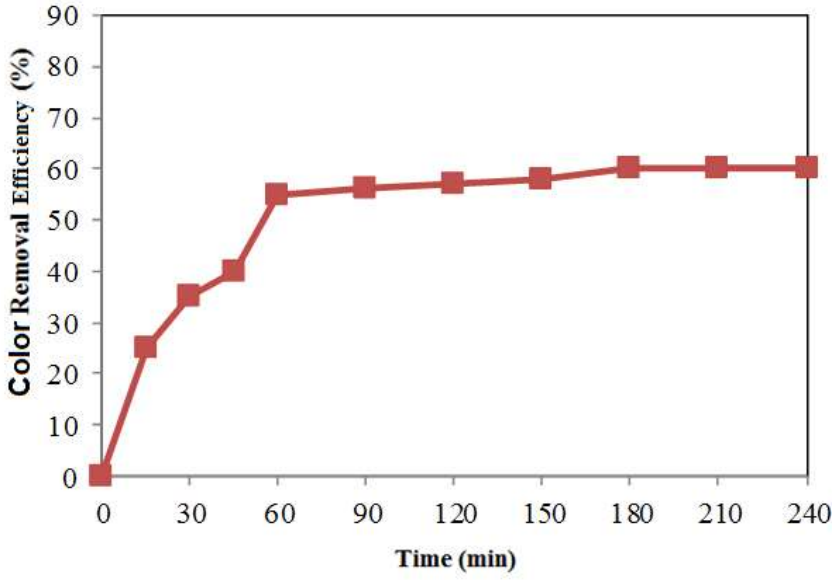


**Fig.2. The effect of the reaction time on the color removal efficiency**

**Effect of pH**

The speed of chemical reactions depends on the pH of the environment, and the pH of the solution directly and indirectly affects the oxidation of chemical substances. In advanced oxidation processes, changes affect the rate of oxidation of organic substances through the production of various radicals ( Chenju *et al*., 2007; Alaa, 2019; Alaa *et al*., 2019).

To determine the effect of environmental pH on the removal of color leachate, the ozone process was investigated under pHs 3, 4, 5, 7, and 9, and the results are shown in Figure (3). Studies using ozone in purification processes have shown that alkaline media have a stimulating effect due to the stimulation they cause in the generation of free radicals. (Alexandre *et al*., 2014).

According to the obtained results, after 60 minutes of the reaction, the highest color removal efficiency was achieved at 85% at a pH of 9. According to the studies conducted, with the increase in pH as a result of increased concentration of OH-, the decomposition rate of ozone increases, and according to equations **(1) and (2)** this leads to the formation of radical species containing Oxygen and secondary oxidants are much stronger than ozone molecules, such as $OH^{\bullet}$ radicals (Alexandre *et al*., 2014). The oxidation potential of $OH^{\bullet}$ is 2.7 V, while the oxidation potential of ozone is 2.07 V. In plot conditions, many compounds that react slowly and selectively with ozone molecules are rapidly and non-selectively decomposed by hydroxyl radicals. $OH^-$ and $OH^-$ act as catalysts in the ozone decomposition process and convert ozone into very active intermediate compounds such as superoxide ion ($O_2^-$) and $HO_2^{\bullet}$ radical. From Linero, in alkaline conditions, the removal rate is higher than in acidic conditions (Guo-Dong *et al*., 2013; Golamreza and Mahdavianpour, 2016).

$$O_3 + OH^- \rightarrow HO_2^- + O_2 \quad (1)$$

$$O_2 + HO_2^- \rightarrow O_3^{-\bullet}, O_2^{-\bullet}, OH^{\bullet}, (Intermediate\ Products) \quad (2)$$

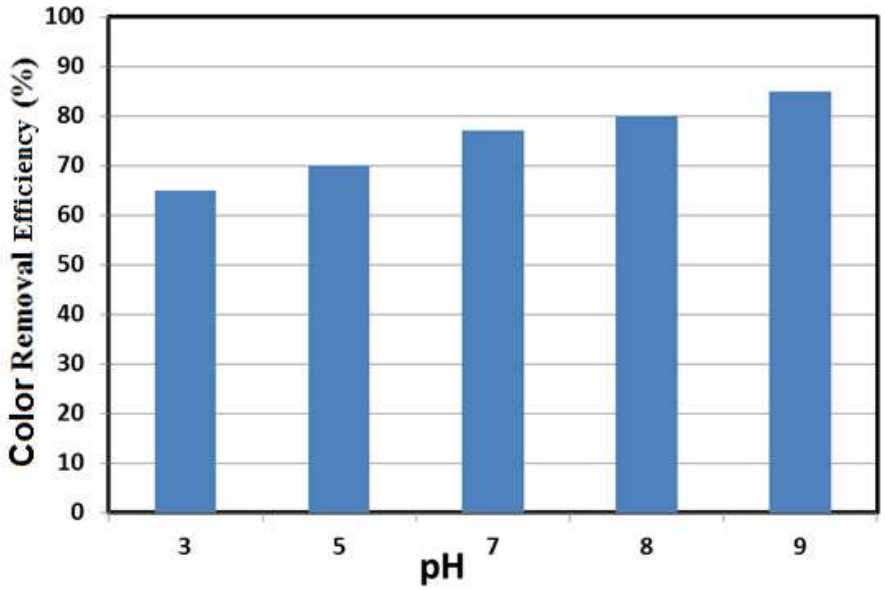


**Fig (3): Effect of pH on the color removal efficiency [ozone mass flow=0.65 g $h^{-1}$ and reaction time of 60 min]**

**Effect of $O_3$ doses**

The effect of ozone mass flow rate on the removal of color is illustrated in **Fig 3.** As shown in **Fig. 3**, by increasing the $O_3$ mass flow rate from 0 to 0.65 g $hr^{-1}$, the removal efficiencies of color increased significantly from 28% to 85%, respectively, due to the higher production of hydroxyl radicals. then removal efficiency was stable, this can be explained, by the high doses of $O_3$ mass flow rates which above the required limit can interfere with formed free radicals and can discourage them ( Maciej *et al*., 2019). Based on the results of this stage, the $O_3$ mass flow rate of 0.65 g $hr^{-1}$ was chosen to perform the following experiments.

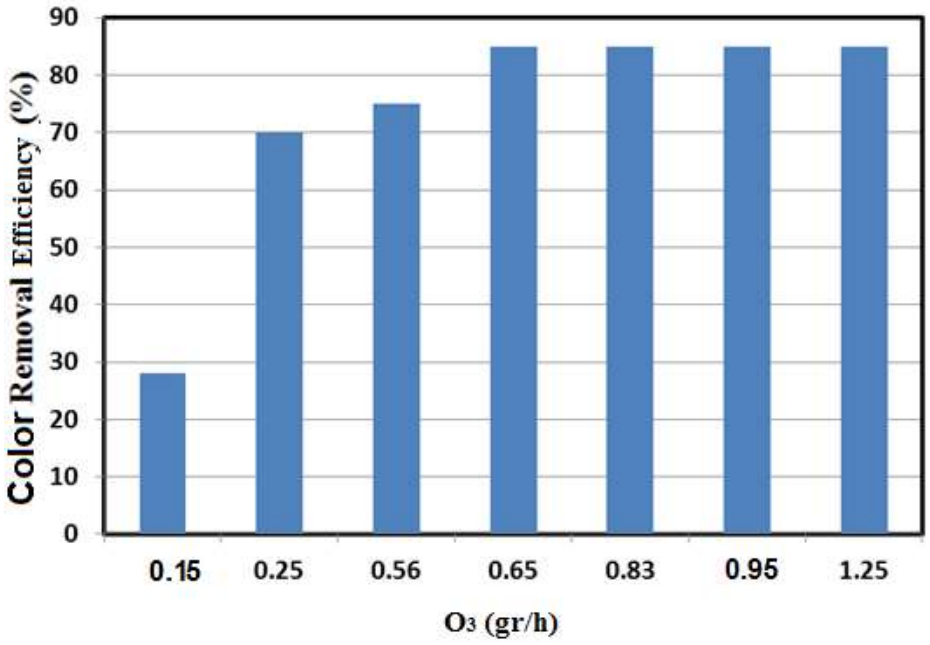


**Fig (3): Effect of the ozone mass flow rate on the color removal efficiency [reaction time of 60 min and pH=9]**

## Conclusion

The main objective of this work was to investigate the capability of an ozone oxidation process to act as a treatment method for leachate on the laboratory scale and in batch mode. The effect of some factors, such as the initial pH, ozone mass flow rate and reaction time, was investigated on the removal rate of the color of the leachate. In this study, maximum color removal rate of 85% was obtained, after 60 minutes ozonation with a 0.65 gr/h ozone mass flow rate, at pH 9.

From the results obtained, it can be identified that the advanced oxidation process with ozone can lead to a significant decrease in the color of the filtered material, which is linked to this decrease in the dissolution of soluble solid particles and their transformation into soluble substances. The study recommends that ozone be combined with other oxidants such as activated carbon, UV rays, and sulfates to enhance its therapeutic potential.

## Acknowledgments

This research has been done in Graduate Faculty of Environment, University of Tehran.

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# التحقق من إزالة اللون من رشاحة مكب النفايات بواسطة الأوزون

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تاريخ الاستلام:21/ 4/ 2024 تاريخ القبول:11/ 7/ 2024

**الملخص**

تعرف الرشاحة على أنها السائل الناتج عن ترشيح مياه الأمطار من خلال مكبات النفايات والعمليات البيوكيميائية في خلايا النفايات نفسها والمحتوى المائي المتأصل في النفايات. قد تحتوي المادة المرتشحة على كميات كبيرة من المواد العضوية (قابلة للتحلل الحيوي، ولكنها أيضًا مقاومة للتحلل البيولوجي)، وتحتوي على مادة عضوية غير قابلة للتحلل الحيوي ووعلى مركبات نيتروجينية. هناك طرق مختلفة لمعالجة الرشاحة وأهم ما يساهم في اختيار الطريقة كمية ونوعية المادة المرتشحة، والمستوى المطلوب والقضايا الاقتصادية. لذلك تم كان الهدف الرئيسي لهذه الدراسة استخدام الأوزون من أجل إزالة اللون من الرشاحة. تم تحقيق الحد الأقصى لإزالة اللون بنسبة 85% بعد 120 دقيقة من الأوزون عند درجة حموضة 9 وعند جرعة أوزون 0.65 جرام/ساعة.

**الكلمات المفتاحية:** الرشاحة، مكب النفايات، الأوزون، إزالة اللون.