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The Effect of Magnetic Treatment on some Physico-Chemical Properties of Landfill Leachate (Wadi Al-Hada)

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ABSTRACT

The landfill leachate contains high concentrations of organic pollutants that can be biological and resistant to it. Therefore, the resulting leachate must be treated from the healthy landfill before disposing of it in the environment. In this research, the technique of improved magnetic therapy was tested to improve some physicochemical properties of landfill leachate. Where a laboratory model was designed to evaluate the performance of the magnetic field with different strengths on the treatment of the leachate field collected from the Wadi al-Hadda landfill in Tartous Governorate-Syria. By the increasing in magnetic field strength from 272 to 678 µT, the removal efficacy of BOD and COD increased from 9 and 19% to 36.7 and 54.7%, respectively, and, the removal efficacy of NO3-N and NO3 increased from 6 and 17% to 24.6 and 46.8%, respectively. Electric conductivity (EC) values also decreased due to the use of magnetic field.

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INTRODUCTION

The annual level of municipal solid waste generation is expected to reach 2.2 billion tons in 2025 (Abdelzaher, 2022; Balboul, Abdelzaher, Hamouda, & Zaki, 2019; Elkhouly, Abdelzaher, & El-Kattan, 2022; Hoornweg & Bhada-Tata, 2012). This high amount of solid waste will generate the remarkable volume of landfill leachate, containing a various spectrum of pollutants, which will lead to serious shocks to the environment, especially natural resources if not treated appropriately (Bandala, Liu, Wijesiri, Zeidman, & Goonetilleke, 2021; Naveen, Mahapatra, Sitharam, Sivapullaiah, & Ramachandra, 2017; Teng, Zhou, Peng, & Chen, 2021; Wijekoon et al., 2022) .

Landfill leachate contains a large organic load and a wide spectrum of pollutants (Chou, Lo, Kuo, & Yeh, 2013; Mokhtarani, Khodabakhshi, & Ayati, 2016), Therefore, dealing with it according to traditional treatment methods does not lead to the required result (Pazoki, Abdoli, Karbassi, Mehrdadi, & Yaghmaeian, 2014; A. M. Soubh, Abdoli, & Ahmad, 2021; A. M. Soubh, Baghdadi, Abdoli, & Aminzadeh, 2018b). In the event of leakage of leachate from the landfill to the groundwater aquifers, it will cause pollution and exit from the investment. Therefore, it is necessary to take remedial measures' especially in landfills that lack integrated management of waste and its products (Naveen et al., 2017).

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Water is a vital and strategic element associated with life, social, economic and agricultural development. The issue of water scarcity and the deterioration of its quality has emerged in many countries of the world due to the large population growth, climate changes, and human activity, which has led to a shortage of water resources and thus the occurrence of a water gap in most countries, and this is the reason Increasing interest in treating wastewater from its various sources, whether industrial, wastewater, or household wastewater, and reusing this water efficiently, especially in countries that suffer from drought and scarcity of natural water resources, and focusing on it as a renewable and essential source of water (Madani, AghaKouchak, & Mirchi, 2016; A. M. Soubh, Baghdadi, Abdoli, & Aminzadeh, 2019; A. Soubh & Mokhtarani, 2016).

Biological processes are successful in treating leachates with the BOD/COD ratios larger than 0.5. However, increasing refractory compounds with time limit the effectiveness of the process(Renou, Givaudan, Poulain, Dirassouyan, & Moulin, 2008). Coagulation and flocculation has been reported to be effective in treating stabilized landfill leachates. The main disadvantage of this process is producing the high volume of sludge. In addition, the concentration of iron or aluminum in the leachate increases(Silva, Dezotti, & Sant'Anna, 2004). Nonbiodegradable organics may be removed using the adsorption process from biologically treated landfill leachate. However, frequent regeneration of columns is needed, which limits the application of adsorption process in treating the leachate (Renou et al., 2008; A. M. Soubh, 2020; A. M. Soubh, Baghdadi, Abdoli, & Aminzadeh, 2018a) .

Wastewater treatment using magnetic technology is one of the promising applications in the fields of agriculture, industry and the environment, as magnetic science has developed greatly, and magnetic properties are not limited to iron and manganese only, but are properties associated with all solid, liquid and gaseous materials, as shown by the various applications of using Magnetic technology varies according to the type of magnet, its source, and the method of its application (Al-wasify, Ali, & Hamed, 2018).

The effect of adding specific weights of magnetic particles to samples of landfill water in the Salamanca region in Spain was studied, then these samples were analyzed before and after addition in order to determine the concentration of pollutants chosen by the study, and the specific weights were: (1, 2, 4, 6 , 8, 12 g) of magnetic particles were added to a sample of (50 ml) of waste water, and the results showed that the removal efficiency reached its maximum value (44.73%) in relation to the chemical oxygen demand (COD) when adding (1 g) of Magnetic particles, as for (NO_3), the maximum value reached (98.71%) when adding (2 g) of magnetic particles

In this study, performances of different magnetic intensities were evaluated to improve physical and chemical properties of landfill leachate. The effects of factors affecting such as contact time and magnetic intensities on treatment of leachate was studied.

MATERIALS AND METHODS

The Wadi Al-Heda Laboratory is located (13 km) southeast of the center of Tartous Governorate, north of the Safita-Tartous public road. The laboratory is divided into three main sections: the fertilizer laboratory, the mechanical and handsome sorting factory of garbage and surface fold.

Waste is sorted at the mechanical and manual sorting station, and the recyclable materials from cartoon and plastic, nylon and aluminum, glass, iron, paper and fabric For use, it is buried in the surface adjacent, in addition to the harsh water that leaks into the soil layers or is used randomly without knowing the negative repercussions of it in the near and long term.

The leachate was collected from random areas of the landfill and transferred in a bowl of polyethylene after mixing it to form a homogeneous mixture and transfer it immediately to the

laboratory and save it in appropriate cooling conditions, and these experiments were conducted in Munir Deeb Industrial Secondary School in the first month of this month, the year (2023 AD). **Table 1**. shows used leachate characteristics.

A model was designed for the treatment device using bobinage wires (copper wires insulated with lacquer), where the number of turns was (N=270) and the length was (L=10cm). It was wrapped on an iron tube with a diameter of (D=2.5 cm), and two plastic containers (a container to store water before treatment and a vessel to receive water), a valve to control the exit of water after treatment, and a power source to provide continuous current where the currents intensity were (I = 0.6, 0.4 and 0.2 A), and the resulting magnetic fields strength were (B =272, 407 and 678µT), respectively. The schematic diagram of magnetic leachate treatment device was showed in **Figure 1.**

The interaction time was studied during the time period from 0 to 1.5 h, at the strength of the magnetic field. 678µT.

The following parameter changes Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), nitrate nitrogen (NO_3-N) or nitrate (NO_3), pH and Electric Conductivity (EC) were studied within the following three magnetic fields (B =272, 407 and 678µT).

RESULTS AND DISCUSSION

Effect of contact time

In order to understand the effect of the contact time, the following factor changes (COD, BOD, NO_3-N, NO_3, pH and EC) were studied within the time domain (0-120 min). **Figure 2** shows the removal efficiency for the previous parameters within the indicated time period. As observed in **Figure 2.** There was a gradual increase in removal efficiency for the studied factors until the time is 15 minutes. Then, it was observed that these changes became stable.

This can be explained that when the pollutant particles are exposed to the magnetic field, the magnetic field changes its kinetic energy this causes the bonds between them to break down and the formation of simpler molecules (Lychagin, 1975), Supports this explanation that the removal efficiency of COD was 44.8 % at the time of 15 minutes. As that, The biodegradability (BOD_5/COD) of unprocessed and treated leachate was increased from 0.5 to 0.7, this indicates that part of the refractory-contaminated materials in the leachate were removed and another part has decomposed into simpler compounds (Ranjbari & Mokhtarani, 2018; A. Soubh &

Table 1. Raw leachate Characteristics

Parameter	Value	Unit
pH	7.6	—
COD	4900	mg L^{-1}
BOD_5	2450	mg L^{-1}
NH_3	465	mg L^{-1}
NO_3-N	105	mg L^{-1}
EC	28.5	mS cm^{-1}

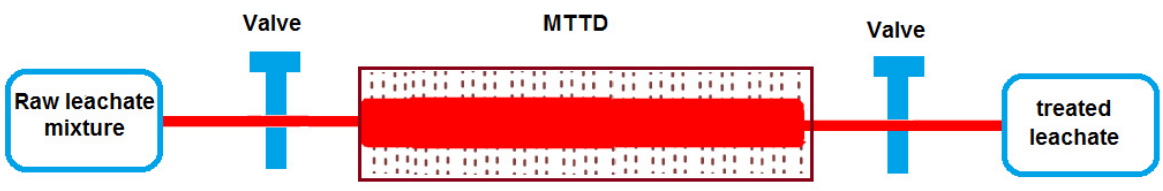

Fig. 1. Schematic diagram of magnetic leachate treatment device.

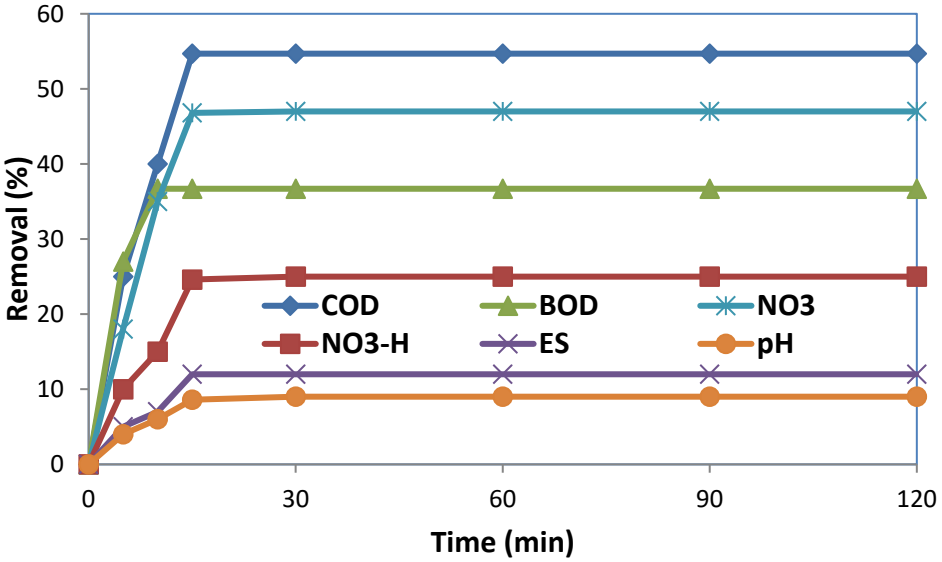

Fig. 2. Effect of contact time on treatment process under effect of magnetic field (B = 678µT).

Mokhtarani, 2016). It was observed that the removal efficiency remained stable at 15 minutes, this stability can be attributed to the fact that a portion of the pollutants has decomposed under those conditions, as for the other part, it was more resistant (A. M. Soubh et al., 2018a, 2018b). Thus, the reaction time of 15 minutes was selected.

Effect of different magnetic intensities

In order to understand the effect of the magnetic field strength on the treatment process, the removal efficiency of (COD, BOD, NO_3-N, NO_3 and EC) were studied under the three magnetic fields (B =272, 407 and 678µT) at the time of 15 minutes.

BOD and COD

BOD and COD are the most important indicators that provide an idea of whether the type of contaminants is biodegradable or resistant to it. Their value also varies from one leachate to another, this can be explained, that the value of BOD is directly related to the used leachate collection systems while COD values are related to waste composition and its age in the landfill, on the other hand, it is also related to the characteristics and design of the site (Canziani et al., 2006). **Figure 3** shows Effect of magnetic intensities on removal efficiency of COD and BOD from leachate**.**

As illustrated in **Figure 3,** by the increasing in magnetic field strength from 272 to 678 µT, the removal efficacy of BOD and COD increased from 9 and 19% to 36.7 and 54.7%, respectively. Decreased values of both BOD and COD indicate decomposition of organic matter both biodegradable and resistant (Othman, Sohaili, Fauzia, & Ni'am, 2009). That may be the reason behind this, exposing the polluted aqueous medium to the magnetic field increases the concentration of dissolved oxygen in it and reduces its surface tension which enhances the process of biodegradation of organic matter as well as its oxidation reactions (Al-wasify et al., 2018). BOD and COD closely related and the ratio between them indicates the level of biodegradability of a sample, the magnetic field contributed significantly to improving this percentage so that it became suitable for conversion into sewage systems (Bernat, Zaborowska, Zielińska, Wojnowska-Baryła, & Ignalewski, 2021).

NO_3-N and NO_3

Nitrogenous compounds in high concentrations have negative effects on the environment,

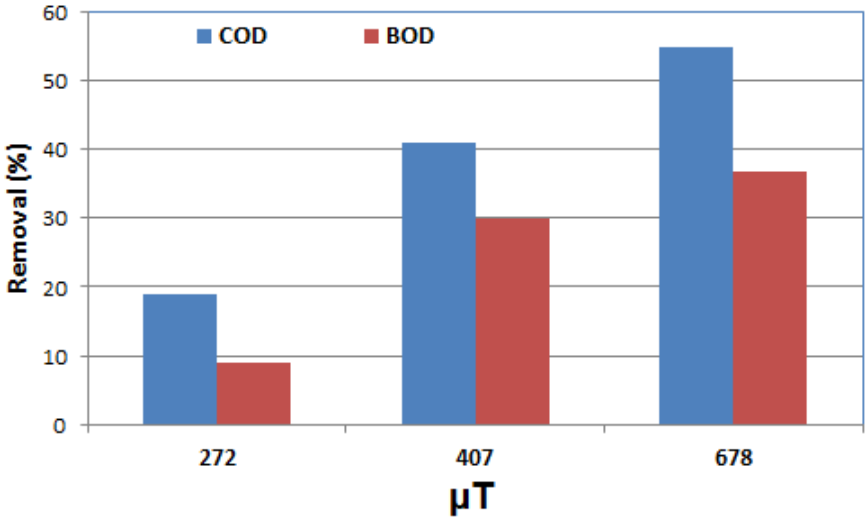

Fig. 3. Effect of magnetic intensities on removal efficiency of COD and BOD**.**

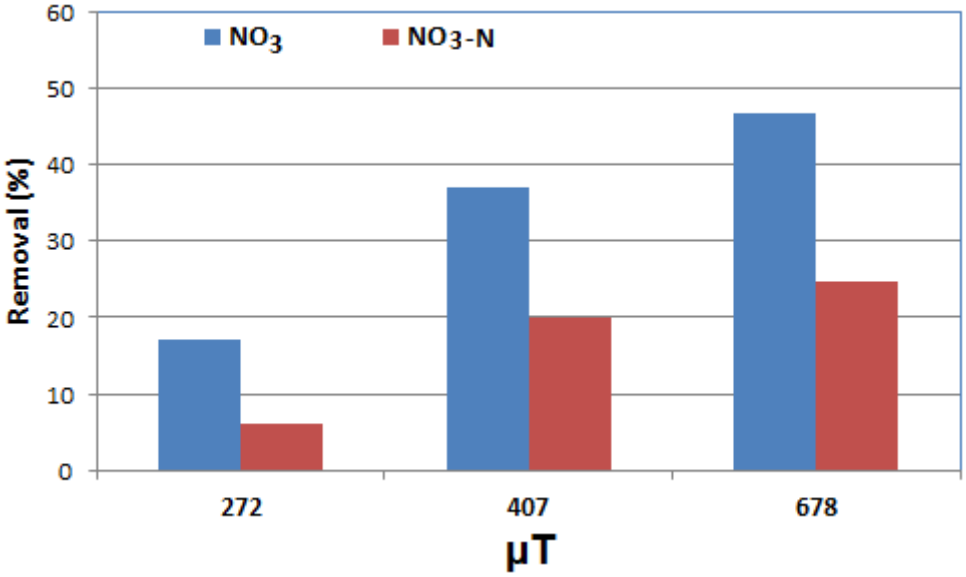

Fig. 4. Effect of magnetic intensities on removal efficiency of NO_3-N and NO_3**.**

as they cause nutrient enrichment of aqueous media and their acidity and it can poison aquatic organisms. Therefore, its removal is an urgent issue (Nanayakkara, Koralage, Meegoda, & Kariyawasam, 2019). The nitrogen in the leachate is formed from the slow decomposition of waste where soluble nitrogen is released (Tyrrel, Leeds-Harrison, & Harrison, 2002). Nitrates are considered fairly non-toxic but they pose a serious danger to humans when they are transformed into nitrite (NO_2^-) by microbes (To, Ma, Nguyen Hoang, & Nguyen, 2020; Zhang et al., 2014). **Figure 4** shows Effect of magnetic intensities on removal efficiency of NO_3-N and NO_3 from leachate**.**

As shown in **Figure 4,** by the increasing in magnetic field strength from 272 to 678 µT, the removal efficacy of NO_3-N and NO_3 increased from 6 and 17% to 24.6 and 46.8%, respectively. This can be illustrated by the fact that the magnetic field leads to the aggregation of particles as it enhances their movement hence its precipitation and its exit from the aqueous medium

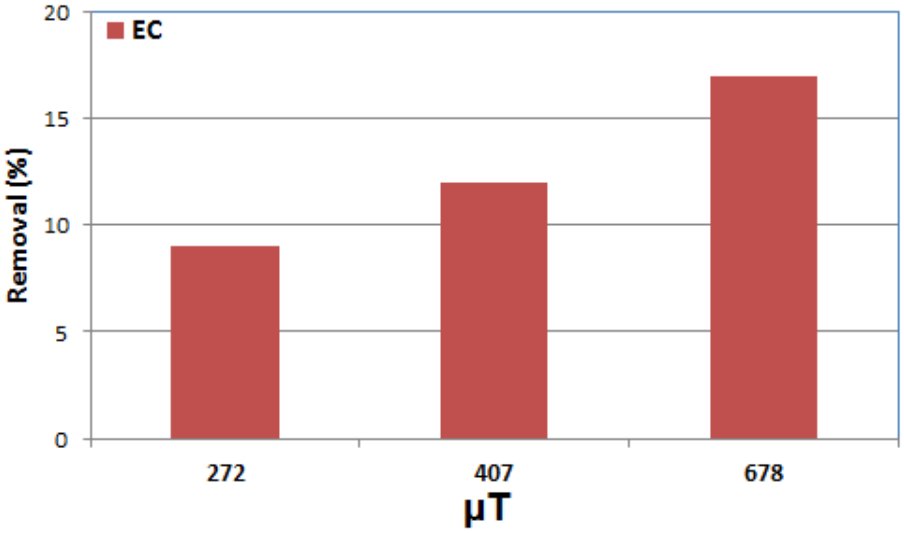

Fig. 5. Effect of magnetic intensities on removal efficiency of EC.

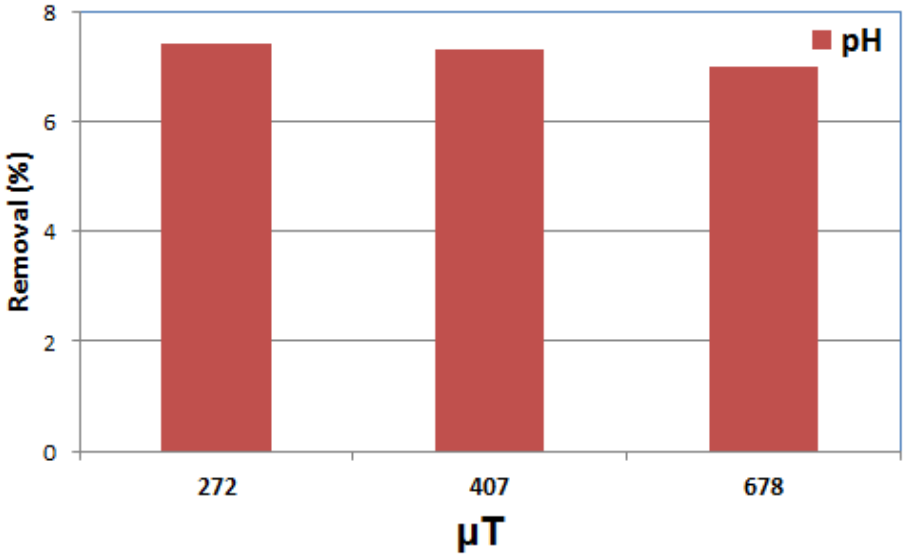

Fig. 6. pH changes under the influence of a magnetic fields

(Sa'at, 2006). On the other hand, exposing the aqueous medium to the magnetic field increases oxidation reactions, which may cause the release of part of the nitrogen gas to the atmosphere (Al-wasify et al., 2018).

Electric conductivity (EC)

EC indicates the ability of water to conduct electric current which are closely related to the amount and concentration of dissolved inorganic and organic minerals (Naveen et al., 2017). As illustrated in **Figure 5,** the increase of magnetic field strength from 272 to 678 µT increased the removal efficacy of EC from 7% to 14%. This can be due to the micro colloidal particles and electrolytic materials present in the leachate subjected to magnetic treatment are in a state of continuous motion similar to the Brownian motion, which eventually leads to its sedimentation and decrease in values of ES (Mohammed, Alkhazan, Ali, & Saddiq, 2010). On the other hand, exposing the leachate to a magnetic field causes of the liquid nucleation where ions combine

and form nuclei which also contributed decrease in values of ES (Duchin & Levine, 2002).

Variations in pH

The pH changes under different magnetic intensities were studied, **Figure 6**. By increasing the magnetic field strength from 0 to 678 μT, the pH of solution decreased from 7.6 to 7.1. The reason for this is attributed to the effect of magnetic fields on hydrogen bonds and released hydrogen ion directly or decomposition of dissolved carbon dioxide and the formation of carbonic acid and therefore reduce values of pH (Maheshwari & Grewal, 2009).

CONCLUSION

In this study, the possibilities of using of different magnetic fields have been used to treat the leachate landfill. The study showed the ability of magnetic field treatment to improve the physicochemical properties. The results also showed the degradation of some of the materials resistant to biological degradation by increasing biodegradability (BOD_5/COD). Magnetic therapy also contributed to reducing the rates of NO_3-N, NO_3 and EC.

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The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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