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Research Article
Effect of Date-Palm Wastes on Some Chemical Properties of Municipal Waste Compost

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Abstract
Decomposition of organic waste in cropland led to production of contaminated liquid named (leachate) that has toxic and hazardous compositions, so it is considered a significant threat for the environment. In this study, Nutrient Film Technique (NFT) with filtered date-palm wastes as an adsorbent for the purification of compost leachate was investigated. In order to be consistent, waste of palm trees were chopped using a special combine, then classified by using a sieve in three sizes 0-0.5, 0.5-1 and 1-2 cm. In each treatment, 30 L of leachate flowed for 72 h in the current system and at the start of the experiment (leachate input) as a control and then at 12, 24, 48 and 72 h after the initial testing, samples of circulating leachate in the system, were taken and parameters Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Soluble Solids (TSS) and concentration of heavy metals (Zn, Cu and Fe) were measured. After 72 h and the last sampling of the first treatment, the system completely emptied and washed. The same procedures were performed in the other treatments. Results showed the highest reduction in BOD_5, COD, TSS in the NFT system for palm wastes in 1-2 cm size, after 72 h. The highest reduction of heavy metals of leachate was also obtained in 1-2 cm size. So it could be an inexpensive method that can be replaced to other forms of methods of leachate treatment in Iran and the world.

Key words: Palm wastes, NFT, leachate, heavy metal, BOD_5, COD

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Leachate is defined as any wastewater or contaminated liquid generated from rain water percolating through solid waste materials, accumulating contaminants and moving into surrounding and subsurface areas (Hamzah *et al*., 2014). In recent years due to increasing population and changing consumption patterns by improving the quality of community life, environmental pollutions are increasing in many parts of Iran, especially large cities and leakage and infiltration of leachate in landfill sites and surface water pollution caused by the use of leachate is one of the major sources of environmental and ground water pollutions. Decomposition of organic waste in crop land with rain water produces a contaminated liquid named leachate. Leachate contamination is due to compositions of ingredients and chemical, biological and physical interactions in decomposition of waste process (Tabatabaei *et al*., 2012) and since prevention of producing leachate is impossible and due to 1/3% of the population growth in Iran that adds about 50 million cubic meters of leachate in every year, methods should be used to prevent the contamination of the water and reduce their emissions in environment. These methods include reducing the volume of leachate, restore, recycle and reuse it (Shayegan and Afshari, 2004).

There are many chemical and physical methods for wastewater treatment but most of the times, the biological methods provide permanent efficient and non-polluting solution to refine and decontamination (Meysami and Saeedi, 2009) and have very compatibility with environment (Talaie *et al*., 2009), since waste disposal management, economical disposal that is environmental and sustainable is considered (Jones *et al*., 2006) and due to the high costs of design, construction and operation, municipal landfill sites are used for biological treatment and it is necessary to minimize problems by scrutiny and scientific research carried out before launch and since this problem can be seen in the projects implemented in the country, today the design, operation and maintenance of most of the specific individual systems receive more attention (Tchobanoglous and Burton, 1991). In this study it is important to use materials and methods that can remove pollutions, particularly heavy metals efficiently and with lowest cost.

In this study that is conducted for the first time, possibility of using a simple, inexpensive, yet efficient system, as a Nutrient Film Technique (NFT) with filtering organic wastes of palm as an adsorbent for the purification of compost leachate was investigated. Habibollahi (2011) used the zeolite as a bed in the NFT system and cultivation of reed for urban compost leachate treatment. The results showed that the use of the bed had a large impact on the reduction of oxygen needs of chemical leachate and provided removal efficiency of 55.3. Vaillant *et al*. (2003) in a research about wastewater by using NFT system and datura plant found that this system was highly efficient in reduction of COD and reduced its concentration strongly. The aim of this study was to investigate the efficiency of Nutrient Film Technique (NFT) with filtered date-palm wastes as an adsorbent for the purification of compost leachate.

MATERIALS AND METHODS

Laboratory model: This research was performed in a Nutrient Film Technique (NFT). The system consisted of a PVC tube of 4 m in length and 11 cm in diameter. The end of the tube was constructed in such a way that could be opened to put the bed and wash. Twenty holes on the tube with 4 cm in diameter and 20 cm intervals were created. A 50 L tank for maintenance leachate and a pump with a flow rate of 22 L min^{-1}, to process leachate was placed in the tank. Beginning and end of the PVC pipe was connected to tank by polyethylene tubes for entry and exit of leachate into the tank. A cache pressure valve to regulate the flow rate and rate of leachate flow was placed on the way out of the tank and the inlet polyethylene tube to the system. Three metal bases with length of 120 cm were made to maintain of PVC pipe and provided tilt required to move the leachate through it. Bases was made in such a way that that their height were adjustable to 5 cm. Tilt of system was considered 1%, it means that there were 1 cm slope for every 100 cm length of tube and 4 cm height difference between the beginning and end of the tube.

Operation and experiment: To set up and start work, sampling of leachate from municipal solid waste process of Esfahan began in the summer of 2014. Process for the purification of waste palm was used as the bed in the system. The wastes of palm trees were as collected in one of the palm groves of Farashband, Fars province and in order to incorporate chopped by using a specific combine then measured by using a sieve in three grading sizes and physical-chemical characteristics of palm beds. To measure Electrical Conductivity (EC) and pH, air-dried samples with distilled water in a ratio of 2:1 (v/v) were mixed and maintained for 24 h at a fixed place, then was extracted by a filter paper, Whatman 42 and finally pH of beds measured by using a pH meter and electrical conductivity of the saturation extract was determined by conductivity meter. The cation exchange capacity was measured using sodium acetate method (Rhoades, 1982). To measure bulk density, sample poured into a cube vessel with dimensions $10\times10\times5$ cm and 5 hit entered the container, then the upper surface of it flatted and samples weighted and bulk density was calculated in g cm^{-3}, in such a way that residue weight was divided by the volume of the container (Baruah and Barthakur, 1998). To calculate the true density of each instance, 4 g of wastes were weighted and poured into pycnometer, then pycnometer half filled with boiled and cooled distilled water and put on steam-bath for some hours until wastes deposited, then pycnometer filled with water and closed the door and then weighted and measures were taken. Total porosity was calculated using the respective equation (Baruah and Barthakur, 1998).

Air porosity by using a pressure plate, the amount of moisture in the pressure 0.1 bar for each experimental treatment was calculated and to measure air porosity, numbers obtained in total pressure 0.1 bar subtracted from the amount of porosity. To calculate capacity of holding moisture, at first the bed was saturated with distilled water and after release of gravity water weighted by balance and then placed into oven for 24 h and its dry mass and weight moisture content were determined by weight method (g/g). Finally to calculate the available water of volumetric moisture contents obtained at a pressure of 0.1 and 0.5 bar, they were subtracted for each of the experimental treatment using a pressure plate.

Experimental treatments: The first treatment consist palm wastes with particles less than 0.5 cm, the second treatment was palm wastes with particles 0.5-1 cm and third treatment was palm wastes with 1-2 cm particles. In each treatment 30 L of leachate flowed in system for 72 h and at the start of the experiment (input leachate) as a control and then at 12, 24, 48 and 72 h after the initial testing leachate samples were taken from circulating leachate in system and parameters COD, BOD_5, TSS and concentrations of heavy metals including zinc, copper and iron were measured. After 72 h and the last sampling of first treatment, the system was emptied and washed completely. The same procedures were performed in other treatments.

To measure BOD_5 of leachate samples, the titration method was used. Measuring BOD_5 using OXITOP is based on measuring pressure differences. To measure COD of leachate samples, reflux distillation method was used (Arnold *et al*., 1992). The total residual particles after drying and evaporation in specified temperature, called Total Solids (TS) that consists of Total Suspended Solids (TSS) and total soluble solids. The TSS refers to total particles remained on the filter (filter paper) after drying (Eaton *et al*., 2005). To measure metals (iron, zinc, copper) using concentrated nitric acid and atomic absorption spectrometer Perkin Elmer model was performed (Eaton *et al*., 2005). After conducting different experiments, drawing diagrams using excel software was performed.

RESULTS

The physical properties of palm in different sizes are listed in Table 1. According to Table 1, the values of density were similar in all three treatments. The highest amount of available water, the capacity of holding moisture and bulk density was related to 0-0.5 cm treatment and the lowest of it was related to 1-2 cm treatment. The highest of total porosity and air porosity in palm treatment was obtained in 1-2 cm particles and the lowest was related to 0-0.5 cm treatment. According to Table 2, the highest EC and pH was related to palm bed with 0-0.5 cm particles size and the lowest of them was related to palm bed with particles size of 1-2 cm. The highest of Cation Exchange Capacity (CEC) in palm bed with 1-2 cm particles, was observed in 51.8 cmol kg^{-1}. According to Fig. 1, all three

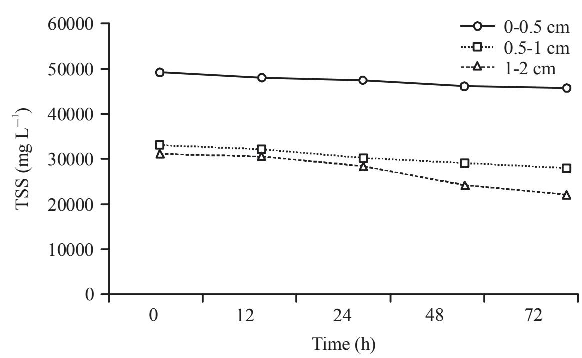

Fig. 1: Changes of leachate TSS during 72 h in effect of flows from palm beds, TSS: Total soluble solid

Table 1: Physical properties of materials in purification beds

Particle size (cm)	Available water (%)	Air porosity (%)	Total porosity (%)	Bulk density (g cm^{-3})	Particle density (g cm^{-3})	Water-holding capacity (%)
Palm (0–0.5)	23.86	8.67	82.6	0.23	1.33	89.56
Palm (0.5–1)	25.13	28.22	87.4	0.16	1.33	57.5
Palm (1–2)	11.91	48.68	88.8	0.14	1.33	37.35

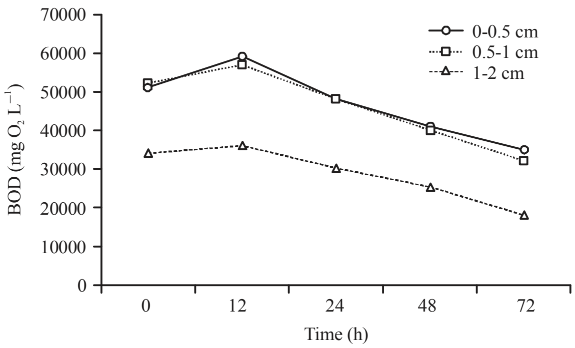

Fig. 2: Changes of leachate BOD_5 within 72 h due to flow of palm beds, BOD_5: Biochemical oxygen demand

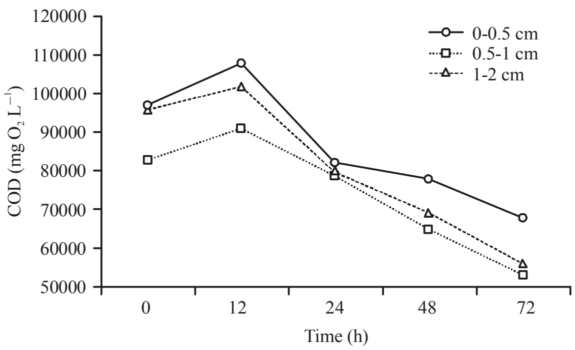

Fig. 3: Changes of leachate COD within 72 h due to flow of palm beds, COD: Chemical oxygen demand

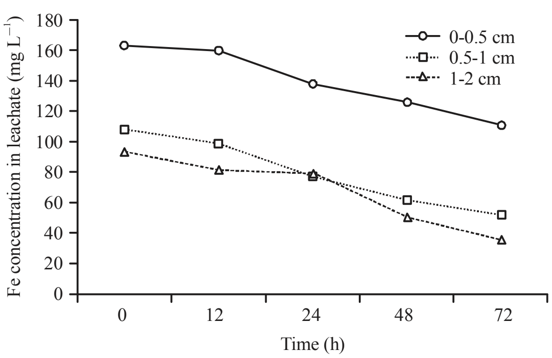

Fig. 4: Changes of leachate Fe within 72 h due to flow of palm beds

palm treatments, the concentration of TSS in the leachate was reduced and the highest reduction was related to 1-2 cm palm treatment. As observed in Fig. 2, the removal amount of leachate BOD_5 in effect of palm beds flow with 0-0.5 and 1-2 cm was relatively same and in all treatments the amount of BOD_5 in 12 h compared to control increased but by the time 24, 48 and 72 h, the amount of BOD_5 was decreased. The amount of COD increased in all tree treatment within 72 h compared to control but in the time to 24, 48 and 72 h, the amount of COD was decreased (Fig. 3). As observed in Fig. 4, passing of leachate from all tree treatment lead to reduction of leachate iron concentration with passage of time and the highest reduction was related to 1-2 cm palm treatment. Passing leachate from palm beds within 72 h led to reduction of copper leachate compared to input time (Fig. 5). According to Fig. 6, in all treatment with passage of time, the amount of zinc compare to control (input leachate) was reduced and this reduction was more in 1-2 cm size.

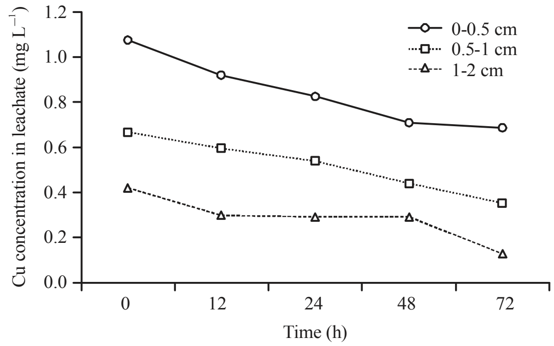

Fig. 5: Changes in concentration of Cu in leachate within 72 h due to flow of palm beds

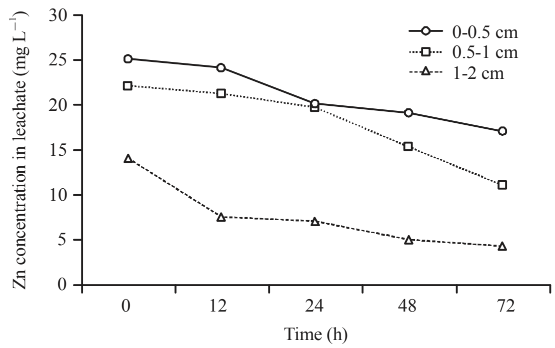

Fig. 6: Changes of leachate Zn within 72 h due to flow of palm beds

Table 2: Some chemical properties of materials in purification beds

Particle size (cm)	pH (-)	EC (dS m^{-1})	CEC (cmol kg^{-1})
Palm (0-0.5)	7.86	3.77	32.5
Palm (0.5-1)	7.65	3.60	33.0
Palm (1-2)	7.48	2.84	51.8

EC: Electrical conductivity and CEC: Cation exchange capacity

DISCUSSION

High bulk density of 0–0.5 (cm) size probably is due to the presence of dust in this size and during chopping and separating the different sizes of palm wastes, maximum amount of fine dust particles in this size entered. With increasing particle sizes, the bulk density reduced which this may be due to the high porosity and large pores in this size. Bulk density is considered one of the most important physical properties. Because light weighting of bed and portability and reduction of transport cost are some factors affecting the suitability of the bed. Palm wastes as a bed especially palm, due to lignin exist in it, lead to the increase bulk density of it. Total porosity and air porosity were more in large particles that is due to less bulk density and making larger porosities (Raviv *et al*., 2001). Bulk density is inversely related to total porosity (Baig *et al*., 1999). Mortezavi (2013) in a research stated some properties of beds and also stated that the highest holding moisture capacity in palm bed with 0-0.5 cm size is equated with 89/65% and the lowest of it is related to 1-2 cm palm bed that is equated with 37.75%. The highest cation exchange capacity was related to particle with 1-2 cm size, because during the crushing palm by combine, palms crush and break sooner have less resistant than larger palms, so these palms have less fiber properties than larger and stronger palms and since increasing fiber properties leads to increase the amount of porosity, absorption rate increase. Al-Shaikh *et al*. (2009) reported that the fine fraction of date palm reduced the nitrate leaching out of soil by approximately 14.86 and 5.90% for low and high water application rate, respectively in case of fine fraction, reduced nitrate losses. However, the corresponding values for coarse fraction were about 9.73 and 4.35%, respectively.

According to obtained results of palm beds as an organic filter, reduced the concentration of suspended solids, because using of absorbent beds increases the level, thereby allowing increased biofilm activity and suspended solids by bacteria that are on the bed converted into microbial biomass. In addition, the suspended solids in the leachate remove physically and some suspended solids are filtered by bed (Chang *et al*., 2002). Therefore the TSS removal is achieved by biological oxidation and physical filtration (Qiu *et al*., 2010). Yavari (2012) for improving wastewater quality by using NFT system showed that total removal efficiency of suspended solids in aerobic conditions within 72 h are increased. Reduction of suspended solids by physical filtration and surface adsorption, indirectly lead to removal of BOD_5. Here microorganisms are also involved in the removal of BOD_5 (Vaillant *et al*., 2002, 2003; Gholikandi, 2006). For this reason, presence of bed and physical filtration increased removal efficiency. Reduction of BOD_5 is a process that needs oxygen, in which carbon oxidation occurs (Vaillant *et al*., 2003). In a NFT system and using plant and bed could reduce BOD_5 to 91% (Vaillant *et al*., 2003). Monnet *et al*. (2002) found that by using NFT system reduced BOD_5 to 95%. Reduction of COD process is a biological oxidation (Qiu *et al*., 2010). On the other hand the reduction of suspended solids by physical filtration and adsorption, indirectly causing the COD removal, so far as removal of 1 g of suspended solids is approximately equal to removal of 0.8-1.5 g of COD (Vaillant *et al*., 2002, 2003; Gholikandi, 2006). Due to this reason in presence of bed and physical filtration, removal efficiency is increased. Vaillant *et al*. (2003) reported that by using NFT system and in presence of bed and datura plant the concentration of COD was reduced about 82%. Yousefi and Zazouli (2008) stated that in ideal conditions, the removal efficiency of COD and heavy metals by application of alum were 21 and 77-91%, respectively, while removal of heavy metals and COD by using ferric chloride was 68-85.5 and 28%, respectively. In another research Qiu *et al*. (2010) observed that zeolite could reduce the amount of COD to 80%. According to the findings of Al-Shaikh *et al*. (2009), reuse the date palm led to increase the fertilizers use efficiency and reduce the problems of groundwater pollution. As observed, in all palm treatments with passage of time, the amount of heavy metals of leachate was decreased and the highest reduction was also related to 1-2 cm palm treatment. In a research by Asadi *et al*. (2008), two rice husk adsorbent and saw dust used for further purification, the power of two mentioned adsorbent for removal of heavy metals were investigated and they stated the major reasons of connecting heavy metals on cellulose materials such as these adsorbents, is creating hydrogen bands, electrostatic attraction and complex formation with functional groups and since palm bed also has cellulose property can lead to reduction of heavy metals. Compared to the tap water, the leachate-contaminated ground water samples and the simulated leachate showed remarkably higher concentrations of Pb, Cd and Cr (Adeyemi *et al*., 2007). Al-Shaikh *et al*. (2009) found that increasing the rate of date palm increased nitrate in soil columns and reduced the nitrate in leachate.

CONCLUSION

The results of present study indicated that increasing time like leachate in NFT system had positive effect and lead to increase removal efficiency, so that the highest amount of reduction in TSS, BOD_5, COD, iron, copper and zinc are also obtained within 72 h. In general it can be concluded that palm wastes bed with particles in 1-2 cm size is suitable for leachate purification and can be as a bed and new and inexpensive alternative method for purification leachate in Iran and world.

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