Journal of Environmental Management 166 (2016) 124–130

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Co-treatment of landfill leachate and municipal wastewater using the ZELIAC/zeolite constructed wetland system

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ARTICLE INFO

Article history:
Received 15 June 2015
Received in revised form
28 August 2015
Accepted 11 October 2015
Available online xxx

Keywords:
Co-treatment
Landfill leachate
RSM
Wetland
ZELIAC
Zeolite

ABSTRACT

Constructed wetland (CW) is a low-cost alternative technology to treat wastewater. This study was conducted to co-treat landfill leachate and municipal wastewater by using a CW system. *Typha domingensis* was transplanted to CW, which contains two substrate layers of adsorbents, namely, ZELIAC and zeolite. Response surface methodology and central composite design have been utilized to analyze experimental data. Contact time (h) and leachate-to-wastewater mixing ratio (%; v/v) were considered as independent variables. Colour, COD, ammonia, nickel, and cadmium contents were used as dependent variables. At optimum contact time (50.2 h) and leachate-to-wastewater mixing ratio (20.0%), removal efficiencies of colour, COD, ammonia, nickel, and cadmium contents were 90.3%, 86.7%, 99.2%, 86.0%, and 87.1%, respectively. The accumulation of Ni and Cd in the roots and shoots of *T. domingensis* was also monitored. Translocation factor (TF) was >1 in several runs; thus, *Typha* is classified as a hyperaccumulator plant.

1. Introduction

Municipal solid waste (MSW) has been a major global problem. With progressive industrialization of developing countries, solid waste has gradually become a threat to the environment. MSW has also been considered as one of the most serious environmental challenges in many cities in the world (Oloruntade et al., 2013). Sanitary landfills have been constructed to manage solid wastes in most countries. Although solid waste management provides benefits, this approach also produces leachates (Aziz et al., 2011). Leachates are generated when moisture mixes with refuse in a landfill. Pollutants become dissolved in a liquid phase, accumulate, and percolate. Landfill leachates are considered as wastewater that has caused adverse environmental impact. Leachates are mainly characterized by high concentrations of particular contaminants. Landfill leachate is treated with several primary methods, including physicochemical and biological processes, and remediation (Aziz, 2012).

Plants have been used in phytoremediation to remediate contaminated soils and waters; phytoremediation is an affordable and non-invasive system (Mojiri et al., 2013). Phytoremediation is also a new approach that provides more ecological benefits than existing methods. Although phytoremediation is cost effective, this method requires technical expertise of project designers with field experiences to choose appropriate species and cultivars for particular metals and regions. Compared with further remediation methods, phytoremediation can be performed with minimal environmental disturbance (Mojiri, 2012, 2011). One of the most vital factors in implementing phytoremediation is the selection of an appropriate plant (Kutty et al., 2009). Constructed wetlands (CW) can be considered as a phytoremediation system. This technique has been commonly applied in several regions, including Asia, America, and Europe (Whitney et al., 2003; Chen et al., 2006; Cortes-Esquivel et al., 2012; Ranieri et al., 2013). Ranieri (2012) stated the potential of constructed wetlands (CWs) to remove nutrients from domestic and industrial wastewater has been well documented. Physicochemical characteristics of wetlands confirm

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http://dx.doi.org/10.1016/j.jenvman.2015.10.020
0301-4797/

positive features to remediate pollutants. An expansive rhizosphere of wetland herbaceous shrubs and tree species also offers an enhanced culture zone for microbes that participate in degradation (Williams, 2002). A CW system specifically engineered to improve water quality is termed as a "constructed wetland treatment system" (Sim, 2003). A wetland system includes permeable substrata, such as gravel, which is normally planted with emergent wetland plants, like *Schoenoplectus*, *Typha*, *Phragmites*, and *Cyperus* (Shehzadi et al., 2014).

Typha is often found in areas near water bodies, such as lakes, lagoons, and riverine areas, in many regions (Esteves et al., 2008). *Typha* is a greatly flood-tolerant species that can allow internal pressurized gas flow to rhizomes because this species is characterized by a well-developed aerenchyma system; this system provides oxygen for root growth in anaerobic substrates (Li et al., 2010). Southern cattail (*Typha domingensis*) is extremely salt resistant and considered as a potential source of pulp and fiber (Khider et al., 2012). For other hand, certainly, *T. domingensis* is the plant species which has been used in treating urban and industrial effluents. Moreover, this plant has been reported recently as a plant species with a high efficiency to accumulate metals when is used in wetland constructed (Teles Gomes et al., 2014). For other hand, *T. domingensis* has been suggested as a biological mechanism to remove high phosphorous concentrations from water (Di Luca et al., 2015). This plant species has been suggested as a biomonitor in phytoextraction technology in areas affected by some metals. Mojiri et al. (2013) and Mojiri (2012) used *T. domingensis* to remove metals from wastewater and leachates from landfill. Indeed, *T. domingensis* can effectively remove pollutants.

This study mainly aimed to (1) co-treat municipal landfill leachate and urban wastewater by using CW and (2) use a new composite adsorbent, particularly ZELIAC, and zeolite in CWs.

2. Materials and methods

2.1. Landfill leachate and domestic wastewater sampling

Municipal landfill leachate samples were obtained from Isfahan Landfill (geographical coordinates 32° 45′ 36″ N and 51° 46′ 31″ E). The total landfill area is approximately 56 ha.

Urban wastewater samples were collected from Isfahan East Wastewater Treatment Plant. Isfahan is a large city located at the center of Iran. The characteristics of municipal landfill leachate and domestic wastewater are shown in Table 1.

2.2. Constructed wetland system

Three fresh, young, and healthy plants (*T. domingensis*) were transplanted to the CW, which contained two substrate layers of adsorbents (named ZELIAC and zeolite, respectively) whose widths were both 2 mm (Fig. 1). The volume of the wetland (height = 40 cm, width = 36 cm) was approximately 43 L. The wetland was constructed by adjusting the lengths of plant roots. Dark polyvinyl chloride was used to establish CW to prevent algal growth. Leachate and wastewater mixture was poured into the wetland, and the samples were collected at different times (contact times). An air pump was used to supply air to the wetland.

2.3. ZELIAC and zeolite preparation

Zeolite, activated carbon, limestone, rice husk ash, and Portland cement have been ground, passed through a 300 mm mesh sieve, and mixed to prepare ZELIAC. Water was added, and the mixture was evenly poured into a mold. After 24 h, the blend was removed from the mold and soaked in water for three days to allow curing. The mixture was allowed to dry for two days; afterward, the mixture was crushed and passed through a sieve. Zeolite and activated carbon were present in ZELIAC; therefore, ZELIAC could function both as an adsorbent and ion-exchanger (Mojiri et al., 2014a).

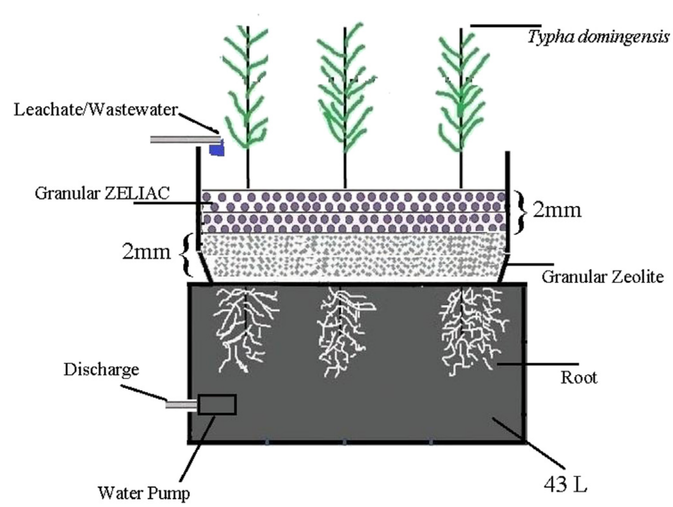

Fig. 1. Constructed wetland in current study.

Table 1
Characteristics of landfill leachate, domestic wastewater and sludge.

No.	Parameter	Leachate average value	Wastewater average value	Standard discharge limit[a]
1	pH	7.95	6.74	6.5–8.5
2	EC (ms/cm)	3.87	1.53	–
3	TSS (mg/L)	607	–	60
4	Colour (Pt. Co)	1817	5.00	–
5	BOD_5 (mg/L)	461.0	45.2	50
6	COD (mg/L)	2301	123	100
7	BOD_5/COD	0.20	–	–
8	Nitrite (mg/L NO_2–N-HR)	41.17	10.1	11
9	NH_3–N (mg/L)	627.0	149.0	2
10	Total organic carbon (mg/L TOC)	40.4	29.0	–
11	Total iron (mg/L)	8.13	1.11	3
12	Total manganese (mg/L)	2.08	0.50	1
13	Total nickel (mg/L)	4.62	0.40	2
14	Total cadmium (mg/L)	2.55	0.31	0.1

[a] Effluent Limitations for Non-Hazardous MSW Landfills in the Iran.

Table 2
XRF results of ZELIAC and Zeolite.

ZELIAC		Zeolite	
Compounds/elements	Composition (%)	Compounds/elements	Composition (%)
C	8.602	SiO_2	67.39
CaO	26.308	Al_2O_3	10.41
SiO_2	51.000	CaO	5.17
Al_2O_3	9.200	K_2O	4.16
Fe_2O_3	1.504	Fe_2O_3	3.92
K_2O	1.201	MgO	1.18
MgO	1.004	Na_2O	1.18
Na_2O	0.925	TiO_2	0.45
P_2O_5	0.028	MnO	0.10
SO_3	0.020	Others	6.04
Others	0.208	–	–

The diameters of ZELIAC and zeolite were both 1 mm (Fakin et al., 2013). Table 2 shows the XRF results for ZELIAC and zeolite.

2.4. Analytical methods

The plant samples were removed, washed initially with tap water and then with distilled water, and divided into small parts. The plant samples, including roots as underground parts and leaves and shoots as aboveground parts, were arranged for laboratory analysis via wet digestion technique (Campbell and Plank, 1998). Total organic carbon content, color, chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammonia (NH_3–N), and metal contents in leachate and Ni and Cd contents in the roots and shoots were monitored through spectrophotometry in accordance with Standard DR/2500 HATCH (APHA, 2005).

2.5. Statistical analysis

The removal efficiencies of COD, NH_3–N, colour, Ni, and Cd were determined by evaluating the target parameters before and after treatment were performed. Removal efficiency was estimated using Equation (1):

$$\text{Removal} \ (\%) = \frac{\left(C_i - C_f\right)*100}{C_i}, \quad (1)$$

where the initial and final concentrations of the parameters are C_i and C_f, respectively.

Design and analysis of experiments (DOE) have been generally applied in planning, analyzing, and running experiments in different fields, like wastewater treatment, food analysis, material production, and medication intake. This method helps researchers achieve their objectives with less effort, cost, and time. The application of DOE in wastewater industries has become prevalent because this method enables efficient data collection and reduces error by excluding non-significant factors from experiments. This method also increases result accuracy within a target range. Response surface methodology (RSM) consists of mathematical and statistical techniques used to model and analyze problems. RSM also aims to optimize responses by determining optimal operating conditions of input variables (independent variables) that influence responses. Optimization is a procedure by which optimum target output for a specific process is determined; this procedure is conducted with a series of experiments to test a range of values and combinations of all factors (Mojiri, 2014).

In the current research, central composite design (CCD) and RSM were employed to design the experiments and data analysis. CCD was implemented by Design Expert Software Version 6.0.7. RSM was employed to control optimum process parameters. RSM involves mathematical and statistical methods suitable to model and analyze problems (Aziz et al., 2011). In this methodology, responses of interest are influenced by several variables; therefore, RSM is applied to optimize these responses (Aziz et al., 2011). The total number of experiments for two factors was 13. Each factor is composed of three levels; thus, a quadratic model is an appropriate model, as shown in Eq. (2).

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} {X_i}^2 + \sum_{i<j}^{k} \sum_{j}^{k} \beta_{ij} X_i X_j + \ldots + e \quad (2)$$

where the response is shown by Y; Xi and Xj are the factors; β0 is a established coefficient; βj, βjj, and βij display the interaction coefficients of linear-, quadratic-, and second-order terms, respectively; the number of analyzed parameters is shown by k; and error is shown by e. The results have been studied through ANOVA in Design Expert Software Version 6.0.7.

Each of the three operating factors was considered at three levels: low (−1), central (0), and high (+1). CCD and RSM were employed to estimate the relationship between the most significant operating variables, namely, react (contact) time (h) and leachate-to-wastewater mixing ratio (%), and their corresponding responses (dependent variables). This procedure aims to optimize operating variables and their responses (Mojiri et al., 2013). Different contact times (12, 42, and 72 h) and leachate-to-wastewater mixing ratios (80, 50, and 20 v/v%) have been used in the wetland system. The removal of five dependent parameters (colour, COD, ammonia, Ni, and Cd) was evaluated as responses to analyze aerobic process. 3D plots with respective contour plots were found from experimental results. The effects of the interaction of the two variables on responses were then analyzed (Table 3).

3. Results and discussions

Table 1 shows that the landfill leachate displayed a high-intensity colour (1817 Pt. Co) and contained high concentrations of COD (2301 mg/L), NH_3–N (627 mg/L), Ni (4.6 mg/L), and Cd (2.5 mg/L). BOD_5 was 461 mg/L, and a low biodegradability ratio (BOD_5/COD) of 0.20 was observed (age > 15 years). In addition, pollutant concentration exceeded the permissible limits issued by the Effluent Limitations for Non-Hazardous MSW Landfills in Iran.

We also co-treated raw leachate with domestic wastewater by using the newly designed wetland to decrease the environmental risks caused by landfill leachate. The 3D surface plots to eliminate contaminants (colour, COD, ammonia, Ni, and Cd) are shown in Fig. 2. The ANOVA results for response parameters and response value under optimum conditions are shown in Tables 4 and 5, respectively.

Table 3
Experimental variables and results.

Run	LW (%)	Contact time (h)	Colour rem. (%)	COD rem. (%)	Ammonia rem. (%)	Ni rem. (%)	Cd rem. (%)
1	50.00	42.0	70.30	85.59	94.99	79.16	79.69
2	50.00	12.0	70.44	83.25	93.28	73.31	74.35
3	50.00	42.0	71.23	84.64	94.95	78.50	77.56
4	20.00	72.0	89.07	85.19	98.12	83.11	84.30
5	50.00	42.0	71.45	84.89	95.78	77.54	77.16
6	50.00	42.0	71.76	85.15	97.03	79.35	80.44
7	50.00	72.0	69.07	83.13	93.87	75.93	77.57
8	20.00	12.0	86.27	82.58	94.53	79.29	79.93
9	50.00	42.0	71.93	85.14	96.94	78.25	76.93
10	80.00	42.0	68.92	70.60	93.97	71.74	72.00
11	80.00	12.0	65.31	69.29	91.51	68.30	68.36
12	20.00	42.0	90.66	87.44	99.28	86.92	88.90
13	80.00	72.0	65.04	68.17	92.27	69.25	69.81

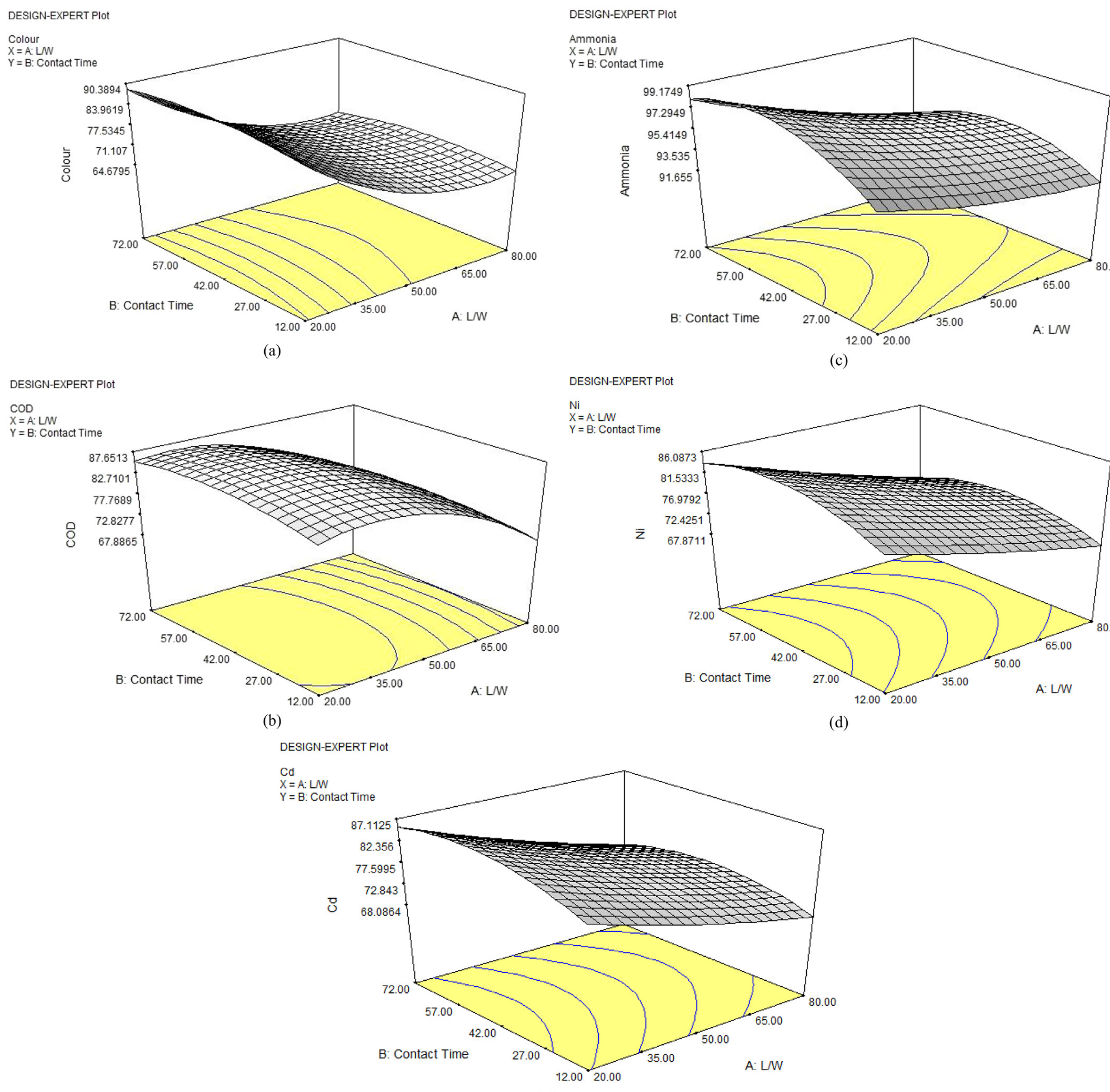

Fig. 2. The 3-D surface plots of (a) Colour, (b) COD, (c) Ammonia, (d) Ni and (e) Cd removal.

Table 4
ANOVA results for response parameters.

Response	Final equation in terms of actual factor[a]	Prob.	R^2	Adj. R^2	Adec. P.	SD	CV	PRESS	Prob. LOF
Colour	$104.35-1.178A + 0.277B + 0.008A^2 - 0.002B^2 - 0.0004AB$	0.0001	0.9930	0.9881	39.06	0.95	1.29	42.91	0.1127
COD	$73.37 + 0.499A + 0.272B-0.007A^2 - 0.002B^2 - 0.001AB$	0.0001	0.9962	0.9934	49.59	0.56	0.68	16.07	0.0919
NH_3-N	$94.01-0.113A + 0.294B + 0.006A^2 - 0.002B^2 - 0.0007AB$	0.0002	0.9154	0.8550	12.42	0.86	0.91	17.22	0.7856
Ni	$79.83-0.252A + 0.466B\ 0.0006A^2 - 0.006B^2 - 0.0007AB$	0.0001	0.9857	0.9754	32.03	0.83	1.10	29.81	0.3093
Cd	$82.32-0.305A + 0.424B + 0.001A^2 - 0.003B^2 - 0.0008AB$	0.0001	0.9488	0.9122	16.51	1.66	2.15	94.39	0.4174

[a] In final equations, where A is leachate to wastewater mixing ratio (%, v/v), B is contact time (h).Prob.: Probability of error; R^2: Coefficient of determination; Adj. R^2: Adjusted R^2; Adec. P.: Adequate precision; SD: Standard deviation; CV: Coefficient of variance; PRESS: Predicted residual error sum of square; Prob. LOF: Probability of lack of fit.

3.1. Colour removal

The dark brown color of the leachate is mostly caused by the oxidation of Fe from ferrous form to ferric form and the formation of ferric hydroxide colloids and complexes with fulvic/humic substances. This finding may also be attributed to the disposal of steel scraps into landfill sites (Nagarajan et al., 2012).

The removal efficiencies of the studied parameters (Table 3) varied from 65.0% (react time = 72 h and leachate-to-wastewater mixing ratio = 80%) to 90.7% (react time = 42 h and leachate-to-wastewater mixing ratio = 20%). Optimum colour elimination (90.4%) was achieved at a react time of 47.9 h and leachate-to-wastewater mixing ratio of 20.0%.

Conventional biological treatments, and chemical and physical treatment processes are commonly used to remove colour from wastewater (Olejnik and Wojciechowski, 2012). A CW is considered as a complex bioreactor. CW treatment systems involve several removal mechanisms, including plant adsorption, microbial degradation, chemical oxidation, and filtration (Lee et al., 2009). Bulc and Ojstrsek (2008) showed that 90% of colour can be removed from textile wastewater by using CW. Mbuligwe (2005) also reported that 77% of colour can be removed from textile wastewater by using CW.

3.2. COD removal

The organic content of leachate is generally measured in terms of COD and BOD_5 (Kamaruddin et al., 2013). COD is defined as the amount of oxygen required to completely oxidize organic constituents to carbon dioxide and water (Tchobanoglous et al., 1993). A decrease in BOD_5/COD ratio also results in a decrease in treatment efficacy (Kliminuk and Kulikowska, 2006).

The removal efficiency of the studied parameters (Table 3) increased from 68.2% (contact time = 72 h and leachate-to-wastewater mixing ratio = 80%) to 87.4% (react time = 42 h and leachate-to-wastewater mixing ratio = 20%). Optimum COD elimination (87.5%) was achieved at a react time of 52.9 h and leachate-to-wastewater mixing ratio of 27.3%.

Villalobos et al. (2013) stated that plants do not play a major role in COD removal because a decrease in the quantity of plants is not directly proportional to the reduction in COD levels. Villalobos et al. (2013) also observed *Typha*/non-media wetland and suggested that medium components are crucial for COD removal, and bacterial activity may be the cause of COD removal in wetlands. Thus, media may provide an appropriate surface where biofilm can form; attached bacteria likely facilitate COD removal (Stottmeister et al., 2003). Lin et al. (2012) investigated the use of landfill leachate treatment by using a subsurface-flow CW. Lin et al. (2012) selected five substrates, particularly coal refuse, fly ash, cinder, soil, and gravel and found that this type of CW results in a highly efficient COD removal. Dhas (2008) reported that activated carbon and limestone mixture is an alternative treatment to remove COD.

In the current study, the two substrates were ZELIAC and zeolite. ZELIAC contains activated carbon, rice husk ash, limestone, Portland cement, and zeolite. These materials can effectively remove COD (Kulikowska and Kliminuk, 2006; Aziz, 2012; Mojiri et al., 2014b). Thus, COD removal in the current study was higher than that in previous studies involving other types of wetlands (Mulidzi, 2010; Collison and Grismer, 2013).

3.3. Ammonia removal

One of the utmost significant problems encountered by landfill operators is the presence of high levels of NH_3-N in landfill leachate over a long period. High amounts of unprocessed NH_3-N can decrease removal efficiency of biological treatment techniques, accelerate eutrophication, and increase dissolved oxygen reduction. Thus, NH_3-N is poisonous to aquatic organisms (Bashir, 2007).

The removal efficiency of NH_3-N (Table 3) ranged from 91.5% (react time = 12 h and leachate-to-wastewater mixing ratio = 80%) to 99.3% (react time = 42 h and leachate-to-wastewater mixing ratio = 20%). Optimum ammonia removal (99.2%) was reached at a react time of 51.4 h and leachate-to-wastewater mixing ratio of 20.0%.

In wetland vegetation systems, nitrogen and ammonia can be removed in leachate through phytoremediation; the effect of root zone should also be considered because plant roots produce oxygen for nitrifying bacteria and other unique microorganisms growing in the rhizosphere of wetland plants (Yang and Tsai, 2014). Lee et al. (2009) stated that denitrification may remove 60%–70% of total nitrogen removal and 20%–30% of nitrogen is derived from plant uptake in CW wetlands. Aziz (2012) reported that majority of NH_3-N is removed biologically. Mulamoottil et al. (1999) reported that treatment efficiencies for ammonia in wetland systems are approximately 90%. Redmond (2012) investigated nitrogen removal from wastewater by using CW and found good removal efficiency.

Table 5
The value of response at optimum conditions.

Independent factors		Responses				
A (%)	B (h)	Colour rem. (%)	COD rem. (%)	NH_3-N rem. (%)	Ni rem. (%)	Cd rem. (%)
20.00	50.28	90.30	86.74	99.17	86.08	87.10

A: Leachate to Wastewater Mixing Ratio; B: Contact Time.

Table 6
Accumulation of metals in roots and shoots of *Thypa*.

Run	Root		Shoot		TF	
	Ni (mg/L)	Cd (mg/L)	Ni (mg/L)	Cd (mg/L)	For Ni	For Cd
1	0.237	0.133	0.246	0.136	1.03	1.02
2	0.009	0.009	0.007	0.006	0.77	0.66
3	0.231	0.135	0.234	0.135	1.01	1.00
4	0.023	0.021	0.021	0.020	0.91	0.95
5	0.214	0.129	0.212	0.129	0.99	1.00
6	0.227	0.130	0.230	0.135	1.01	1.03
7	0.243	0.164	0.267	0.175	1.09	1.06
8	0.008	0.007	0.006	0.005	0.75	0.71
9	0.216	0.124	0.210	0.120	0.97	0.96
10	0.224	0.159	0.228	0.161	1.01	1.01
11	0.164	0.096	0.135	0.075	0.82	0.78
12	0.019	0.013	0.015	0.010	0.78	0.76
13	0.291	0.178	0.328	0.195	1.12	1.09

3.4. Nickel and cadmium removal

Heavy metal pollution has been considered as one of the most serious problems related to landfill leachates. Heavy metal treatment is of utmost concern because heavy metals are recalcitrant and persistent in the environment. Heavy metals are not biodegradable; these substances may also be present in landfill leachate in different chemical/physical forms (El-Salam and Abu-Zuid, 2014).

The removal efficiency of Ni (Table 3) varied from 68.3% (react time = 12 h and leachate-to-wastewater mixing ratio = 80%) to 86.9% (react time = 42 h and leachate-to-wastewater mixing ratio = 20%). Optimum Ni removal (86.0%) was observed at a contact time of 49.0 h and leachate-to-wastewater mixing ratio of 20.0%. Moreover, the removal efficiency of Cd (Table 3) ranged from 68.4% (react time = 12 h and leachate-to-wastewater mixing ratio = 80%) to 88.9% (react time = 42 h and leachate-to-wastewater mixing ratio = 20%). Optimum Cd elimination (87.1%) was achieved at a contact time of 51.3 h and leachate-to-wastewater mixing ratio of 20.0%.

In wetlands, plants can uptake metals. Moreover, media and substrates can help facilitate metal removal. Wojciechowska and Waara (2011) reported metal removal rates of 90.9%–99.9% by using CW. Kamrudzamana et al. (2012) showed that 91.51%–99.20% of Fe can be removed by using CW.

Lesage et al. (2007) also observed that the Cd removal efficiency of a CW is approximately 91%, which is close to the value obtained in the current study. Khan et al. (2009) found the lowest removal efficiency (40.9%) of Ni. The removal efficiency of Ni in the present study is higher than that reported by Hadad et al. (2006) and Maine et al. (2007).

In the current study, *T. domingensis* and two substrates, namely, ZELIAC and zeolite, were used. These materials could be effective as adsorbents and ion exchangers. Mojiri (2014) removed 70% of metals from landfill leachate by using ZELIAC. Mojiri et al. (2013) reported that metals are eliminated by *T. domingensis* with a removal efficiency of 73%.

3.5. Accumulation of nickel and cadmium in roots and shoots of *Thypa domingensis*

Heavy metals, such as Cd, Ni, Zn, Co, Mn, and Pb, can be accumulated in plants by up to 100 or 1000 times more than those taken up by non-accumulator (excluder) plants. The uptake efficiency of a plant can be significantly improved (Tangahu et al., 2011). Table 6 shows the concentrations of Ni and Cd in the roots and shoots of *Typha* in each run. The accumulation of metals in the roots and shoots increased as Ni and Cd concentrations in leachate and wastewater mixture increased. The same trend was observed when contact time was increased. These results are consistent with those of Karimi (2013).

Phytoremediation efficiency can be characterized by calculating a translocation factor (TF). TF indicates the capacity of a plant to store MTE in upper parts. TF is also defined as the ratio of metal concentration in upper plant parts to metal concentration in roots (Chakroun et al., 2010). Furthermore, TF corresponds to the performance of a plant in translocating accumulated metals from roots to shoots. TF is estimated as follows (Padmavathiamma and Li, 2007).

$$\text{TF(Translocation Factor)} = \frac{C_{shoot}}{C_{root}}$$

Table 6 shows that TF was >1 in several runs. A TF of >1 indicates that a metal is translocated from roots to aboveground parts (Jamil et al., 2009). Yoon et al. (2006) proposed that only plant species with TF of >1 can be used for phytoextraction.

4. Conclusion

The levels of particular contaminants in municipal landfill leachate exceeded the allowable discharge restrictions for colour, COD, ammonia, Ni, and Cd. Pollutants from landfill leachate and urban wastewater were removed by using a newly designed CW. *T. domingensis* was transplanted in the CW, which contained two layers of adsorbents (ZELIAC and zeolite). An air pump was used to supply air to the wetland. CCD and RSM were employed to optimize parameters. The main conclusions of current research are offered below.

(1) The designed CW could eliminate 90.3%, 86.7%, 99.1%, 86.0%, and 87.1% of colour, COD, ammonia, Ni, and Cd, respectively.
(2) Removal efficiencies decreased as leachate ratio in the leachate and wastewater mixture increased.
(3) The accumulation of Ni and Cd in the roots and shoots of *T. domingensis* was monitored. Current results showed that TF was >1 in several runs. Thus, *Typha* is considered as a hyperaccumulator plant.

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