Ecological Engineering 74 (2015) 13–19

Contents lists available at ScienceDirect

Ecological Engineering

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

Short communication

Vermicompost as a strong buffer and natural adsorbent for reducing transition metals, BOD, COD from industrial effluent

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ARTICLE INFO

Article history:
Received 26 June 2014
Received in revised form 5 October 2014
Accepted 9 October 2014
Available online 24 October 2014

Keywords:
Industrial effluent
Vermicompost
Biofilter
Transition metal
BOD and Langmuir isotherm

ABSTRACT

The experiment was conducted to evaluate the role of vermicompost as strong buffer and natural adsorbent to reduce the transition metals, BOD, COD, total dissolved solids (TDS) and total suspended solid (TSS) under laboratory condition from three industrial effluent viz. beverage, distillery and paper mill. Adsorbent (vermicompost) prepared from cow dung with the help of exotic earthworm *Eisenia fetida* was used in a glass column reactor (38 cm × 3.2 cm i.d). The effluents were passed through the different amount of vermicompost (20 g, 50 g and 100 g) with particle size upto 230 μm. The maximum adsorption capacity was studied by applying the linear Langmuir and Freundlich isotherm model. The maximum adsorption was noticed for Cu and the least for Zn. Freundlich adsorption isotherm was best fitted for Cu in distillery effluent (n = 4.25) followed by Mn in beverage, paper mill and distillery effluent (n = 5.81, 4.95 and 7.75 respectively), Fe and Zn in beverage industry (n = 2.31 and 7.01). Vermicompost act as a strong buffer to neutralize the pH of the effluent. The pH of the filtrate came to be 7.8 for beverage and paper mill effluent and 5.8 for distillery effluent. EC of the filtrate increased to 4.0 mS/cm for beverage effluent, 6.1 mS/cm for paper mill effluent and 8.1 mS/cm for distillery effluent from its initial value of 2.0, 4.8 and 6.9 mS/cm respectively. The value of COD was 2.5 times less than their respective initial values. Vermicompost removed the high BOD of the industrial effluents and it came down to 174.0 mg/L for beverage industry, 260.0 mg/L for paper mill effluent and 5806.0 mg/L for distillery effluent from its initial value of 387.5 mg/L, l440.0 mg/L and 17200.0 mg/L respectively. TDS and TSS of the effluents respectively came down to 72.0 mg/L and 246.0 mg/L for beverage effluent, 210.0 mg/L and 230.0 mg/L for paper mill effluent and 206.7 mg/L and 105.7 mg/L for distillery effluent.

1. Introduction

Waste reduction by recycling is an important part of any integrated liquid waste management system. Heavy metals are toxic even in the minute quantities; therefore, no metal should exceed the limit by 3 mg/L in the effluent. The most common technologies for removing heavy metals from waste water include chemical precipitation, chemical oxidation/reduction, reverse osmosis, ion exchange, electrochemical treatment and evaporation recovery etc. pH is the most important parameter influencing the adsorption rate and capacity of adsorption (Jordao et al., 2007; Waranusantigul et al., 2003; Yadav and Garg, 2009). The presence of humic acid in vermicompost enhances metal ion adsorption. Humic acids are insoluble at acidic pH and soluble at higher pH, while fulvic acids are soluble in water at all pH values (Calace et al., 1999; Stanley, 1994). Functional carboxyl and hydroxyl group in humic substances were found to be related to biological activity (Fan et al., 2008a). In their molecular structure, there are both polar and non polar substituent, therefore they can interact both with soluble and insoluble compound (Gonzalez-Martinez et al., 2007). Metal ion bind to fulvic acid at multiple sites corresponding to salicylic/phthalic acid sites as well as lower energy delocalized sites (Patterson et al., 1992). Fulvic acids are generally more aliphatic and less aromatic than humic acid and are richer in carboxylic, phenolic and ketonic group. It has negative charges on its surface, which enables it to have high capacity to adsorb metal ion from aqueous solution and thereby to retard contaminant migration (Fan et al., 2008b). The presence of humic acid enhances metal ion sorption at low pH and reduces the metal sorption at high pH values. The increase of sorption is correlated with sorption of humic substances on the mineral surface followed by the interaction of the metal ion with surface sorbed humic acid, whereas the reduction of sorption is explained by the formation of

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http://dx.doi.org/10.1016/j.ecoleng.2014.10.028
0925-8574/

soluble M-HS complexes which stabilize the metal ion in aqueous solution (Zhiwei et al., 2009).

Industrial effluent has to be treated to reduce the organic load before discharge into water bodies. Liquid phase adsorption has been shown to be an effective way for removing suspended solids, odors, organic matter and oil from aqueous solution in term of initial cost, simplicity of design, ease of operation and insensitivity to toxic substances (Annadurai et al., 2002). However these techniques have certain disadvantages, including higher operational cost, residual metal sludge, disposable etc. Due to prohibitive cost of these processes, the use of agriculture residue or industrial byproduct having biological activities has been received with considerable attention (Mor et al., 2006). In recent years a number of adsorption material such as moss peat, Ho et al. (1995), melon seed husk, Okieman and Ohyenkpa (1989), sheep manure waste Abu Al-Rub et al. (2002), bagasse and fly ash Rao et al. (2002), waste apricot Erdogan et al. (2005), tea factory waste Malkoc and Nuhoglu (2006), Duck weed *Lemna gibba* L., Verma and Suthar (2014), *Parthenium hysterophorus* Lata et al. (2007) and vermicomposts (Matos and Arruda, 2003; Jordao et al., 2007) have been tested to remove heavy metals from waste water. Vermicompost is being utilized within commercially available on-site domestic waste treatment systems however, there are few reported studies that have examined this medium for the purpose of wastewater treatment (Taylor et al., 2003).

The current study is based on exploring vermicompost as a strong buffer and natural adsorbent for reducing transition metals, Biological oxygen demand (BOD) and chemical oxygen demand (COD) from industrial effluents. Column studies provide the most practical application in the treatment of industrial effluent. The solution continuously enters and leaves the column so that complete equilibrium is never established at any stage between the solute in solution and amount adsorbed (Lata et al., 2007).

The vermicompost residues obtained after the purification of effluent might be used in agriculture. So, new solution had to be sought to amend this problem. This paper reports the use of vermicomposts (produced from cattle dung) to reduce BOD, COD and for purifying effluents containing Cu, Mn, Fe and Zn collected from beverage, paper and distillery industry and its buffering capacity.

2. Material and methods

2.1. Vermicompost as an adsorbent material

For the experiment, vermicompost prepared from cattle dung using exotic earthworm *Eisenia fetida* was procured from vermifarm of Guru Nanak Dev University, Amritsar. After homogenizing and drying to constant weight (moisture 6%) the vermicompost was sieved in order to obtain the particle size upto 230 μm and the material was stored in plastic bags for further experiment.

2.2. Industrial effluent

Effluent of beverage, paper mill and distillery industry was procured from Coco-Cola Amritsar Crown Caps Ltd., Jandiala, Verma Paper Mill, Amritsar and Khasa Distillery, Khasa, Amritsar, Punjab, India. The initial pH of beverage, paper and distillery effluent at the time of collection was 9.97, 7.1 and 4.5 respectively. The initial physico-chemical parameters of industrial effluents are given in Table 1.

2.3. Chemical analysis

Electrical conductivity (EC) and pH were determined over HM digital meter-COM-100 and Equip-tronics EQ-614-A respectively. Biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solid (TDS) and total suspended solid (TSS) were determined by using the method given in APHA (1998). Transition metals (Cu, Fe, Mn and Zn) were measured by the method of APHA (1998) using varian AAS-240 FS Germany. Standard solutions were prepared by using the nitrate salts of the estimated heavy metals.

2.4. Experimental design

Experiment was carried out using glass column of size 38 cm length and 3.2 cm i.d. Glass column was filled with vermicompost (adsorbent) prepared from cow dung with the help of exotic earthworm *Eisenia fetida*. Adsorption studies for metal ion in industrial effluents were performed by percolating the solution through packed column by hand poring method. Throughout the experiment vermicompost was used only once and its mass was replaced after each effluent treatment. Aliquots of the effluents were collected after their adsorption on vermicompost in a flask for determination of pH, EC, TDS, TSS, TS, metals concentration, BOD and COD. The concentration of above mentioned physico-chemical parameters were determined before and after vermicompost treatment (C_0 and C_e respectively).

In first phase, the 100 mL of effluent was passed through glass column packed with vermicompost on dry weight basis (50 g) flowing at 10 drops/min at its natural pH to know its effects on EC, pH, BOD, COD, TDS and TSS.

In second phase, 100 mL of effluent was passed through glass column packed with vermicompost on dry weight basis (20 g, 50 g and 100 g) to know its effect on metals uptake.

The removal percentage (R%) is defined as the ratio of difference in metal concentration before and after adsorption ($C_0 - C_e$) to the initial concentration of metal in the industrial effluent (C_0) was calculated using Eq. (1):

$$R(\%) = \frac{C_0 - C_e}{C_0} \times 100 \quad (1)$$

Table 1
Initial and final physico-chemical parameters of different industrial effluents (mean ± S.E).

Physico-chemical parameters	Beverage effluent		Paper mill effluent		Distillery effluent	
	Initial	Final	Initial	Final	Initial	Final
pH	9.97 ± 1.2	7.8 ± 0.26	7.1 ± 1.5	7.8 ± 0.10	4.5 ± 0.1	5.8 ± 0.32
EC (mS/cm)	2.0 ± 1.0	4.0 ± 0.03	4.8 ± 0.9	6.1 ± 0.15	6.9 ± 1.2	8.1 ± 0.18
TDS[a]	360.0 ± 12.0	72.0 ± 1.15	780 ± 8.9	210.0 ± 6.4	1140.0 ± 3.5	206.7 ± 3.09
TSS[a]	1230.0 ± 9.8	246.0 ± 1.0	1300 ± 6.8	230.0 ± 5.7	2220.0 ± 6.6	105.7 ± 1.29
TS[a]	1590 ± 9.8	318.0 ± 1.0	2080 ± 6.8	440.0 ± 5.0	3360.0 ± 6.3	312.4 ± 1.5
BOD[a]	387.5 ± 11.9	174.0 ± 1.0	440.0 ± 12.8	260.0 ± 5.7	17200.0 ± 28.90	5806.0 ± 61.2
COD[a]	1000.0 ± 6.8	440.0 ± 2.8	1240.0 ± 8.9	530.0 ± 5.7	42200 ± 20.0	18000.0 ± 55.1

[a] Weight in mg/L.