Cleaning Heavy Metal Pollution of Wastewater with Compost Application

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Abstract* – In the present study, a kinetic experiment investigated the adsorption of Zn, Cu and Cd from aqueous systems onto different compost materials. The treatment has been attempted via batch experiments under various solution concentrations. It probes mainly three adsorbents which their characteristics are as follow, 1. Felgyő is a green waste and sewage sludge. 2. Garé is a communal sewage sludge, slurry mud and chicken manure with straw. 3. Sioagárd is green biomass/ bio waste. The metal initial concentration solutions was ranging from 0 to 50000 µg/g as contaminants and 13 samples were prepared of mixing 10 ml of liquid with 1g of compost as one sample ,accordingly the fusion placed in shaker for 24 hours thus the combination was centrifuged, filtered and the heavy metal concentration was determined with atomic absorption spectrophotometry. Each heavy metal treatment was replicated three times for quality assurance and the kinetic data were well described by Langmuir model, hence Curves were plotted for the adsorption of heavy metal on the adsorbent. The maximum amount sorbate of heavy metal (A_{max} $mgkg^{-1}$) is 44245 for Cu by Garé compost followed by Cd 40107 and less for Zn with record of 26803 by the same compost. Higher amounts were sorbed from Cd, Cu and less from Zn solutions. Characterization of the adsorbents was one of the key focal areas of experiment investigation. The result indicated that adsorption efficiency decreased with increase in the initial solution concentration. At lower heavy metal concentrations practically all of the heavy metals ions were removed by the compost application whereas in higher concentrations the fix value ratio of heavy metal ions decreased to 40 %, however the amount of the compost per sample remained with 1g.

Key words – Heavy metal, compost, adsorption, wastewater, langmuir.

I. Introduction

Heavy metal pollution is one of the most important environmental problems today. Various industries produce and discharge wastes containing different heavy metals into the environment. Sources of discharge of heavy metals reported by [1]–[4]. Cadmium, copper, zinc, copper, nickel, lead, mercury and chromium are often detected in industrial wastewaters. Various methods of treatment for industrial wastewater have been reported in literature. Wastewater contains substantial amounts of toxic heavy metals, which create problems [5], [6]. Numerous health problems reported in literature from exposing to heavy metal due the contamination in water consumed directly or through food chain. [7] Reported several health problems by exposing to theses heavy metals and clinical aspects of chronic toxicities .Therefor it was essential for researches to investigate and find solution to remove the heavy metal by conducting several type of treatments with different kind of removals. Literature revealed various experiments conducted in the few decades. Removing metal ions from contaminated water typically run by chemical and biological removing technologies. Conventional techniques for removing metal ions solution have been testified. Conventional methods were widely used for removing heavy metal from aqua solutions thus results are vary from one application to another. Chemical precipitation is the most common utilized conventional technique. Activated carbon was commonly used to uptake heavy metal However, the high cost of the activation process limits its use in wastewater treatment applications [8]. Conventional methods have been used such as chemical precipitation, coagulation, ion exchange, solvent extraction and filtration, evaporation and membrane methods. [9] Summarized the advantages and disadvantages of those conventional metal removal technologies from aqueous. Cost is one of the main factor for applying any application and be used widely and effectively, therefor many researches has considered abundant material easy and cost effective of use. [10] Reported several applications used by researchers for removal of heavy metal ions using low-cost adsorbents. Recently, adsorption has become one of the alternative treatments [11]. Basically, adsorption is a mass transfer process by which a substance is transferred from the liquid phase to the surface of a solid, and becomes bound by physical and/or chemical inter- actions [12]. The foremost benefits of biosorption technology are its efficacy in reducing the concentration of heavy metal ions to very low levels and the use of low-cost biosorbent materials.

1.1. Objective

The aim of this paper is to investigate and measure the efficiency of heavy metal adsorption of Cd, Cu and Zn by applying compost materials application as sorbents

II. Methodology

2.1. Preparation of compost materials

Tree type of compost were collected from local different locations from Hungary, packed in laboratory bags, compost was grounded using a laboratory mill and then sieved to 2mm. One gram compost was weighted to fit one sample bottle with screw cap. 13 samples were prepared for single set, and 3 replications were conducted to carry the test for one single metal followed by the same steps for other composts besides the heavy metals. Finally, every set of samples has 10 ml of concentration solution per each bottle plus one gram of compost, concentration solution range from 0 to 50000 µg/g of one single metal and the homogeneous mixture was ready to be investigated.

2.2. Characterization of composts

The chemical composition of all composts is shown in Table [I] and the values are expressed in percentage. The compost material characteristics are as follow, 1. Felgyő Green waste and sewage sludge. 2. Garé Communal sewage sludge, Slurry mud and chicken manure with straw. 3. Sioagárd Green biomass/ bio waste. The experiment revealed that the chemical composition of the compost material was a key factor for the percentage removed of the heavy metal.

TABLE 1

CHEMICAL PROPERTIES OF COMPOST MATERIALS

Compost Material	Dry mater	pH_{kCl}	pH_{H2O}	Organic Mater %	NH_4-N mg/kg	NO_3-N mg/kg	Salt %	Total N %	Total P_2O_5%	Total K_2O%
1. Felgő	64.3	6.0	6.6	24.7	17.8	942	1.8	1.1	0.7	0.7
2. Garé	46.3	5.1	5.4	50.0	95.8	2175	4.5	2.6	31233	13453
3. Sióagrd	61.7	7.0	7.3	62.2	16.5	1461	1.3	1.0	16554	9998

2.3. Concentration solution

Cd, Cu and Zn Sulphate added separately to distilled water in the laboratory and the value of concentration was determined in a range of 0 to 50000 µg/g, mixture was adjusted to the desired value then the concentration solution filled 13 bottles to make an initial concentration of (0–50000 µg/g) for each metal. The initial concentration provides an important driving force to overcome all mass transfer resistances of solutes between the aqueous and solid phases. The impact of initial heavy metal concentration on the rate of sorption are shown in Fig. (2), (4) and (6). From those figures we can learn that the metal removal differ with varying of initial heavy metal concentration.

2.4. Method

Batch adsorption experiments were carried out by shaking a series of samples containing same amounts of different concentration solution with mixture of 3 different composts used to sorb the heavy metal separately. The compost materials used were mixed with concentration range of (0, 50, 100, 250, 500, 100, 250, 500, 10000, 25000, 30000, 40000, and 50000 µg/g) of Zn, followed by Cu and last was cadmium. After the composts has been collected, the product was ground and sieved to 2mm which transferred to small flask with screw cap which contained 1g compost plus 10 ml of concentration solution , and then immerged in a shaking machine as a complete set containing 13 samples at a constant speed of 125 rpm. Shaking every set of experiments for 24 hours. All the experiments were performed in duplicate method and the adsorbate and adsorbent were separated by high speed centrifugation at 6000 rpm for 7 minutes. In this stage of the experiment the adsorbent particles were separated from the suspensions by filtration through 0.43 µm filter paper. The residual concentration of heavy metals was determined by the Atomic absorption photometer. The measured data were fitted to Langmuir function.

III. Results and discussion

The compost has a significant impact on the uptake of heavy metals in this The results obtained are shown in Fig. . (1), (2) and (3) in terms of compost effect on the sorption of Cd, Cu. and Zn from the aqueous solution onto the different sorbents in relation of the metal ions removed percent. It is clear that Cd, Cu and Zn ions were effectively adsorbed in the composts and the maximum adsorption of Cd, Cu and Zn ions using compost occurred at 0 to 10000 µg/g by 100 % respectively,. The results in Fig. (2), (3) and (4) show that the equilibrium capacity of cadmium, copper and zinc removal by the different adsorbents increased significantly as the of the concentration solution increased. If the initial pH was too high, copper and zinc ions precipitated out and this deflected the purpose of employing the sorption process as the sorption process is kinetically faster than the precipitation [13]. The adsorptive capacities of Cu, and Zn ions increased rapidly as the concentration value increased, above 10000 µg/g the adsorptive capacities of Cd, Cu and Zn ions increased, but at a slower rate. Because of the competitive adsorption between hydrogen ion and the heavy metal cation [14]. The adsorption equilibrium were analysed for Langmuir models using linear and non-linear regression programme of Statistics 6.0 software. This software was used to determine the rate constant and order of reaction for heavy metals adsorption on compost material. It was observed that the metal uptaken by composts varied with varying of initial solution concentration and composts as shown in Fig. (1), (2) and (3).The cadmium in Fig (1) adsorbed was higher in compost 2. Garé then 3. Sioagárd and less in 1.Felgyő, the maximum adsorbed capacity in compost 2. Garé was recorded 40107 while in 3.Sioagrad was 30669 and recorded less amount adsorbed in 1. Felgyő with 26594, the equilibrium constant presented in table [II] was 0. 037 at compost 1. Felgyő, 0,027 at compost 3. Sióagárd and less steep at compost 2. Garé. In table .(5), cupper has recorded the highest amount in Fig. (2) of 44242 adsorbed into compost 2. Garé and 30237 in compost 3. Sióagárd finely in compost 1. Felgyő was the lowest amount sorbet of cupper with record of 26350. The curves in table Fig (2) and equilibrium constant K. [III] have shown higher steepness in compost 3. Sióagárd 0.05, then 1. Felgyő, 0.04 and lesser in 2. Garé 0.02, respectively. Maximum adsorbed amount of Zinc is shown in table [IV] into compost 2. Garé 26802, at 3. Sióagárd compost was 19928, lesser into compost 1. Felgyő with 15822 up taken. Table [IV] and Fig. (3) indicated the steepness of curve is higher with 0.03 in compost 2. Garé, followed by compost 1. Felgyő with record of 0.02 and lesser steep at compost 3. Sióagárd with 0.01.

Conclusion

All the 3 compost materials used for cleaning the water polluted with Cd, Cu, Zn respectively, could sorb practically the total amount of 100 % of heavy metals up to 10000 µg/g concentrations.

It was observed that the metal removal varied with varying initial metal concentration**.** The cupper show its vanity by adsorbing into compost 2. Garé, followed by cadmium Garé2 and last was zin in 2. Garé. The tree heavy metals adsorbed better into 2. Garé compost material rather than 1. Felgyő and 3. Sióagárd. 2. Garé compost has demonstrated outstanding removal capabilities for heavy metals. At common heavy metal pollutions of waste water the compost materials could be effective sorbent of heavy metal ions.

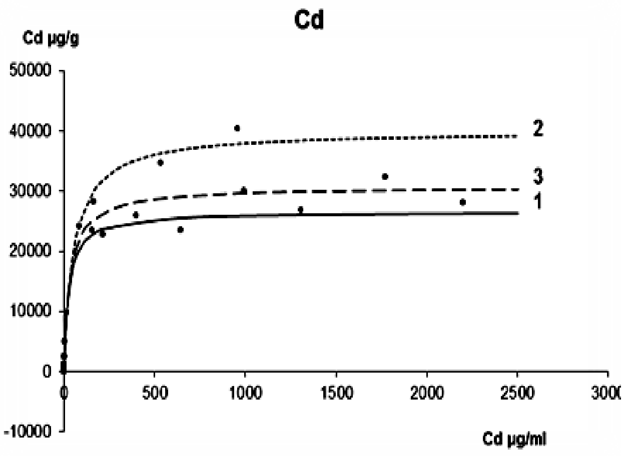

Fig. 1. Cd sorption curves of compost materials

TABLE 2

MAXIMUM AMOUNT (A) AND EQUILIBRIUM CONSTANT (K) OF CD SORBED ON COMPOST MATERIALS LANGMUIR ISOTHERM

Compost material	A µg^{-1}	K
1. Felgyő	26594	0.037
2. Garé	40107	0.017
3. Sióagárd	30669	0.027

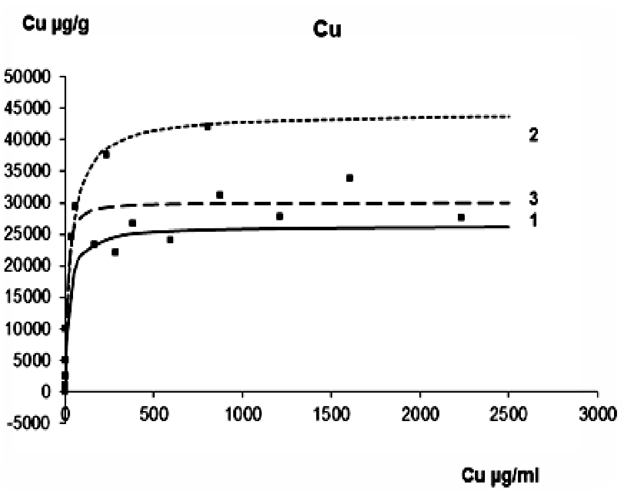

Fig. 2. Cu sorption curves of compost materials

TABLE 3

MAXIMUM AMOUNT (A) AND EQUILIBRIUM CONSTANT (K) OF CU SORBED ON COMPOST MATERIALS LANGMUIR ISOTHERM

Compost material	A µg^{-1}	K
1. Felgyő	26350	0.049
2. Garé	44242	0.028
3. Sióagárd	30273	0.058

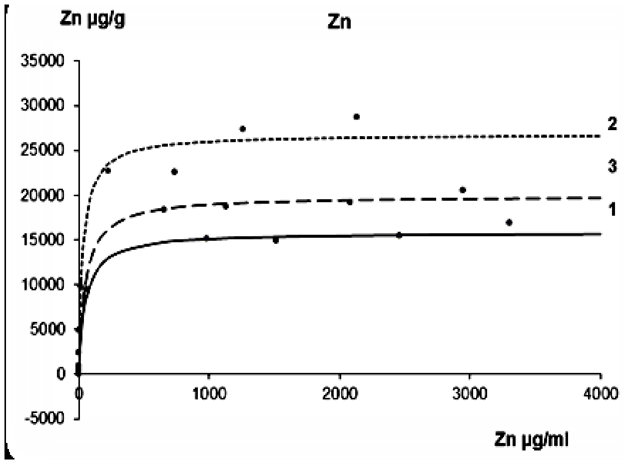

Fig. 3. Zn sorption curves of compost materials

TABLE 4

MAXIMUM AMOUNT (A) AND EQUILIBRIUM CONSTANT (K) OF ZN SORBED ON COMPOST MATERIALS LANGMUIR ISOTHERM

Compost material	A µg^{-1}	K
1. Felgyő	15822	0.0200
2. Garé	26802	0.0310
3. Sióagárd	19928	0.0191

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