Leonardo Journal of Sciences
ISSN 1583-0233
Issue 14, January-June 2009
p. 227-234

Sorption Potentials of Waste Tyre for Some Heavy Metals (Pb Cd) in Aqueous Solution

Austin Kanayo ASIAGWU[1], Patrice-Anthony-Chudi OKOYE[2], Orji IFEOMA[2]. and Patrick. Ejo. OMUKU[2]

[1]*Department of Chemistry, Delta State University, Abraka Nigeria*
[2]*Department of Pure & Industrial Chemistry Nnamdi Azikiwe University, Awka Nigeria*
E-mail: drasiagwu@yahoo.com

Abstract

An investigation into the adsorption potential of activated and inactivated waste tyre powders for some heavy metals (Pb^{2+} and Cd^{2+}) in their aqueous solution has been studied. The result indicated that inactivated waste tyre is a good non-conventional adsorbent for the removal of Cd from aqueous solution. A total of 93.3% of Cadmium contents was removed. The inactivated waste type proved a good adsorbent for the removal of Pb^{2+} 5g of 500µm activated tyre removed over 86.66% of Pb^{2+} from solution.

Keywords

Actions and inactivation, adsorption, removal of heavy metal from aqueous solution.

Introduction

The tremendous increase in the use of heavy metals over the past few decades has inevitably resulted in an increased influx of metallic substances in aquatic environment (1). Heavy metal pollution in the aquatic environment is a major health problem. This is because metals are toxic and non-biodegradable (2). Despite the toxicological effects of Cadmium, it has a wide range of uses. The most significant use of cadmium is in the Ni-Cd batteries which

are rechargeable. The batteries exhibit high output, long life, low maintenance and high tolerance to physical and electrical stress (3). Other uses of Cadmium includes, metal coatings, pigments, stabilizers for PVC, in alloys and electroplating. It can also be employed to photo cells, photometry for ultraviolet sun-ray, filaments for incandescent high, and electrodes and in density as an amalgam (4). Similarly, lead has a wide range of uses. It is used in storage batteries, allays, solder, ceramics and plastic. Applied in petrol refining, halogenations, extraction, sulphooneation, manufacture of pigments, insulation cables and wiring household, printing inks glass, textiles and so (Robert and Rowland). It is also toxic. These metals find their way into the aquatic environment through waste water discharge (5). Because they are non-biodegradable, they tend to accumulate in aquatic organisms. Feeding in such aquatic organisms as fish, crabs or using such contaminated water can lead to metal poisoning in man. Heavy metals pose health hazards, if their concentrations exist above the allowable limits. Even when the limits are not exceeded, there are still the potentials of a long term poisoning, since they are known to accumulate within biological systems. The increasing awareness of the environmental consequences arising form heavy metal accumulation of aquatic environment has lead to the demand for the treatment of industrial wastewater before discharge into aquatic environment.

Conventional treatment process for metal contaminated wastewater include ion-exchange, chemical precipitation, ultra-filtration, electrochemical deposition and carbon adsorption. These methods though effective are not economically feasible for small and medium scale industries, because of the relatively high costs (6), (7). Hence the need to explore cost effective alternative methods of adsorbents for the treatment of metals contaminated wastewater.

There are some readily available waste materials that possess potentials of cheap adsorbents for the treatment of metal contaminated wastewater. A number of workers have investigated such materials like melon seed husks, maize cob, and groundnut husk and oil-palm fibre (8). There is still the need to investigate the adsorptive potentials of other cheap and readily available materials that may constitute the class of waste products in the environment. This present work is aimed at examining the potentials of activated and unactivated waste tyre in the removal of (adsorbent) of cadmium and lead from their aqueous solution.

Materials and Method

Waste tyre used in this work was a Michelin brand, collected from a vulcanizer in Onitsha, Nigeria. This tyre was sliced into bits, the metal-threading removal, while the sliced tyres was washed thoroughly with detergent and rinsed severally with clean water to remove any residue. The washed tyre was allowed to dry under the sun.

The dry waste tyre was then ground to powder using a crushing machine. The powder was sieved using the electrical vibration shaker to obtain particle sizes of 500µm, 250µm and 125µm.

The resulting waste tyre powder was subjected to chemical activation, using hydrochloric acid. The activation process was carried out by mixing a known weight (1g, 2g, 3g, & 5g) of waste tyre powder with a known volume of 1mHcl as the activating agent in a ratio of 20cm^3 of 1MHCL to 250g of waste powder, in an evaporating dish. The sample was allowed to dry at room temperature. Various masses of 1g, 2g, 3g, and 5g for each of the three particle sizes were weighed and kept in polythene away from moisture.

The varying particle sizes of 500µm, 250µm and 123µm for active and inactive waste tyre power were weighed out in 1g, 2g, 3g and 5g samples and were packed properly into different burettes and exactly 10mls of 20mg/1 of standard Pb $(NO_3)_2$ and allowed for a contact period of 30m minus, for adsorption to take place. The burette tap was then opened after 30 minus and the solution was allowed to drain slowly and the eluent collected and labelled properly. This procedure was repeated for Cd $(NO_3)_2$. $4H_2O$ standard solution (30mg/L). The eluent and the stock solution were assayed for metal ions (Pb^{2+} and Cd^{2+}) left in the solution using the Atomic Absorption Spectrophotometer with air acetylene flame of 2600°C at a measurement time of 4 seconds.

- Metal flame tyre lamp wavelength
- Cd Air Acetylene 228.8nm
- Rd Air Acetylene 217.0nm
- Absorbance = (Co-c)/co

Results and Discussion

The findings of this work are contained in tables 1, 2, 3, 4, 5, 6 and 7. Table 1 shows the variation of 1g waste tyre powder at different particle sizes. The data below showed that the inactivated waste tyre had very high adsorptivity as compared to that of the activated one. This is an indication that the activation did not really increase the porosity and internal surface area of the adsorbent. The adsorpitivity of Cd^{2+} as compared to that of Pb^{2+} were high. The waste tyre whether activated or not, functions as good adsorbent for the adsorption of Cd^{2+} from aqueous solution. However, it is worth nothing that activated tyre proved a poor adsorbent for the removal of lead ion from solution via 1g mass of adsorbent. The particle size, did not have any appreciable influence on the adsorption of Cd^{2+} and Pb^{2+}, but there was noticeable difference in the adsorptivity of activated waste tyre powder of Pb^{2+}. This observation is at variance with the theory which states that adsorptivity increase with increase in particle size (Vasenth Kumer, Subanandam Ramamurthi and Sivanesan 2004).

Table 2 shows that the inactivated waste tyre is a better adsorbent for the removal of Pb^{2+} and Cd^{2+} $acid^{2+}$ from aqueous solution as compared to the activated waste tyre powder. The inactivated waste tyre had higher adsorptivity, though Cd^{2+} is more favoured. However, the activated waste tyre did not show the properties of a good adsorbent in respect to the adsorption of Pb^{2+} ion, but increase in particle size, showed increased adsorption.

The variation in adsorption potential of 3g waste tyre powder at varying particle sizes is shown in table 3. The Cd^{2+} showed high affinity for waste tyre powder. It was observed that activation did not increase adsorptivity as the inactivated adsorbent has high adsorption ability than the activated. Also the adsorption of Pb^{2+} by activated waste tyre showed great deviation as there was increase in metal concentration in one of the samples than in the stock solution. Using an adsorbent of 5g (Table 4), it was observed that inactivated waste tyre powder has high adsorptivity than the activated one. Similarly, adsorptivity increase gradually with increase in particle size, which theoretically had to be the reverse since smaller particle size has large internal surface area available as adsorption site (Ford 1981). This deviation may be due to the fact that smaller particle size floated in the column when the adsorbent was added. Similarly, it was observed that the activated waste tyre showed improved adsorption with increase in mass of the adsorbent. However, Pb^{2+} was greatly adsorbed by 500µm of 5g adsorbent as shown in table 4.

Table 5, represent percentage of Pb and Cd metal concentration adsorbed by activated and inactivated waste powder. The results showed that the percentage of Cd^{2+} adsorbed was high compared to Pb^{2+} and that the inactivated waste tyre proved a good adsorbent in the adsorption of Cd^{2+} from solution. However, the activated waste tyre also appreciably adsorbs Cd^{2+}. It was generally observed that the increase in mass of the adsorbent did not greatly influence the adsorption capacity, but increase in mass had significant effect in the adsorption of lead was, where it had the maximum adsorption with activated waste tyre powder 2+ 5g mass adsorbent and 500µm particle size.

The variation of mass of adsorbent with adsorptivity of Pb^{2+} and Cd^{2+} and 125µm particle size, table 6 showed that the adsorptivity of metal ions from solution decreased with increase in the mass of adsorbent. Also the general trend of absorptivity (Krishnan and Concilia 1987) decreased with increase in mass attributed to the quantity of the adsorbent floating on top of the adsorbent, being much, but only a little surface area of the adsorbent is in contact with adsorbate. 250µm of 5g activated waste powder was observed to be a good adsorbent for Cd^{2+} as the adsorptivity increased appreciably.

For 500µm particle size, the variation mass of adsorbent with adsorptivity of metal ions (Pb^{2+} and Cd^{2+}) Table 7, showed that the variation in mass did not affect the adsorptivity of Cd^{2+} by unactivated waste tyre of 500µm particle. This was evident because metal concentration adsorbed remained the same despite change in mass (10). The metal concentration adsorbed using activated waste tyre showed that the adsorptivity of Cd^{2+} decreased with increase in mass of adsorbent, while Pb^{2+} had maximum adsorption with increase in mass.

Table 1. Variation in Adsorptivity of 2g Waste Tyre Powder at Different Particle Sizes

Particle size (µm)	Metal conc. Adsorbed (PPM)			
	Activated waste tyre powder		Unactivated	
	Pb	Cd	Pb	Cd
125µm	6	22	24	27
250µm	9	22	21	28
500µm	18	25	26	28

Table 2. Variation in Adsorptivity of 3g waste tyre powder at different particle sizes.

Particle size (μm)	**Metal conc. Adsorbed (PPM)**			
	Activated waste tyre powder		**Unactivated**	
	Pb	Cd	Pb	Cd
125μm	-9	18	15	27
250μm	0	21	18	27
500μm	12	24	27	28

Table 3. Variation in Adsorptivity of 5g waste tyre powder at different particle sizes

Particle size (μm)	**Metal conc. Adsorbed (PPM)**			
	Activated waste tyre powder		**Unactivated**	
	Pb	Cd	Pb	Cd
125μm	9	11	-30	23
250μm	-9	28	15	26
500μm	26	20	3	28

Table 4**.** Percentage of Pb & Cd metal conc. Adsorbed by Activated and unactivated waste tyre powder

Mass of Adsorbent	**Particle size (μm)**	**Metal conc. Adsorbed (PPM)**			
		Activated waste tyre powder		**Unactivated**	
		Pb	Cd	Pb	Cd
1g	125μm	50	86.67	86.67	93.33
	250μm	60	86.67	80	93.33
	500μm	70	90	90	93.33
2g	125μm	20	73.33	70	90
	250μm	30	73.33	70	93.33
	500μm	60	83.33	86.67	93.33
3g	125μm	-30	60	50	90
	250μm	0	70	60	90
	500μm	40	80	90	93.33
5g	125μm	30	36.66	-100	76.66
	250μm	-30	93.33	50	86.66
	500μm	86.66	66.66	10	93.33

Table 5**.**Variation of mass of Adsorbent with Adsorptivity of Pb^{2+} and Cd^{2+} at 125μm particle size

Particle size (μm)	**Metal conc. Adsorbed (PPM)**			
	Activated waste tyre powder		**Unactivated**	
	Pb	Cd	Pb	Cd
1g	15	26	26	28
2g	6	22	24	27
5g	9	11	-30	23

Table 6. Variation of mass of Adsorbent with Adsorptivity of Pb2+ and Cd2+ at 250µm particle size

Particle size (µm)	**Metal conc. Adsorbed (PPM)**			
	Activated waste tyre powder		**Unactivated**	
	Pb	Cd	Pb	Cd
1g	18	26	24	28
2g	9	22	21	28
3g	0	21	18	27
5g	-9	28	15	26

Table 7. Variation mass of Adsorbent with Adsorptivity of Pb^{2+} and Cd^{2+} at 500µm Particle size

Particle size (µm)	**Metal conc. Adsorbed (PPM)**			
	Activated waste tyre powder		**Unactivated**	
	Pb^{2+}	Cd^{2+}	Pb^{2+}	Cd^{2+}
1g	21	27	27	28
2g	18	25	26	28
3g	12	24	27	28
5g	26	20	3	28

Conclusion

The activated and the inactivated waste tyre powder are good adsorbent for the removal of Cd^{2+} from aqueous solution. However, the inactivated waste tyre powder proved a better adsorbent as such; resources should be spent on activation of the waste tyre powders, since it did not actually increase the porosity of the adsorbent. The particle size of 500µm proved the ideal particle size of waste tyre powders that gave appreciable results in the adsorption of Cd^{2+} from aqueous solution.

Variation in the mass of the adsorbent din not really affect the adsorptivity, as such any suitable mass within the range of that used in this research can be used practically. However, inactivated waste tyre powder showed over 90% maximum efficiency for the removal of Pb^{2+} from aqueous solution. While the activated one proved good adsorbent only when 5g mass adsorbent was used with 500µm particle size. Therefore, the inactivated waste tyre powder can be practically utilized in the removal/adsorption of Pb^{2+} and Cd^{2+} from actually polluted wastewater from industries.

References

1. Harrison R.M. and LAXEN D.P.H.; Metals in Environmental Chemistry Chem, Br. Vol. 16: 316-320, 1980.
2. COREPCIOGIE M.O. and Henry C.P. The adsorption of heavy metals onto hydrous activated carbon; water resources 21 (9); 1031-1044, 1987.
3. Hoale, R.A. The Chemistry of Environment. John Willey and Sons. New York. 15-20, 1978.
4. Okeimen, F. E. Esther U. O. and David E. O. Sorption of Cadmium and Lead ions on modified groundnut husk. Nigerian-Chem. Tech. Biotechnology Vol. 31: 97-99, 1999.
5. Gurper W.K., Jaln C.K. Ali J, Sharma M. and Sani V.K.; Removal of Cadmium and Nickel from wastewater using biagasse fly ash-sugar industry waste. Water Resources 37: 4038-4044, 2003.
6. Cheremshoff, P. and Elizabeth F. Carbon Adsorption. Handbook, Michigan Am Arbor Science Series 15:1-2, 1979.
7. Lelvan, S. B. Hubner, A. Weston A. and Matadich N.. Removal of Hexavalent and metal cations by selective and novel carbon adsorbent, carbon 36:219-226, 1998.
8. Okamen F. E. and Onyekpa V. U. Removal of heavy metal ions from aqueous solution with melon seed husks. Biological waste 29:11-16, 1989.
9. Vasanth Kummer K., Subanandam V. Ramamurthi S. and Sivanesan S.; Solid-liquid adsorption for wastewater treatment, principle, design and operation, 2004.
10. Azab, M.S. and Peterson, P.J. The Removal of Cd from waste water by the use of biological sorbent. Water science Technology Vol. 21: 1705-1706, 1989.