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Studies in Adsorption of Some Toxic Metal Ions on Citrus sinensis Skin and *Coffea arabica* Husk: Agricultural Byproduct

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Adsorption of toxic metal ions like Hg^{2+}, Pb^{2+} and transition metal Zn^{2+} ion on different agricultural byproducts were measured by UV-visible spectrophotometer-108. Adsorption of metal ions follows the order polymerized *Citrus sinensis* (mosambi) skin > *Coffea arabica* (coffee) husk for Hg^{2+} and Pb^{2+} and *Citrus sinensis* skin < *Coffea arabica* husk for Zn^{2+} metal ion. *Citrus sinensis* skin showed maximum adsorbing capacity for Hg^{2+} and Pb^{2+} metal ions. It could also be seen that Hg^{2+} metal ion is a good adsorbing adsorbate as compared to Pb^{2+} and Zn^{2+} metal ions. The values of Freundlich constants (n and k) are estimated from graph which are found to be $1/n < 1$ and $k > 1$.

Key Words: Adsorption, Toxic, Metal ions, *Citrus sinensis* skin, *Coffea arabica* husk.

INTRODUCTION

The force of attraction existing between molecules in any state of matter shows an intermolecular attraction or cohesive force of attraction. Adsorption shows the collection of adsorbate on the surface of adsorbent due to cohesive force of attraction. The phenomenon of higher concentration of any molecule species at the surface than in the bulk of a solid or liquid also shows the adsorption. McBain suggested that absorption and adsorption take place simultaneously.

The presence of toxic metal ions like Hg^{2+}, Pb^{2+}, Sr^{2+}, Zn^{2+}, etc. in industrial waste has attracted worldwide attention. Several methods which include chemical precipitation, ion exchange, ultra-filtration, electrochemical treatment etc. are suggested for the removal of these metal ions. Few workers have suggested methods for the adsorption of their ions by using inexpensive agricultural byproducts[1,2] tree barks[3-6], peanut skin[7], orange skin and banana husk[8], agricultural waste materials[9] like rice straw and paddy husk. In the present investigation we studied the adsorption of Hg^{2+}, Pb^{2+} and Zn^{2+} by inexpensive agricultural

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products such as *Citrus sinensis* skin (mosambi) and *coffea arabica* husk (coffee husk). The quantitative estimations of these metal ions before and after adsorption are made by UV-visible spectrophotometer.

RESULTS AND DISCUSSION

The data of amount of adsorption are presented in Table 1–3. The result of adsorption of Hg^{2+} as observed by *Citrus sinensis* skin and *Coffea arabica* husk is greater than that of Pb^{2+} and Zn^{2+}. It is noted from Tables 1–3 that the order of amount of adsorption for *Citrus sinensis* skin and *Coffea arabica* husk is $Hg^{2+} > Pb^{2+} > Zn^{2+}$. It may be seen that the adsorption of metal ions increases with respect to increase in concentration of metal ion.

Formation curves were constructed between log c (c = concentration) *vs.* log (ΔA). There are formation straight line graphs for all the systems for every toxic metal. The values of Freundlich constants (n and k) are also estimated from graph which are found to be $1/n < 1$ and $k > 1$. These values are shown in Table-4. These values show good agreement with the concept of freundlich. The values of constants depend on the nature of the adsorbate and adsorbent, the value of 'n' is always greater than one.

TABLE-1
DATA OF ADSORPTION WITH CONCENTRATION FOR Hg^{2+} IONS AT $\lambda_{max} = 298$ nm

Conc. of metal ion in mol dm^{-3}	log (conc.)	Ab	*Citrus sinensis* skin			*Coffea arabica* husk		
			Aa	ΔA	log (ΔA)	Aa	ΔA	log (ΔA)
0.01	–2.000	0.269	1.080	0.811	–0.09097	1.051	0.782	–0.10679
0.02	–1.6989	0.278	1.094	0.816	–0.08830	1.084	0.806	–0.09366
0.03	–1.5228	0.289	1.108	0.819	–0.08671	1.100	0.811	–0.09097
0.04	–1.3979	0.301	1.122	0.821	–0.08565	1.113	0.812	–0.09044
0.05	–1.3010	0.308	1.132	0.824	–0.08407	1.124	0.816	–0.08830

TABLE-2
DATA OF ADSORPTION WITH CONCENTRATION FOR Pb^{2+} IONS AT $\lambda_{max} = 305$ nm

Conc. of metal ion in mol dm^{-3}	log (conc.)	Ab	*Citrus sinensis* skin			*Coffea arabica* husk		
			Aa	ΔA	log (ΔA)	Aa	ΔA	log (ΔA)
0.01	–2.000	0.913	1.174	0.261	–0.5833	1.139	0.226	–0.6458
0.02	–1.6989	0.921	1.189	0.268	–0.5718	1.161	0.240	–0.6197
0.03	–1.5228	0.930	1.204	0.274	–0.5622	1.183	0.253	–0.5968
0.04	–1.3979	0.940	1.212	0.272	–0.5654	1.200	0.260	–0.5850
0.05	–1.3010	0.944	1.221	0.277	–0.5575	1.208	0.264	–0.5783

TABLE-3
DATA OF ADSORPTION WITH CONCENTRATION FOR Zn^{2+} IONS AT λ_{max} = 303 nm

Conc. of metal ion in mol dm^{-3}	log (conc)	Ab	*Citrus sinensis* skin			*Coffea arabica* husk		
			Aa	ΔA	log (ΔA)	Aa	ΔA	log (ΔA)
0.01	–2.000	0.723	0.927	0.204	–0.6903	0.949	0.226	–0.6458
0.02	–1.6989	0.741	0.954	0.213	–0.6716	0.962	0.221	–0.6556
0.03	–1.5228	0.754	0.970	0.216	–0.6655	0.978	0.224	–0.6497
0.04	–1.3979	0.762	0.982	0.220	–0.6575	0.990	0.228	–0.6420
0.05	–1.3010	0.770	0.992	0.222	–0.6536	1.000	0.230	–0.6382

where Ab = Absorption before adsorption; Aa = Absorption after adsorption; ΔA-Difference in absorption.

TABLE-4
THE DATA FOR FREUNDLICH CONSTANTS k AND n FOR Hg^{2+}, Pb^{2+}AND Zn^{2+} METAL ION SOLUTIONS

System	λ_{max}	k values	n values
Hg(II)-*Citrus sinensis* skin	298 nm	1.1994	65.01
Pb(II)-*Citrus sinensis* skin	305 nm	3.4994	27.32
Zn(II)-*Citrus sinensis* skin	303 nm	4.2657	13.33
Hg(II)-*Coffea arabica* husk	298 nm	1.2050	50.00
Pb(II)-*Coffea arabica* husk	305 nm	3.4830	12.50
Zn(II)-*Coffea arabica* husk	303 nm	3.8940	10.00

EXPERIMENTAL

Citrus sinensis skin and *Coffea arabica* husk were collected from Melghat situated in Satpura hills and exposed to sunlight for one week. Subsequently they were ground, exposed to sunlight for 18 h and were preserved in plastic bottles with airtight corks. The solutions of different concentrations (0.01 M, 0.02 M, 0.03 M, 0.04 M and 0.05 M) of Hg^{2+}, Pb^{2+} and Zn^{2+} salts were prepared in double distilled water and were placed in different conical flasks. 0.5 g of each of the adsorbents was weighed accurately and placed in each conical flasks. The flasks were corked and shaken in mechanical shaker for 1 h. The solutions were filtered, pH of filtrates was measured and filtrates were preserved in airtight glass bottles.

The change in absorption of metal ions before and after adsorption were measured by UV-visible spectrophotometer-108. The data obtained, the amount of adsorption along with concentration, are presented in Tables 1–3. The values of Freundlich constants are presented in Table-4.

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