

**Summary Report of Experiments Investigating the  
Sorption of Five Anions to EC-MB Bone Char**

**Prepared By**

**Vinka Craver, Ph.D.**

**and**

**James Smith, Ph.D.**

**February 14, 2006**

**For**

**George Alther**

**Biomin, Inc.**

**P. O. Box 20028**

**Ferndale, MI 48220**

## Table of Contents

Phosphate removal from water by EC-MB Bone Char .....	4
Chromate removal from water by EC-MB Bone Char.....	5
Selenite removal from water by EC-MB Bone Char .....	6
Arsenate removal from water by EC-MB Bone Char .....	7
Fluoride removal from water by EC-MB Bone Char.....	8
Summary of the removal of five anions from water by EC-MB Bone Char.....	9

This report presents Tables and Figures summarizing the results from five column experiments studying the sorptive capacity of EC-MB Bone Char to five aqueous anion solutions. A 30-inch long (76.2 cm) by 3-inch diameter (7.62 cm) column was constructed from PVC and filled with the sorbent material to be studied. A peristaltic pump forced an aqueous anion solution containing in the range of 200-400 mg/L of the respective anions up through the column to displace void-space air and ensure maximum contact with the sorbent material. A regeneration process was applied during the arsenate and fluoride experiments. The regeneration process consisted of filling the column with a solution of sodium hydroxide 10 N overnight. After that, the column was rinsed with tap water for five minutes before feeding it again. Samples were collected periodically at the outflow of the column and analyzed using atomic absorption spectrometry and HACH colorimetric methods.

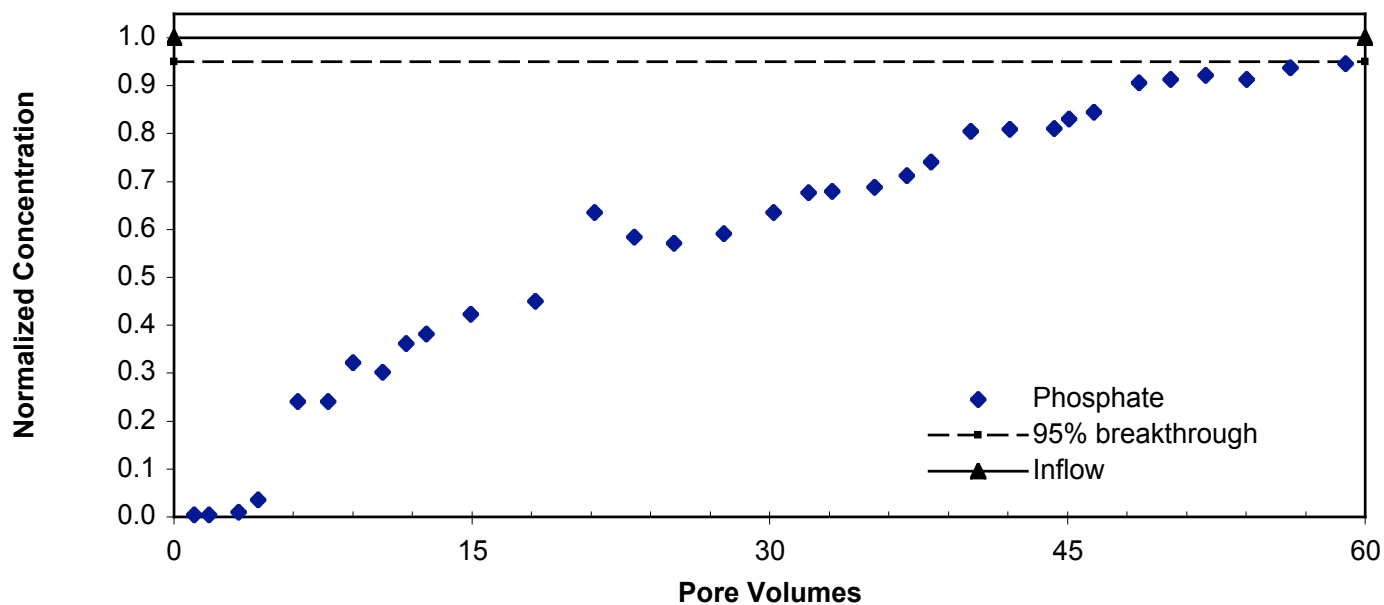
## Phosphate removal from water by EC-MB Bone Char

**Table 1.** Sorbent mass, porosity, flow rate and residence time information for the phosphate experiment.

Mass of Sorbent		Porosity	Flow Rate		Residence Time
(kg)	(lbs)		(mL/min)	(gal/hr)	
2.5	5.5	0.41	70.7	1.1	20

**Table 2.** 95% breakthrough for EC-MB Bone Char given in pore volumes and minutes along with estimated mass of phosphate sorbed per mass of sorbent in mg/kg, lb/lb and percent basis.

Breakthrough		Mass sorbed		Mass Sorbed/Mass Sorbent		
PV	min	(mg)	(lb)	(mg/kg)	(lb/lb)	(% by sorbent)
60	1200	18,820	0.041	7528	0.0075	0.75



**Figure 1.** Breakthrough curve of phosphate through a column of EC-MB Bone Char

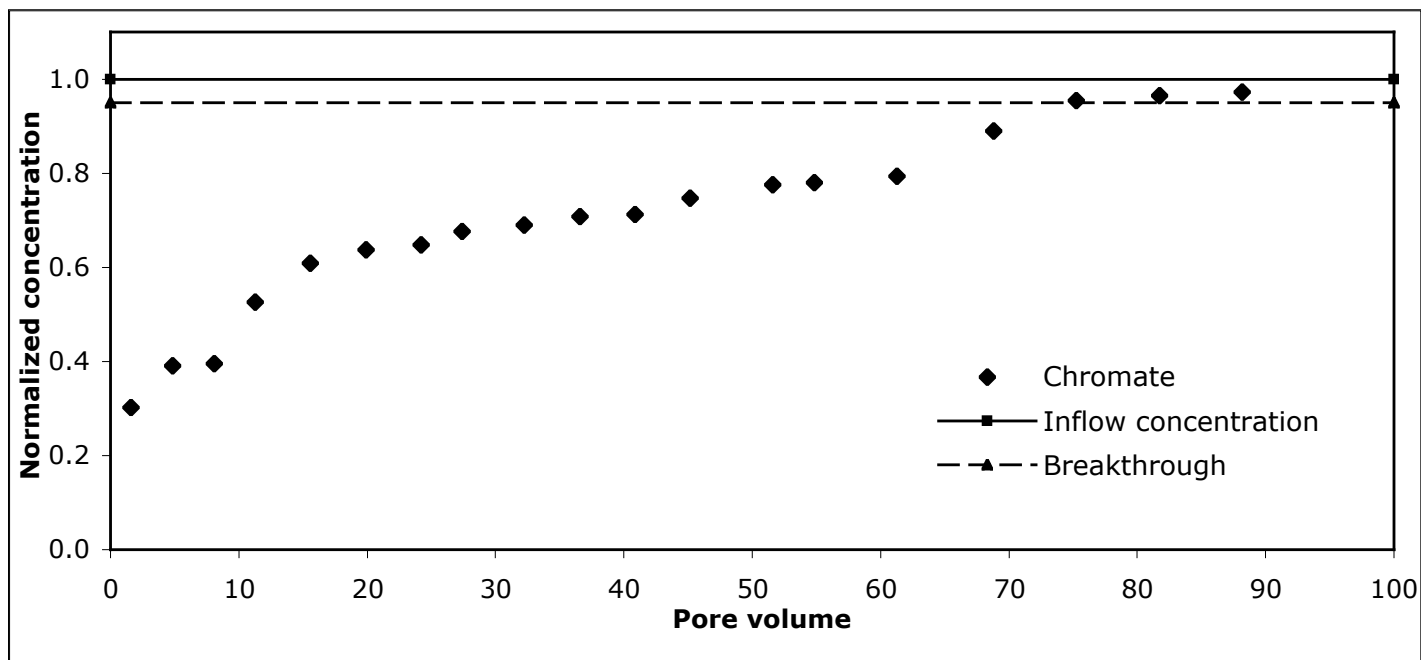
## Chromate removal from water by EC-MB Bone Char

**Table 3.** Sorbent mass, porosity, flow rate and residence time information for the chromium (VI) experiment.

Mass Sorbent		Porosity	Flow Rate		Residence (min)
(kg)	(lb)		(mL/min)	(gal/hr)	
2.3	5.06	0.56	210	3.4	9

**Table 4.** 95% breakthrough for EC-MB Bone Char given in pore volumes and minutes along with estimated mass of chromium (VI) sorbed per mass of sorbent in mg/kg, lb/lb and percent basis

Breakthrough			Mass sorbed		Mass Sorbed/Mass Sorbent		
PV	BV	min	(mg)	(lb)	(mg/kg)	(lb/lb)	(%by sorbent)
75	42	675	25,372	0.056	11031	0.011	1.10



**Figure 2.** Breakthrough curve of chromate through a column of EC-MB Bone Char

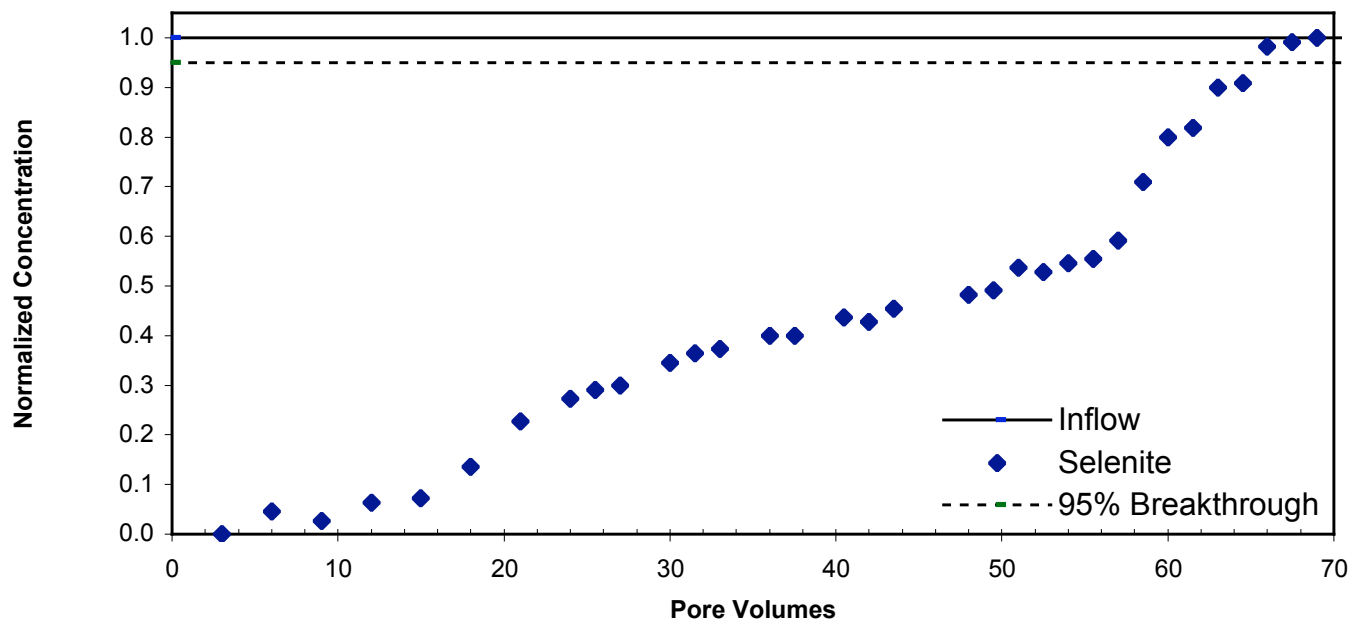
## Selenite removal from water by EC-MB Bone Char

**Table 5.** Sorbent mass, porosity, flow rate and residence time information for the selenium experiment.

Mass of Sorbent		Porosity	Flow Rate		Residence Time
(kg)	(lbs)		(mL/min)	(gal/hr)	
1.8	4.0	0.46	99.4	1.61	20

**Table 6.** 95% breakthrough for EC-MB Bone Char given in pore volumes and minutes along with estimated mass of selenium sorbed per mass of sorbent in mg/kg, lb/lb and percent basis.

Breakthrough		Mass sorbed		Mass Sorbed/Mass Sorbent		
PV	min	(mg)	(lb)	(mg/kg)	(lb/lb)	(% by sorbent)
66	1320	12,066	0.03	6703	0.0075	0.67



**Figure 3.** Breakthrough curve of selenite through a column of EC-MB Bone Char

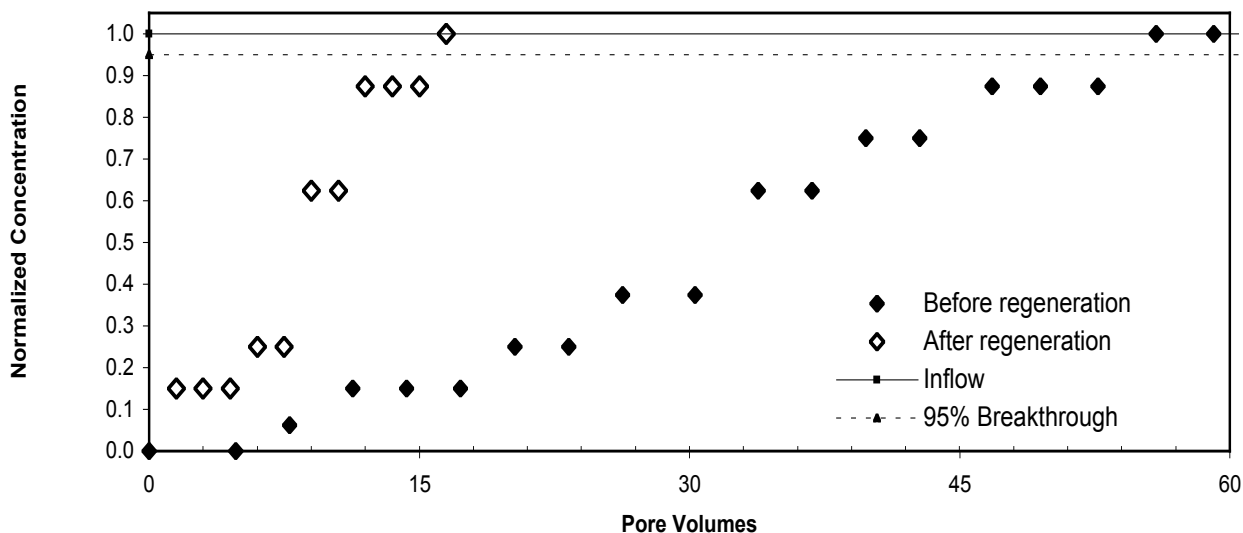
## Arsenate removal from water by EC-MB Bone Char

**Table 7.** Sorbent mass, porosity, flow rate and residence time information for the arsenate experiment.

Mass of Sorbent		Porosity	Flow Rate		Residence Time
(kg)	(lbs)		(mL/min)	(gal/hr)	
0.335	0.7	0.29	6	0.1	18

**Table 8.** 95% breakthrough for EC-MB Bone Char given in pore volumes and minutes along with estimated mass of arsenate sorbed per mass of sorbent in mg/kg, lb/lb and percent basis

	Breakthrough		Mass sorbed		Mass Sorbed/Mass Sorbent		
	PV	min	(mg)	(lb)	(mg/kg)	(lb/lb)	(% by sorbent)
<b>Breakthrough before regeneration</b>	56	1,008	2,346	0.0052	7,003	0.0074	0.74
<b>Breakthrough after regeneration</b>	17	306	714	0.0016	2,131	0.0023	0.23
<b>Total</b>	73	1,314	3,060	0.0068	9,134	0.0097	0.97



**Figure 4.** Breakthrough curve of arsenate through a column of EC-MB Bone Char

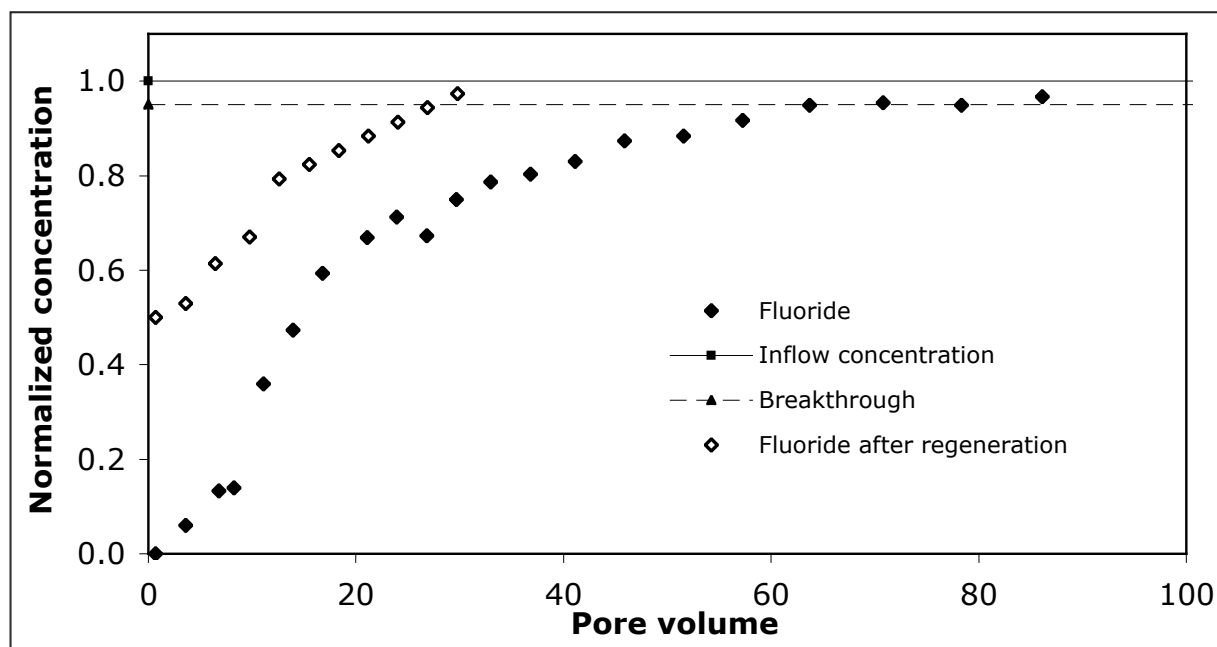
## Fluoride removal from water by EC-MB Bone Char

**Table 9.** Sorbent mass, porosity, flow rate and residence time information for the fluoride experiment.

Mass Sorbent		Porosity	Flow Rate		Residence (min)
(kg)	(lb)		(mL/min)	(gal/hr)	
1.9	4.2	0.34	56	0.89	21

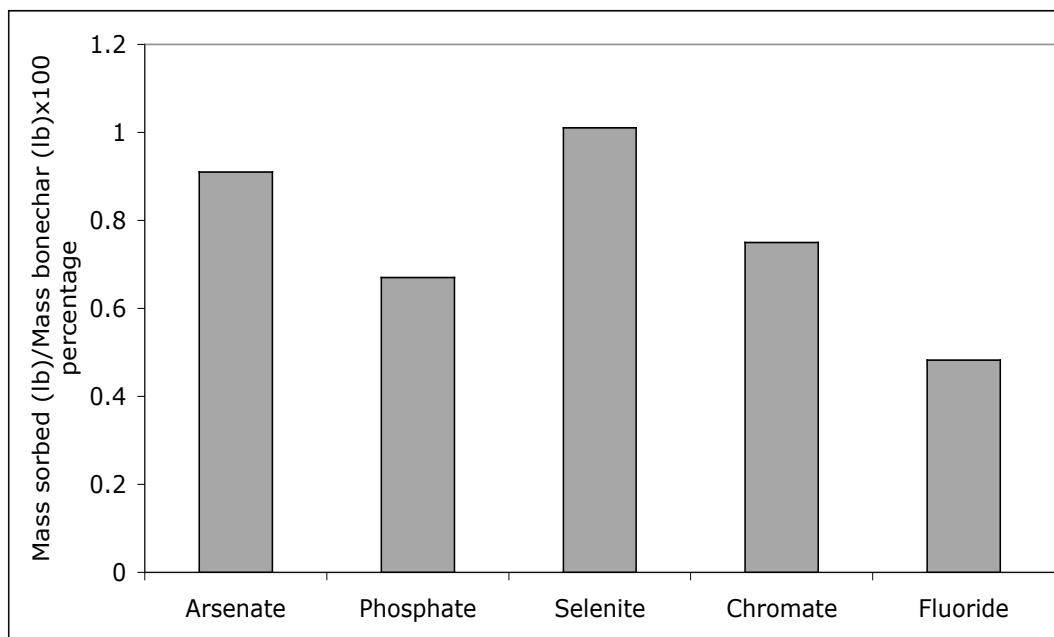
**Table 10.** 95% breakthrough for EC-MB Bone Char given in pore volumes and minutes along with estimated mass of fluoride sorbed per mass of sorbent in mg/kg, lb/lb and percent basis.

	Breakthrough		Mass sorbed		Mass Sorbed/Mass Sorbent		
	PV	min	(mg)	(lb)	(mg/kg)	(lb/lb)	(% by sorbent)
<b>Fluoride before regeneration</b>	63	1323	6903	0.0152	3633	0.00363	0.363
<b>Fluoride after regeneration</b>	27	567	2250	0.0050	1184	0.00118	0.118
<b>Total</b>	90	1890	9153	0.0201	4817	0.00482	0.482



**Figure 5.** Breakthrough curve of fluoride through a column of EC-MB Bone Char

## Summary of the removal of five anions from water by EC-MB Bone Char



**Figure 6.** Bar charts quantifying the approximate sorption capacity of EC-MB Bone Char for each of five anions.