

Supporting Documents:

Chemical and Microbial Leaching of Valuable Metals from PCBs and Tantalum Capacitors of Spent Mobile Phones

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S-1. Chemical composition of waste PCBs and tantalum capacitors (VICs) without HF
Precious Metals

Sample	Au (208.207 nm)			Pd (265.945 nm)			Ag (328.068 nm)			Ta (263.558 nm)		
	mg/L	g/kg	Avg. (g/kg)	mg/L	g/kg	Avg. (g/kg)	mg/L	g/kg	Avg. (g/kg)	mg/L	g/kg	Avg. (g/kg)
PCB-0.75a	1.61	0.40	0.4	0.08	0.02	0.00	9.4	2.35	2.2	0.1	0.03	0.02
PCB-0.75b	1.47	0.37		0.06	0.02		8.4	2.10		0.09	0.02	
PCB-0.50a	4.13	1.03	1.0	0.04	0.01	0.00	7.51	1.88	1.4	0.07	0.02	0.02
PCB-0.5b	3.59	0.90		0.05	0.01		3.38	0.85		0.1	0.03	
PCB-0.25a	4.56	1.14	1.2	0.13	0.03	0.00	8.51	2.13	1.8	0.04	0.01	0.01
PCB-0.25b	4.69	1.17		0.1	0.03		5.5	1.38		0.07	0.02	
Cap-0.75	1.01	0.51	-	0.01	0.01	-	29.9	14.95	-	0.32	0.16	-
Cap-0.5	1.21	0.61	-	0.02	0.01	-	39.9	19.95	-	0.22	0.11	-

S-2. Leaching with organic acids

Sample	Cu (327.395 nm)		Fe (261.382 nm)		Al (394.401 nm)		Mn (257.610 nm)		Ni (232.138 nm)		Pb (283.305 nm)		Zn (206.200 nm)		Au (208.207 nm)		Pd (340.458 nm)		Ag (328.068 nm)		Ta (268.517 nm)		
	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	
Citric Acid Leaching																							
PCBs	14104.6	45.27	710.90	14.05	510.31	58.66	149.67	11.09	788.09	35.34	500.89	47.70	1591.0	45.33	0.01	0	u	0	0.51	0.23	u	0	
Ta.Cap	2307.89	43.14	667.13	23.24	189.86	48.68	1743.6	21.19	645.65	45.15	443.45	31.68	267.34	43.12	u	0	u	0	3.1	0.21	u	0	
Oxalic Acid Leaching																							
PCBs	4869.7	15.63	401.71	7.94	168.52	19.37	59.43	4.40	250.81	11.25	34.87	3.32	69.63	1.98	u	0	u	0	0.1	0.05	u	0	
Ta.Cap	1122.45	20.98	272.01	9.48	49.61	12.72	321.54	3.91	329.45	23.04	96.61	6.90	26.01	4.20	u	0	u	0	u	0	u	0	

S-3. Leaching with inorganic acids

Sample	Cu (327.395 nm)		Fe (261.382 nm)		Al (394.401 nm)		Mn(257.610 nm)		Ni (232.138 nm)		Pb (283.305 nm)		Zn (206.200 nm)		Au (208.207 nm)		Pd (340.458 nm)		Ag (328.068 nm)		Ta (268.517 nm)		
	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	
Sulfuric Acid Leaching																							
PCBs-0.75	30399.94	97.56	3464.89	68.48	670.11	77.02	651.85	48.29	1680.32	75.35	49.33	4.70	3071.65	87.51	0.05	0.13	u	0	0.91	0.41	u	0	
Nitric Acid Leaching																							
PCBs-0.75	29709.62	95.35	3909.76	77.27	685.11	78.75	856.34	63.43	1498.45	67.20	267.21	25.45	2991.65	85.23	0.45	1.13	u	0	121.9	55.41	0.04	1.30	

S-4. Bacterial leaching of PCBs varying pulp density

Sample	Cu (224.700 nm)		Fe (259.940 nm)		Al (309.271 nm)		Mn (260.568 nm)		Ni (230.078 nm)		Pb (283.305 nm)		Zn (210.442 nm)		Au (208.207 nm)		Pd (340.458 nm)		Ag (338.068 nm)		Ta (263.558 nm)	
	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)
Pulp Density 2%																						
PCBs	6025.36	96.68	899.1	88.84	121.9	70.06	120.9	43	440.66	98.8	1.69	0.80	541.22	77.10	0.07	0.88	u	0	0.05	0.1	u	0
Pulp Density 7%																						
PCBs	19700.12	90.32	2788.67	78.73	399.99	65.68	289.78	30.66	1372.88	87.95	4.59	0.62	1703.64	69.34	0.05	0.18	u	0	0.1	0.06	u	0
Pulp Density 10%																						
PCBs	26990.65	86.62	3659.34	72.32	509.88	58.61	399.69	29.61	1870.77	83.89	8.7	0.83	2304.9	65.67	u	0	u	0	0.14	0.06	u	0

S-5. Bacterial leaching of PCBs varying ferrous iron concentration

Sample	Cu (224.700 nm)		Fe (259.940 nm)		Al (309.271 nm)		Mn(260.568 nm)		Ni (230.078 nm)		Pb (283.305 nm)		Zn (210.442 nm)		Au (208.207 nm)		Pd (340.458 nm)		Ag (338.068 nm)		Ta (263.558 nm)	
	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)
Ferrous Iron Concentration 1g																						
PCBs	5190.09	83.28	658.66	65.08	78.65	45.20	81.44	30.16	431.65	96.78	1.75	0.83	382.09	54.43	0.04	0.5	u	0	0.15	0.34	u	0
Ferrous Iron Concentration 3g																						
PCBs	5379.09	86.31	779.09	76.99	101.01	58.05	82.01	30.37	409.76	91.87	1.81	0.86	399.01	56.84	0.03	0.38	u	0	0.21	0.48	u	0
Ferrous Iron Concentration 5g																						
PCBs	5781.99	92.78	802.98	79.35	103.45	59.45	88.99	32.96	425.77	95.46	1.79	0.85	419.65	59.78	0.03	0.40	u	0	0.28	0.64	u	0
Ferrous Iron Concentration 7g																						
PCBs	5899.44	94.66	831.45	82.16	109.99	63.21	113.09	41.89	430.21	96.46	1.77	0.84	439.68	62.63	0.04	0.50	u	0	0.31	0.70	u	0

S-6. Bacterial leaching of PCBs and tantalum capacitor scrap varying particle size

Sample	Cu (327.395 nm)		Fe (261.382 nm)		Al (394.401 nm)		Mn (257.610 nm)		Ni (232.138 nm)		Pb (283.305 nm)		Zn (206.200 nm)		Au (208.207 nm)		Pd (340.458 nm)		Ag (328.068 nm)		Ta (268.517 nm)		
	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	
Particle Size 0.5mm																							
PCBs	5409.54	86.80	782.19	77.29	96.76	55.61	102.67	38.03	397.09	89.03	6.00	2.86	411.09	58.56	0.05	0.60	u	0	0.09	0.20	u	0	
Ta.Cap	941.99	88.04	446.98	77.87	58.98	75.62	945.99	57.47	235.77	82.44	26.79	9.57	71.65	57.78	u	0	u	0	0.66	0.23	u	0	
Particle Size 0.75mm																							
PCBs	5098.45	81.81	739.02	73.03	81.92	47.08	96.03	35.57	369.67	82.89	5.03	2.40	390.08	55.57	0.03	0.38	u	0	0.02	0.05	u	0	
Ta.Cap	891.65	83.33	423.08	73.71	53.02	67.97	837.6	50.89	220.04	76.94	16.06	5.74	68.67	55.38	u	0	u	0	0.16	0.05	u	0	

S-7. Fungal leaching of metals by A.Niger spores and filtrate

Sample	Cu (327.395 nm)		Fe (261.382 nm)		Al (394.401 nm)		Mn(257.610 nm)		Ni (232.138 nm)		Pb (283.305 nm)		Zn (206.200 nm)		Au (208.207 nm)		Pd (340.458 nm)		Ag (328.068 nm)		Ta (268.517 nm)	
	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)	mg/L	metal leached (%)
Fungal leaching by <i>A.Niger</i> spores																						
PCBs	579.40	9.30	114.34	11.30	33.09	19.02	1.2	0.44	57.87	12.98	1.4	0.67	34.14	4.86	u	0	u	0	0.02	0.05	u	0
Ta.Cap	14.01	1.31	5.99	1.04	2.95	3.78	51.09	3.10	21.76	7.61	4.99	1.78	3.46	2.79	u	0	u	0	0.19	0.06	u	0
Fungal leaching by <i>A.Niger</i> filtrate																						
PCBs	3219.65	51.66	300.66	29.71	129.91	74.66	12.9	4.78	276.1	61.91	44.65	21.26	243.40	34.67	u	0	u	0	0.12	0.27	u	0
Ta.Cap	651.77	60.91	145.99	25.43	54.54	69.92	376.09	22.85	200.06	69.95	42.55	15.20	55.99	45.15	u	0	u	0	0.5	0.17	u	0