

CHAPTER IV

RESULTS

Experiment 1 to 13 were set to investigate the extraction system of APDC-MIBK extraction system following by back extraction with nitric acid. Their results are grouped into 5 groups according to the purpose of investigation.

1. APDC-MIBK Extraction System.

This part presents the results of investigated conditions which affect the extraction efficiency of Cu, Ni, Pb and Zn in treated seawater sample.

1.1 Effect of the Analytical Step and Shaking Time on the Recovery of Cu. The recovery yield of Cu from Experiment 1 are given in Table 4.1 and Fig. 4.1.

For the Experiment 1A, the results are showed in Table 4.1-a and the percentage extraction of Cu are plotted versus the shaking time in Fig. 4.1-a. The percentage extractions increase rapidly from 69.8 % to 83.0 % at shaking time between 30 s to 2 min. The percentage extraction increase and vary from 88.8 % to 103.2 % after 2 min shaking time. However, the minimum shaking time to obtain at least 90 % is around 5 min. For the Experiment 1B, the percentage extraction that show in Fig. 4.1-b and Table 4.1-b is 92.2 % at 30 s shaking time and more than 96 % at 2 min - shaking time. After 2 min, the percentage extraction slightly increase from 98.4 % to 103.4 %.

In Fig. 4.1-c, Experiment 1B gives the percentage extraction at shaking time among 30 s to 2 min (92.0 to 96.0 %) higher than Experiment 1A (69.0 to 80.0 %). After 2 min, the different percentage extractions between Experiment 1A and 1B are not more than 1 time. Thus, the process of Experiment 1B should be the best process and also 2 min should be the optimum shaking time for APDC-MIBK Extraction System.

1.2 Effect of APDC Concentration on the Recovery of Cu.

From Table 4.2 and Fig 4.2, the percentage extraction at concentrations of APDC from 1-6 %(w/v) increase from 89.2 % to 103.2 % and the average percentage extraction vary from 91.4 % to 102.3 %. At 1 % (w/v) APDC gives 91.9 % of extraction and from 2 % to 6 % (w/v) APDC the percentage extraction is more than 99 %. Thus, 2 % (w/v) APDC/100 ml of seawater sample is the optimum quantities of APDC to be used in the APDC-MIBK Extraction System.

1.3 Effect of Volume of MIBK on the Recovery of Cu. The

percentage extraction of Cu of Experiment 3 are plotted versus the volume of MIBK in Fig. 4.3 and their results are showed in Table 4.3. Volume of MIBK at 2 ml gives 82 % extraction and from 5 ml to 15 ml MIBK give the percentage extraction more than 99 %. Thus, the optimum volume of MIBK is 5 ml for using in APDC-MIBK Extraction System.

1.4 Effect of pH on the Recovery of Cu. Fig. 4.4 and Table 4.4 show the results of percentage extraction of Cu from Experiment 4. From pH 2.5 to 4.5 give the percentage extraction more than 90 %, after that the percentage extraction slightly decrease to 88 %. From pH 6-8, the percentage extraction decrease from 72.9 % to

59.9 %. Thus, the optimum range of pH at the extraction step lie between 2-5.

1.5 Effect of Shaking Time on the Recovery of Zn. At 2 min-shaking time, the percentage extraction of Zn is 81.6 %. Shaking time from 4 to 10 min give the percentage extraction from 98.3 % to 101.5 % as show in Fig. 4.9 and Table 4.9. Thus, the optimum shaking time for extraction Zn is 2 min.

1.6 Effect of pH on the Recovery of Ni, Pb and Zn. The percentage extraction of Ni, Pb, and Zn, which are the results from Experiment 7, 8 and 10, are given in Fig. 4.6 - 4.8 and 4.10 respectively.

For Ni, at the range of pH from 2 to 6 give the percentage extraction from 101.2 % to 91.8 % as shows in Fig. 4.7. After pH 6, the percentage extraction tends to decrease from 83.8 % to 77.9 %.

For Pb, the percentage extraction, which varying from pH 2 to 4, are 89.9 % to 99.9 % as shows in Fig. 4.8. After pH 4, the percentage extraction tends to decrease from 99.9 % to 92.5 % and the values are not so much difference between pH 5 to 8.

For Zn, the percentage extraction vary from 76 % to 103.5 % at pH of aqueous from 2 to 8 as show in Fig. 4.10 and Table 4.10. From pH 2 to 3, the percentage extraction below 90 % and from pH 4 to 8, the percentage extraction reach 100 % and almost steady around 100 %.

Thus, the optimum range of pH of aqueous phase,

seawater sample, of Ni, Pb and Zn for APDC-MIBK Extraction System are 2-6, 4-8 and 4-8.

2. Back Extraction System.

This part presents the results of investigated conditions which effect the extraction efficiency of Cu.

2.1 Effect of Shaking Time on the Recovery of Cu by Back Extraction with Nitric Acid. The results of Experiment 5 are given in Fig. 4.5 and Table 4.5. The percentage extraction are increased from 72.9 % to 97.1 % by increasing the shaking time from 30 s to 8 min. For shaking time more than 8 min, the percentage extraction tend to decrease from 97.1 % to 93.6 %. However, the percentage extraction is still more than 90 % as shows in Fig. 4.5. Thus, the optimum shaking time for back extraction is 5 min.

2.2 Effect of Volumes of Nitric Acid on the Recovery of Cu by Back Extraction. From Fig. 4.6 and Table 4.6, which are the results of Experiment 6, the volume of 4N nitric acid, which was used in back extraction, at 1 ml to 3 ml give the percentage extraction from 70.5 % to 84.4 %. The volume of 4N nitric acid from 5 ml to 20 ml give the percentage extraction higher than 91 % and increasing to 97.1 % as show in Fig. 4.6. Thus, the optimum volume of 4N nitric acid for back extraction is 5 ml.

3. Stability of Metals in the Acid Extract.

This part is the results of single extraction of Cu, Ni, Pb and Zn by using an improved APDC-MIBK Extraction System and also the stability times of these metals in acid extract. The results of

Experiment 11 are given in Fig. 4.11 and Table 4.11. No significant change in the concentration of Zn is found during the storage period studied, 63 days. For Cu, Ni and Pb, there are slightly change in the concentration during 28 days of storage, after that, their concentrations quickly decrease.

4. Reinvestigation the Appropriated pH on the Recovery of Cu, Ni, Pb and Zn by Dithizone-Chloroform Extraction System.

The results of Experiment 12 are given in Fig. 4.12 and Table 4.12.

For Cu, at pH from 1-5 give the percentage extraction from 90.7 % to 81.4 % and the maximum percentage extraction is 90.7 % at pH 1. The percentage extractions begin to decrease from pH 5 (85.3 %) to 8 (68.56 %). The percentage extractions of Ni tends to increase from pH 5 (27.7 %) to 8 (100.9 %), for Pb, it trends to increase from pH 4 (44.3 %) to 5 (100 %) and decrease to pH 8 (87 %). For Zn, the percentage extraction tends to increase from pH 3 (46.5 %) to pH 8 (99 %).

Thus, the optimum range of pH for extraction of Cu, Ni, Pb and Zn for Dithizone-Chloroform Extraction System are 1-3, 7-8, 5-8 and 5-8 respectively.

5. Validation of Improved Solvent Extraction System.

The Certified Reference Materials which are obtained from the Division of Chemistry, Marine Analytical Chemistry Standard Program, National Research Council of Canada, are used as a material for validation of Improved APDC-MIBK Extraction Method. Because of

the limited of volume of the certified materials, the validation could be done one time only.

The results of Experiment 13 are showed in Table 4.13. The measured values of Cu, Ni, Pb and Zn which are obtained from the improved method (APDC-MIBK Solvent Extraction System) and Dithizone-Chloroform solvent extraction system are compared with the reported values of the certified reference materials. Even though the validtion of the improved method has been done only one time, their obtained results of Cu, Ni, Pb and Zn seem to be closed to the reported values of the certified reference materials and are more than the obtained results of Dithizone-Chloroform solvent extraction system. However, some measured results from both the solvent extraction systems are higher than the reported values. This is because of the contaminations during the analysis.

Table 4.1 The concentrations and percentage extractions of Copper from the Experiment 1 using Process 1A and 1B.

Process 1A

Shaking Times (min)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
0.5	3.10	62.0	3.88	77.6	3.49	69.80
1.0	3.94	78.8	ND	ND	3.94	78.80
1.5	ND	ND	4.15	82.92	4.15	83.00
2.0	4.00	80.00	ND	ND	4.00	80.00
4.0	4.44	88.80	ND	ND	4.44	88.80
5.0	ND	ND	4.77	95.40	4.77	95.40
10.0	4.60	92.00	5.06	101.20	4.83	96.60
15.0	4.48	89.60	4.44	88.80	4.46	89.20
20.0	5.16	103.20	ND	ND	5.16	103.20
25.0	ND	ND	4.94	98.80	4.94	98.80

ND : Not determined.

Process 1B

Shaking Times (min)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
0.5	4.71	94.20	4.50	90.00	4.61	92.20
1.0	4.83	96.60	4.73	94.60	4.78	95.60
2.0	4.83	96.60	4.81	96.20	4.82	96.40
4.0	4.88	97.60	4.96	99.20	4.92	98.40
8.0	5.29	105.80	5.04	100.80	5.17	103.40
10.0	5.06	101.20	5.15	103.00	5.11	102.20
20.0	4.94	98.80	4.88	97.60	4.91	98.20

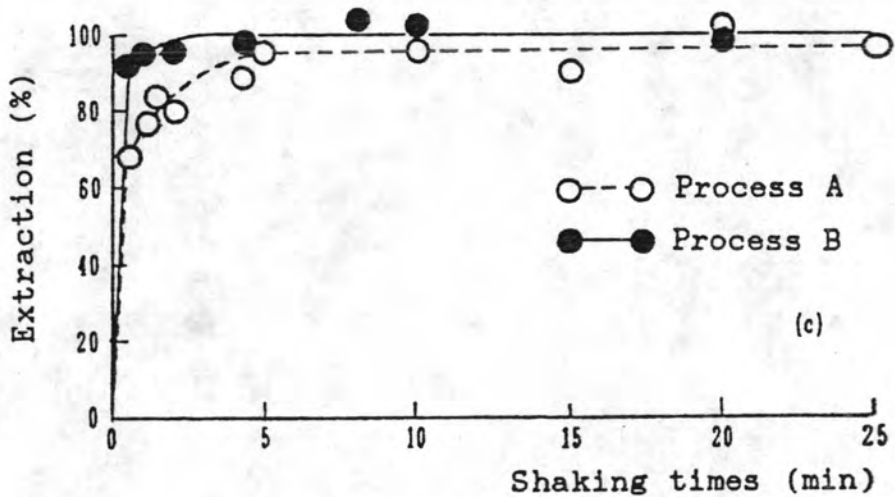
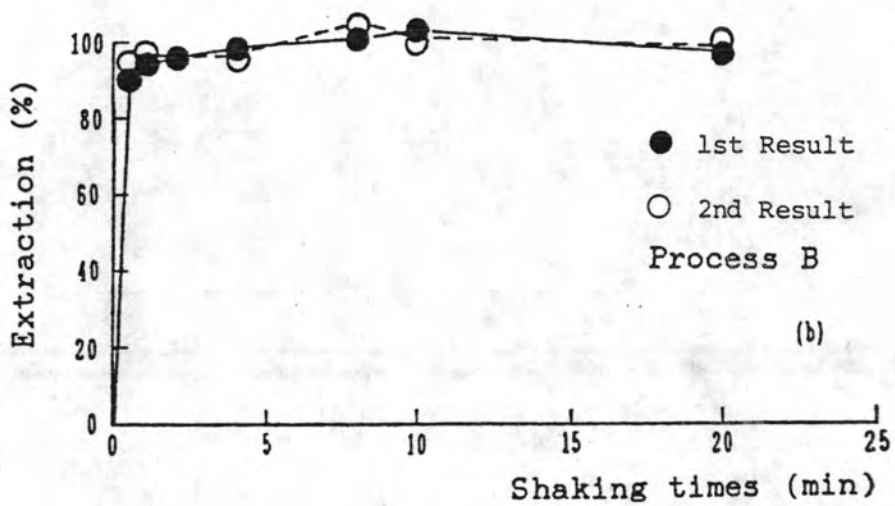
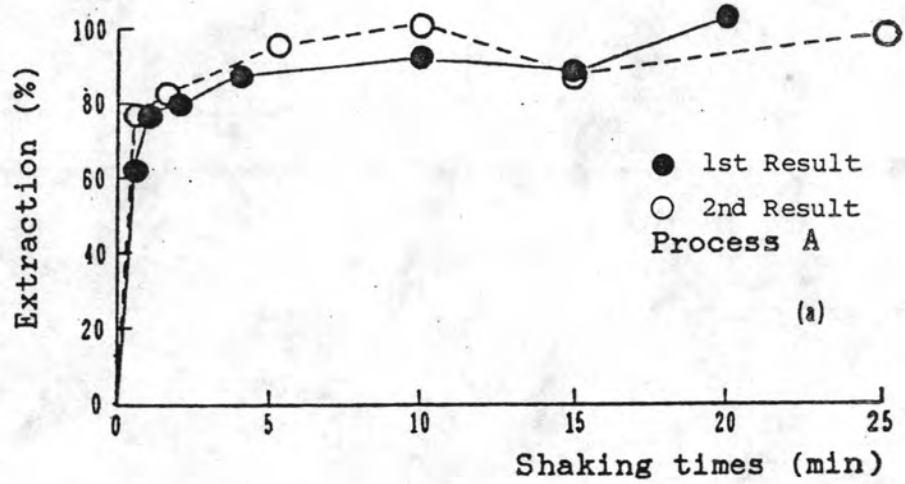


Fig. 4.1 Percentage extraction of Copper by varying shaking times and process of adjusting pH from Experiment 1.

- (a) The results from Process A
- (b) The results from Process B.
- (c) Comparative average percentage extraction between Process A and B.

Table 4.2 The concentrations and percentages extractions of Copper at the various concentration of APDC (Experiment 2).

Concentrations of APDC (% w/v)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. (ppb)	Ext. (%)
1	4.462	89.24	4.731	94.62	4.597	91.94
2	4.962	99.24	5.093	100.78	5.001	100.02
4	5.007	101.54	5.000	100.00	5.093	100.78
6	5.153	103.06	5.077	101.54	5.115	102.30

Table 4.3 The concentration and percentages extractions of Copper at the various volumes of MIBK (Experiment 3).

Volumes of MIBK (ml)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
2.5	3.748	74.96	4.457	89.14	4.103	82.06
5.0	4.915	98.30	5.040	100.80	4.978	99.56
10.0	4.957	99.14	4.998	99.96	4.978	99.56
15.0	4.949	98.98	5.123	102.46	5.036	100.72

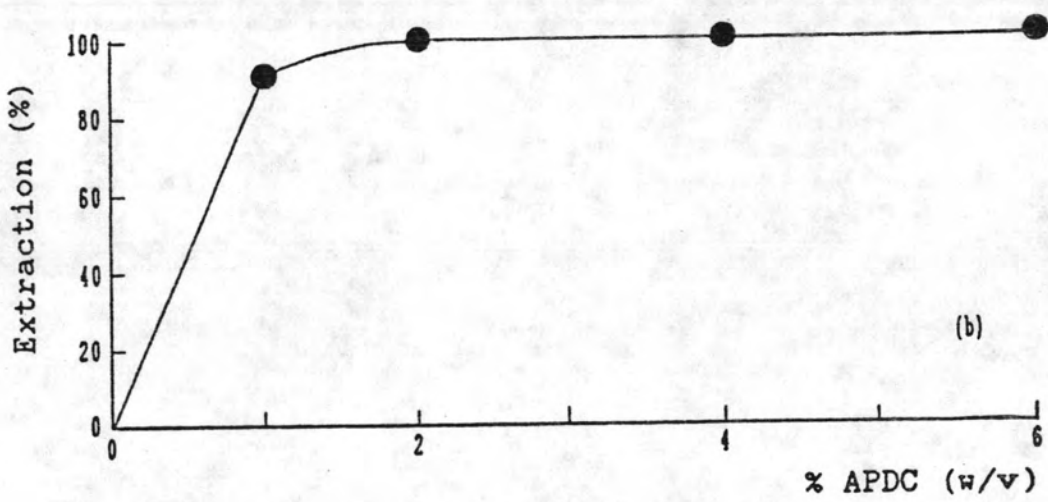
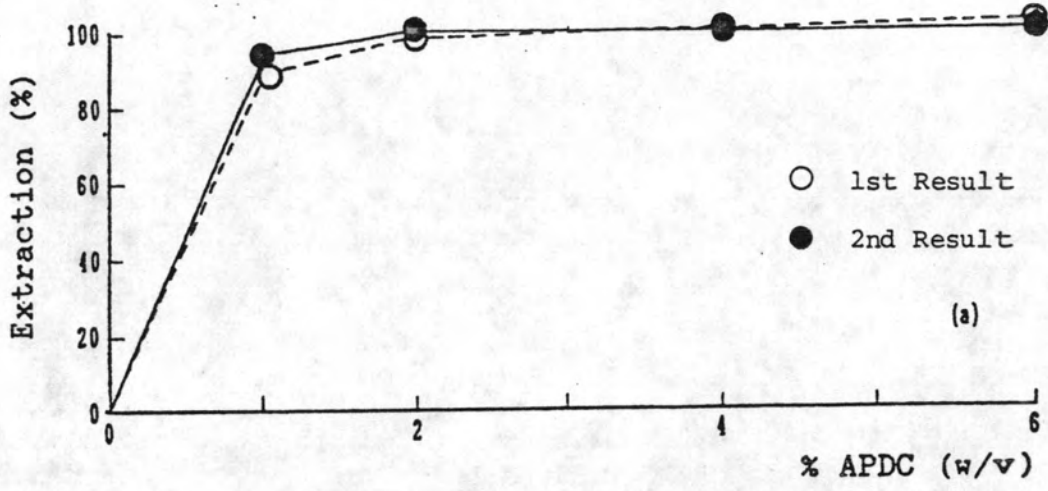


Fig. 4.2 Percentage extraction of Copper by varying concentrations of APDC from Experiment 2.
(a) Percentage extraction of copper.
(b) Average percentage extraction from (a).

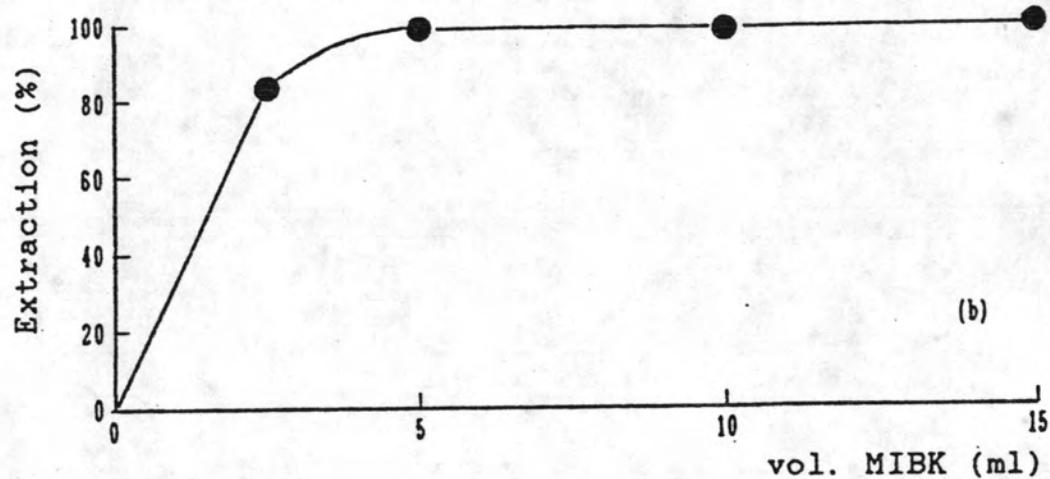
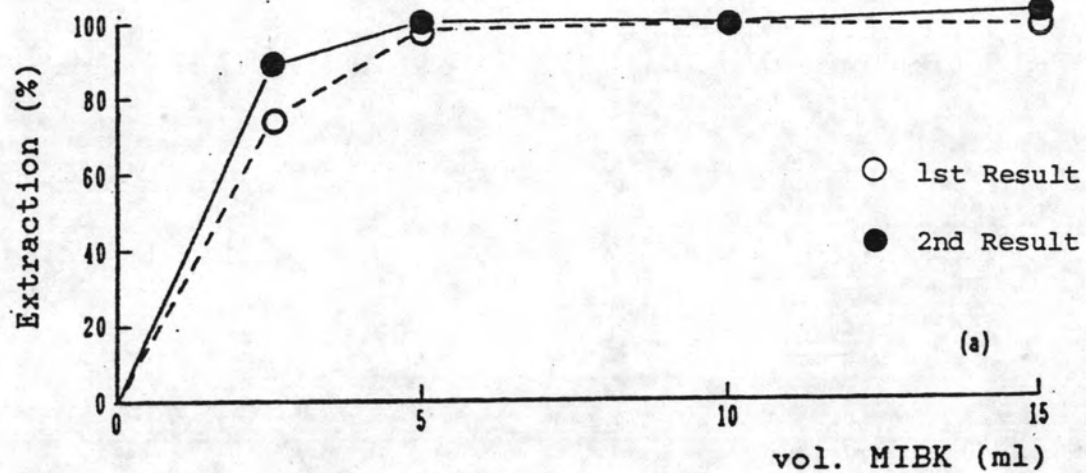


Fig. 4.3 Percentage extraction of Copper by varying volumes of MIBK from Experiment 3.
(a) Percentage extraction of copper.
(b) Average percentage extraction from (a)

Table 4.4 The concentration and percentages extractions of Copper at various pH's

(Experiment 4).

pH	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
							Conc. ($\mu\text{g/l}$)	Ext. (%)
2.0	4.290	85.80	4.291	85.82	4.360	87.20	4.314	86.28
2.5	ND	ND	ND	ND	4.999	99.98	4.999	99.98
3.0	4.916	98.32	4.665	93.30	4.787	95.74	4.789	95.78
3.5	ND	ND	ND	ND	4.573	91.46	4.573	91.46
4.0	4.415	88.30	4.708	94.16	4.680	93.60	4.601	92.02
4.5	ND	ND	ND	ND	4.892	97.84	4.892	97.84
5.0	4.499	89.98	4.373	87.46	4.360	87.20	4.411	88.22
6.0	3.791	75.82	3.499	69.68	ND	ND	3.645	72.90
7.0	2.914	58.28	3.083	61.66	ND	ND	2.999	59.98
8.0	3.368	67.36	3.249	64.98	ND	ND	3.309	66.18

ND : Not determined.

Table 4.5 The concentration and percentages extractions of at the various shaking times

for the back extraction of Copper (Experiment 5).

Shaking Times (min)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
							Conc. ($\mu\text{g/l}$)	Ext. (%)
0.5	4.255	85.12	3.830	76.61	2.999	59.98	3.695	73.90
1.0	3.724	74.49	3.614	72.33	3.599	71.98	3.646	72.93
2.0	3.829	76.60	3.935	78.73	5.597	111.94	4.454	89.09
4.0	5.211	104.25	4.680	93.63	3.799	89.98	4.563	95.95
8.0	5.347	102.87	4.571	91.49	ND	ND	4.959	97.18
10.0	4.786	95.75	4.893	97.88	ND	ND	4.840	96.82
20.0	4.466	89.35	4.893	97.88	ND	ND	4.680	93.62

ND : Not determined.

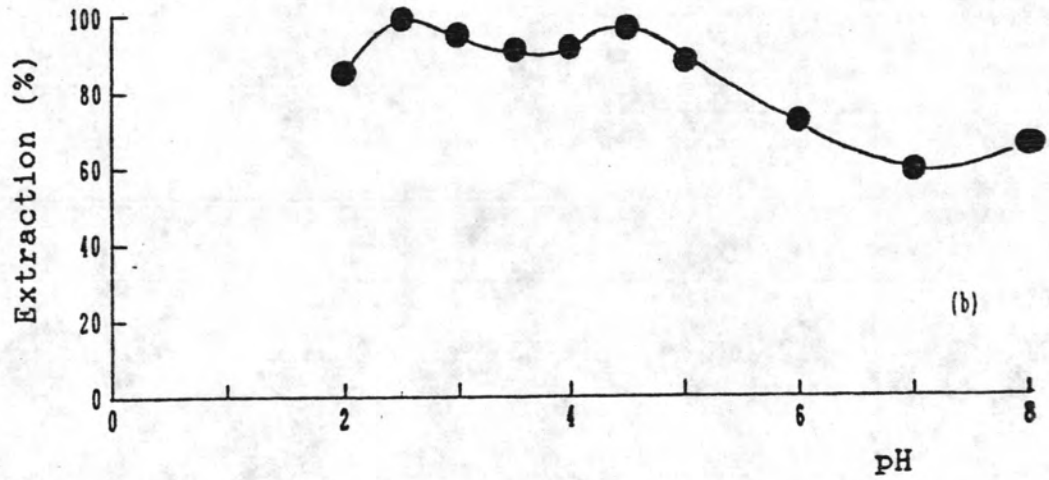
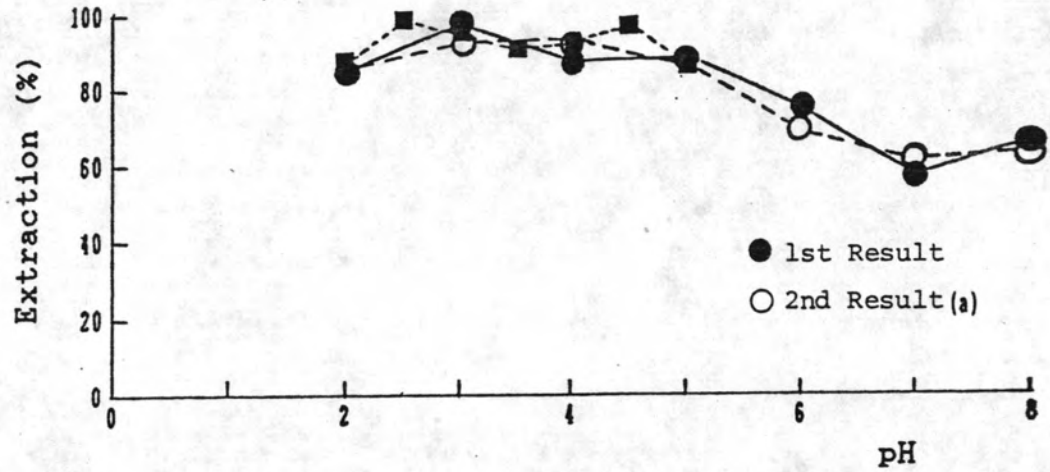


Fig. 4.4 Percentage extraction of Copper by varying pH of the treated seawater from Experiment 4.
 (a) Percentage extraction of copper.
 (b) Average percentage extraction from (a).

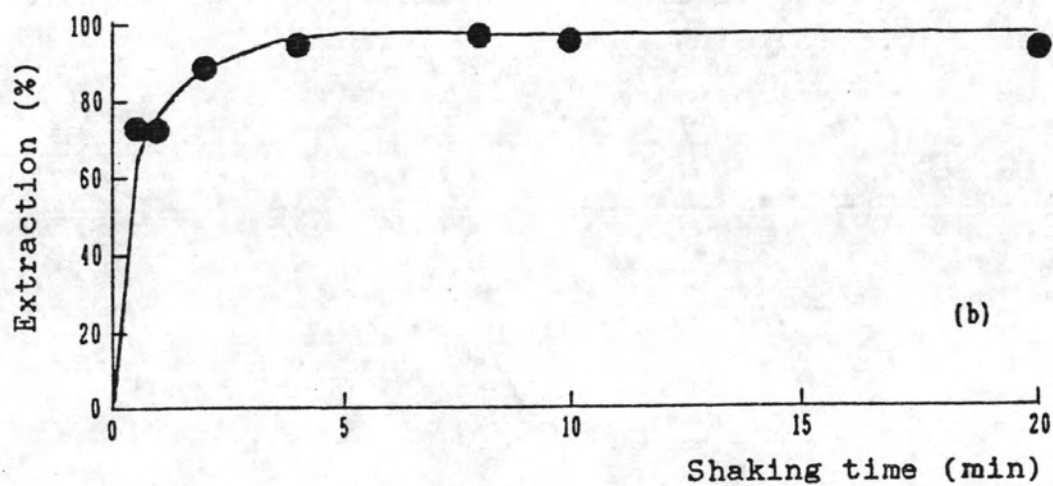
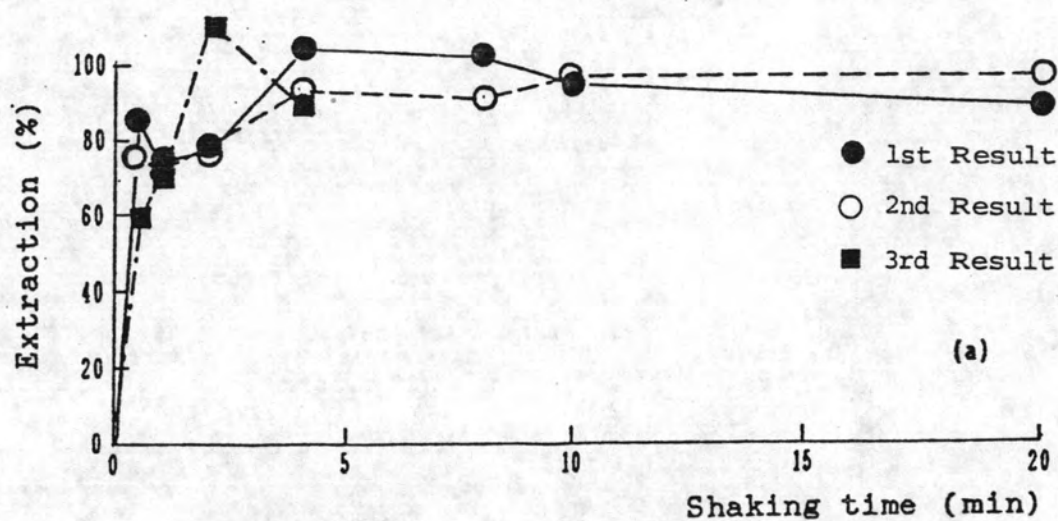


Fig. 4.5 Percentage extraction of Copper by varying shaking times from Experiment 5.
 (a) Percentage extraction of copper.
 (b) Average percentage extraction from (a).

Table 4.6 The concentration and percentages extractions of Copper at the various volumes of 4N Nitric acid (Experiment 6).

Volumes of 4N Nitric acid.(ml)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
							Conc. ($\mu\text{g/l}$)	Ext. (%)
1	3.078	61.56	3.478	69.56	4.022	80.44	3.526	70.52
3	4.318	86.36	4.198	83.96	4.156	83.12	4.224	84.48
5	4.280	85.60	4.579	91.58	4.938	98.76	4.599	91.98
7	4.758	95.16	4.339	86.78	4.822	96.44	4.639	92.78
10	4.977	99.54	4.379	87.58	4.939	98.78	4.765	95.30
15	ND	ND	ND	ND	4.856	97.12	4.856	97.12
20	ND	ND	ND	ND	4.772	95.44	4.772	95.44

ND : Not determined.

Table 4.7 The concentration and percentages extractions of Nickel at various pH's (Experiment 7).

pH	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
2.0	5.129	102.58	4.999	99.98	5.064	101.28
3.0	5.263	105.26	4.866	97.32	5.065	101.29
4.0	5.130	102.60	4.998	99.96	5.064	101.28
5.0	4.998	99.96	4.866	97.32	4.932	98.64
6.0	5.006	101.32	4.114	82.28	4.590	91.80
7.0	4.705	94.10	3.675	73.50	4.190	83.80
8.0	4.261	85.22	3.529	70.58	3.895	77.90

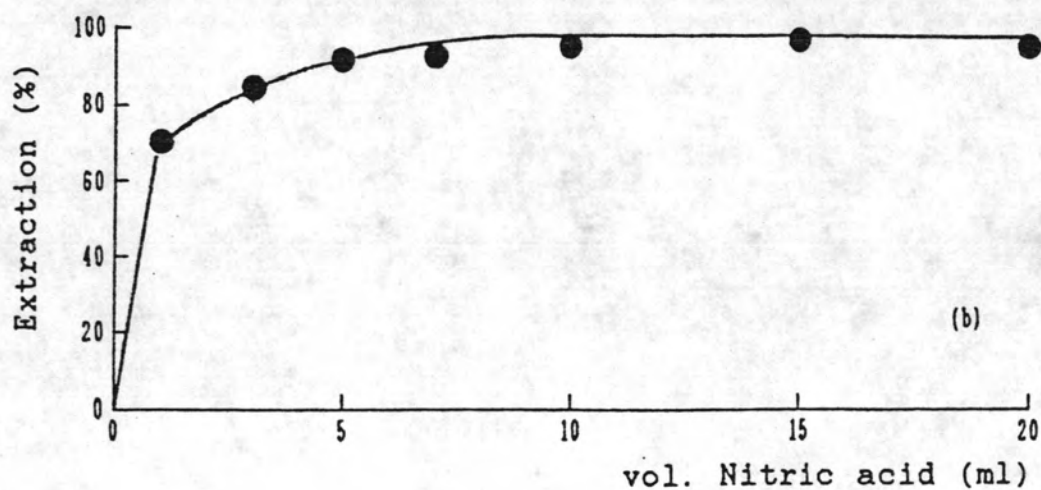
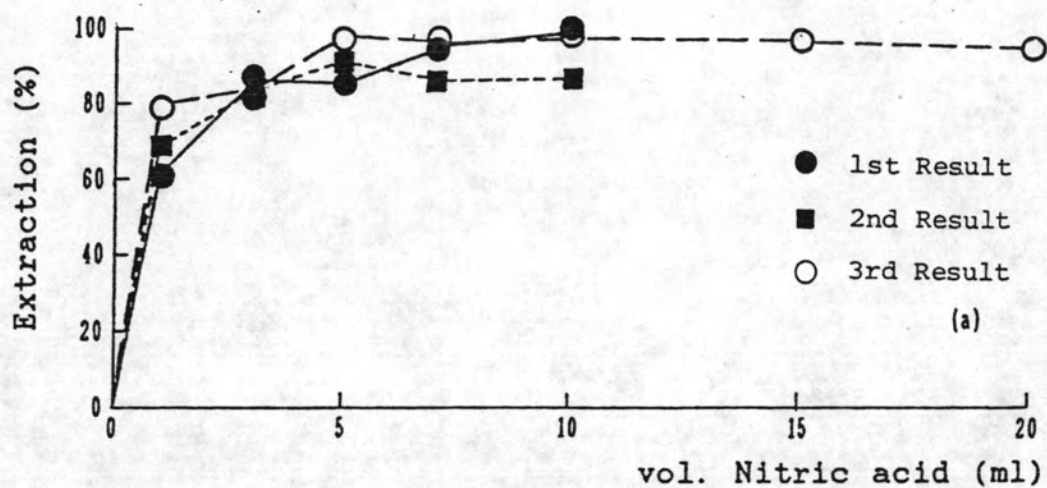


Fig. 4.6 Percentage extraction of Copper by varying volumes of 4N nitric acid for Back extraction from Experiment 6.
 (a) Percentage extraction of copper.
 (b) Average percentage extraction from (a).

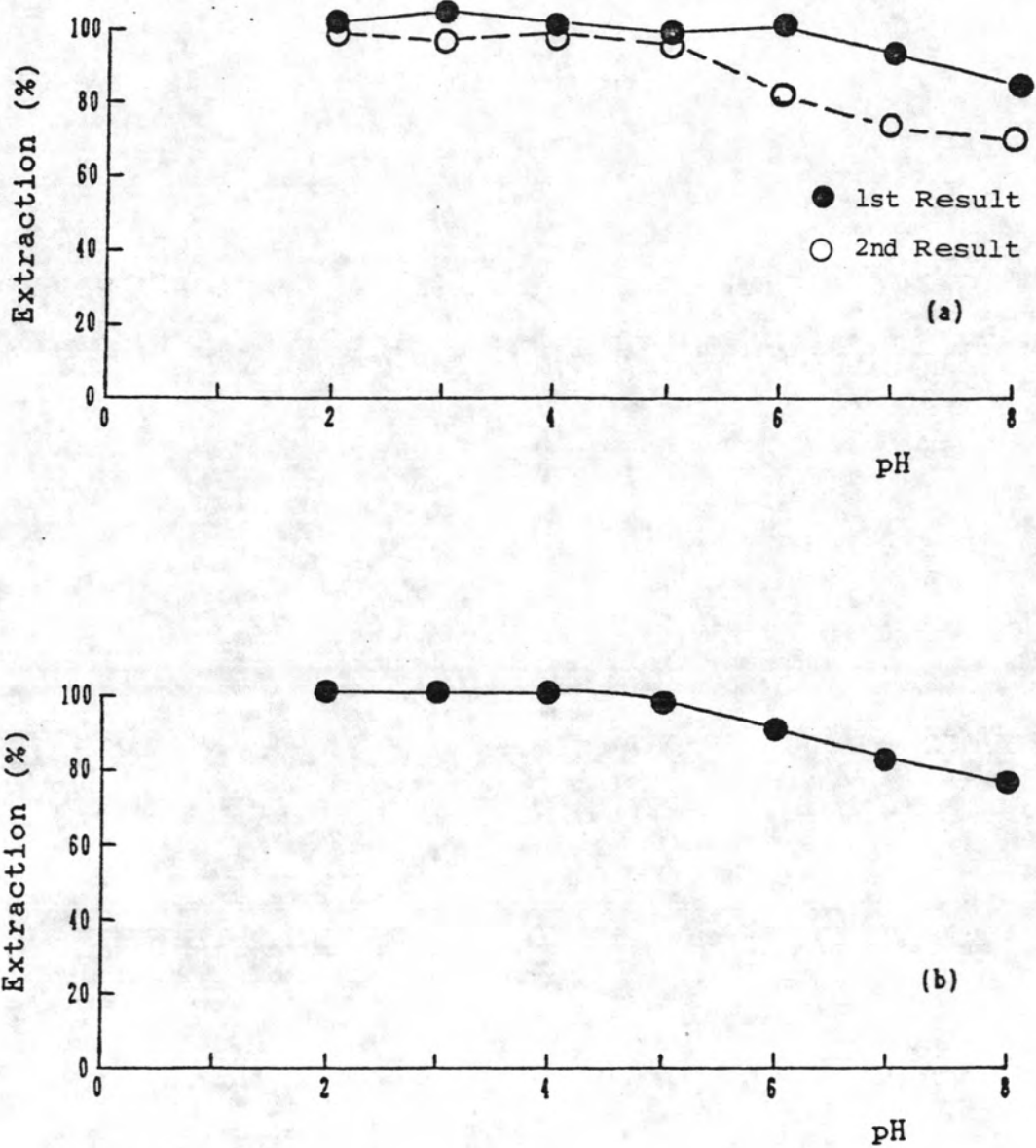


Fig. 4.7 Percentage extraction of Nickel by varying pH of treated seawater from Experiment 7.
(a) Percentage extraction of nickel.
(b) Average percentage extraction from (a)

Table 4.8 The concentration and percentages extractions of Lead at various pH's
(Experiment 8).

pH	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
2.0	3.675	73.50	5.311	106.22	4.493	89.96
3.0	4.849	96.98	4.997	99.94	4.923	98.46
4.0	4.998	99.96	4.997	99.94	4.998	99.95
5.0	4.994	99.88	4.406	88.12	4.700	94.00
6.0	4.263	85.26	4.997	99.94	4.627	92.54
7.0	4.706	94.12	4.852	97.04	4.779	95.58
8.0	4.557	91.14	4.702	94.04	4.630	92.59

Table 4.9 The concentration and percentage extractions of Zinc at the various shaking
times (Experiment 9).

Shaking Times (min)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
2.0	4.331	86.02	3.831	76.62	4.081	81.62
4.0	4.832	96.64	4.998	99.96	4.915	98.30
8.0	5.328	106.56	4.829	96.58	5.079	101.57
10.0	4.995	99.90	5.159	103.18	5.077	101.54
20.0	4.163	83.26	5.163	103.26	4.663	93.26

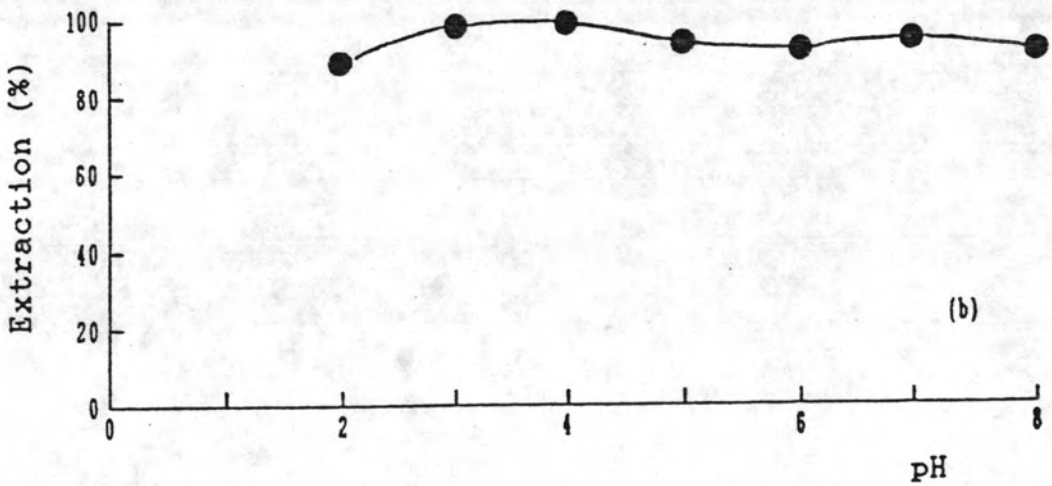
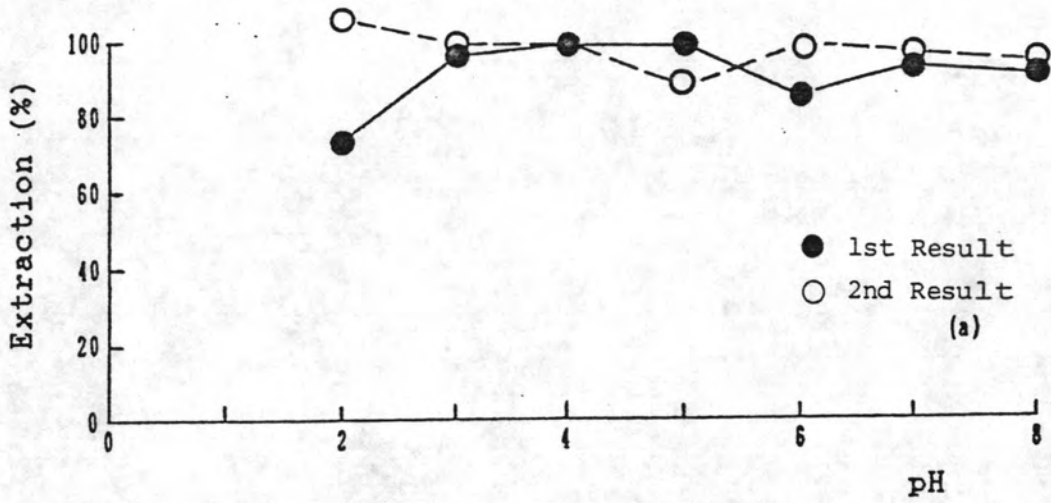


Fig. 4.8 Percentage extraction of Lead by varying pH of treated seawater from Experiment 8.
 (a) Percentage extraction of lead.
 (b) Average percentage extraction from (a).

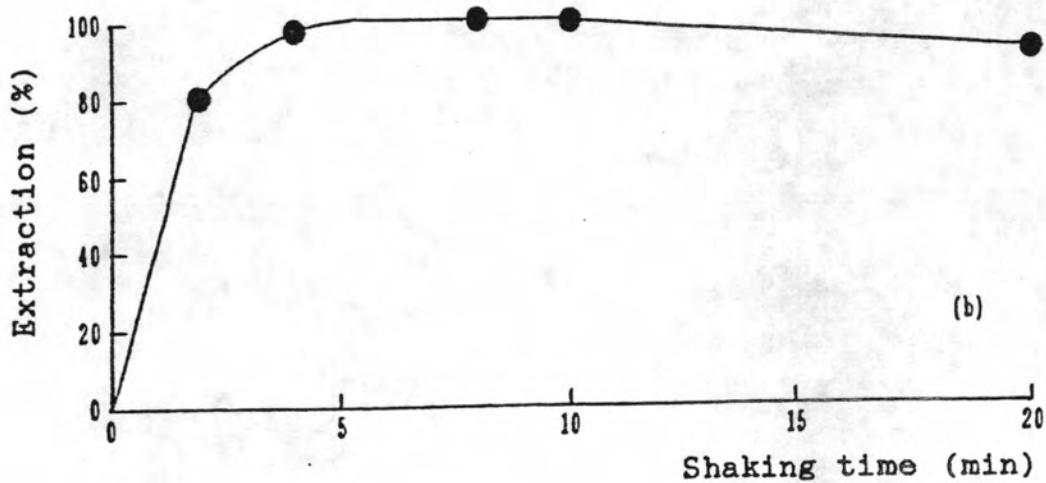
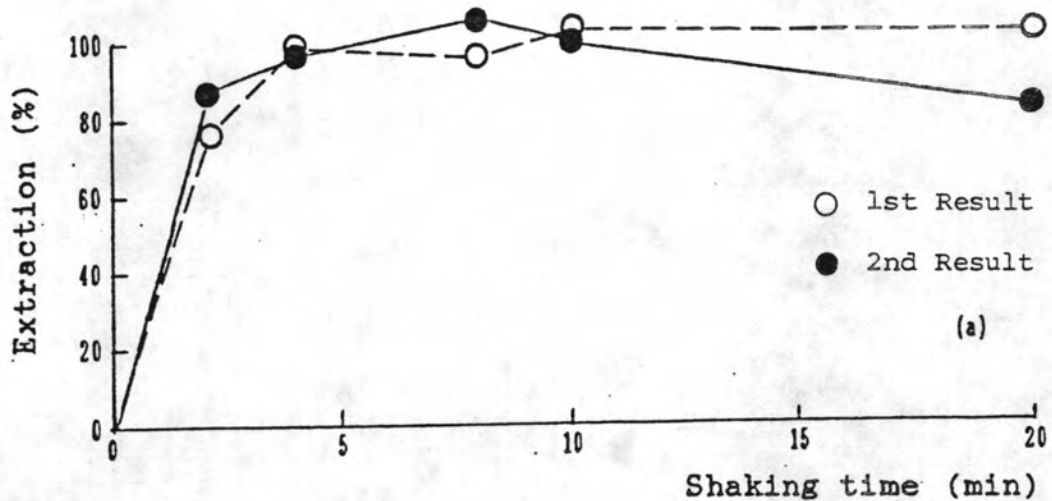


Fig. 4.9 Percentage extraction of Zinc by varying shaking times from Experiment 9.
(a) Percentage extraction of zinc.
(b) Average percentage extraction from (a).

Table 4.10 The concentration and percentage extractions of Zinc at various pH's
(Experiment 10).

pH	Conc. ($\mu\text{g/l}$)	Ext. (%)	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
					Conc. ($\mu\text{g/l}$)	Ext. (%)
2.0	4.500	90.00	3.100	62.00	3.800	76.00
3.0	4.000	80.00	4.450	89.00	4.230	84.60
4.0	4.800	96.00	4.900	98.00	4.850	97.00
5.0	4.950	99.00	5.200	104.00	5.080	101.50
6.0	5.000	100.00	5.050	101.00	5.030	100.50
7.0	4.950	99.00	5.150	103.00	5.050	101.00
8.0	4.950	99.00	5.400	108.00	5.180	103.50

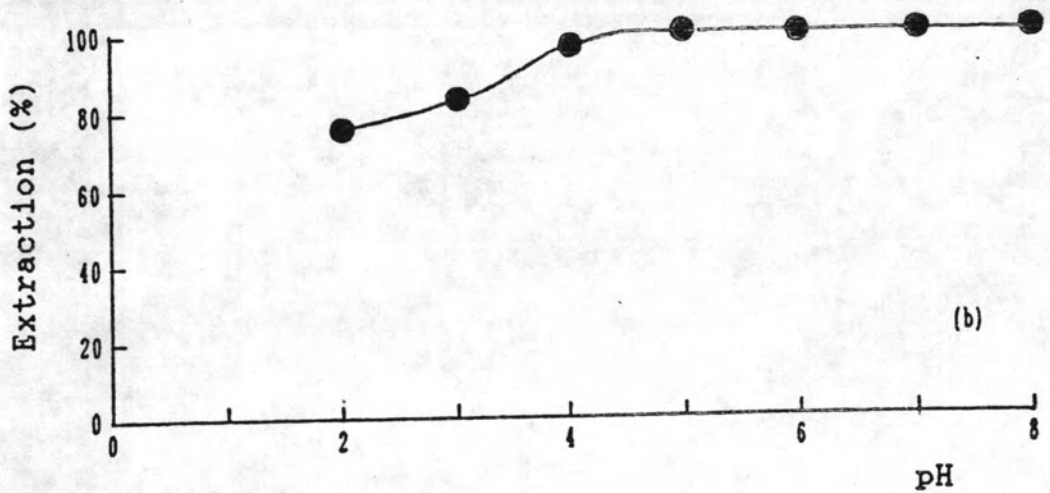
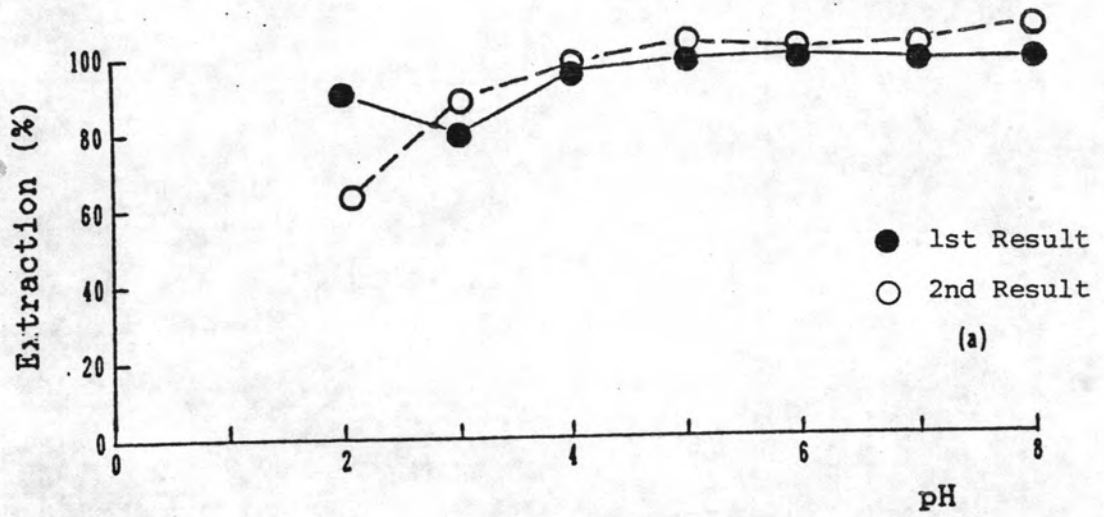


Fig. 4.10 Percentage extraction of Zinc by varying pH of treated seawater from Experiment 10.
 (a) Percentage extraction of zinc.
 (b) Average percentage extraction from (a).

Table 4.11 The stability time (weeks) of Cu, Ni, Pb and Zn after extracted with 4N nitric acid by back extraction method (Experiment 11).

Week	Cu				Ni				Pb				Zn			
	Conc. ($\mu\text{g/l}$)	Ext. (%)	Average		Conc. ($\mu\text{g/l}$)	Ext. (%)	Average		Conc. ($\mu\text{g/l}$)	Ext. (%)	Average		Conc. ($\mu\text{g/l}$)	Ext. (%)	Average	
			Conc. ($\mu\text{g/l}$)	Ext. (%)			Conc. ($\mu\text{g/l}$)	Ext. (%)			Conc. ($\mu\text{g/l}$)	Ext. (%)			Conc. ($\mu\text{g/l}$)	Ext. (%)
0	5.124	102.50	5.093	101.86	5.000	100.00	4.943	100.70	5.000	100.00	4.870	97.50	4.900	98.00	5.070	101.00
	5.062	101.24			4.886	97.70			4.750	95.00			5.252	105.00		
2	5.069	101.38	5.034	100.60	4.792	95.84	4.792	95.84	4.640	92.86	4.550	91.00	4.800	96.00	5.000	100.00
	5.000	100.00			4.792	95.84			4.460	89.28			5.200	104.00		
4	4.625	92.50	4.587	91.75	4.456	89.12	4.130	82.60	4.464	89.28	4.196	83.93	4.700	94.00	4.820	96.50
	4.550	91.00			3.804	76.08			3.929	78.58			4.950	99.00		
6	3.950	79.00	3.750	75.00	3.757	75.14	3.716	74.32	2.975	59.50	2.400	48.00	4.650	93.00	4.770	95.50
	3.550	71.00			3.675	73.50			1.825	36.50			4.900	98.00		
7	3.116	62.32	3.079	61.59	1.375	27.50	1.325	26.50	1.174	23.51	1.141	22.80	4.600	92.00	4.720	94.50
	3.043	60.86			1.275	25.50			1.108	22.16			4.850	97.00		
9	2.955	59.11	2.905	58.11	1.374	27.48	1.323	26.46	0.422	8.44	0.412	8.25	4.500	90.00	4.650	93.00
	2.856	57.13			1.272	25.44			0.403	8.06			4.800	96.00		

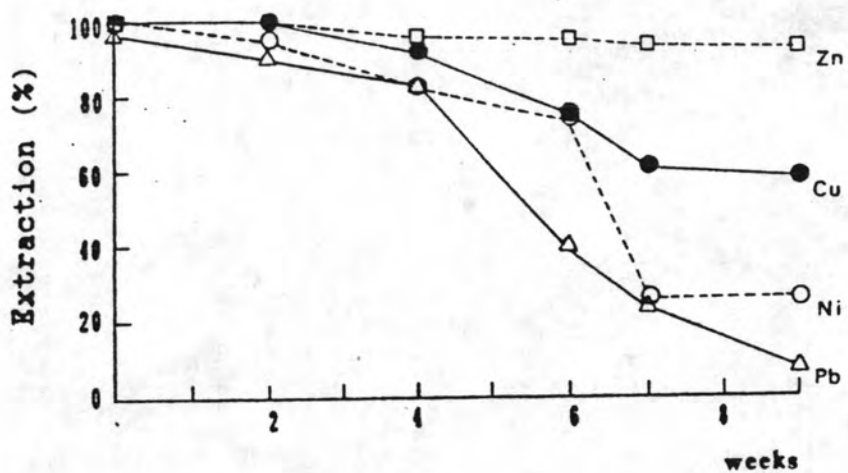


Fig. 4.11 Stability time (week) of Cu, Ni, Pb and Zn in nitric acid extract by APDC-MIBK Extraction System from Experiment 11.

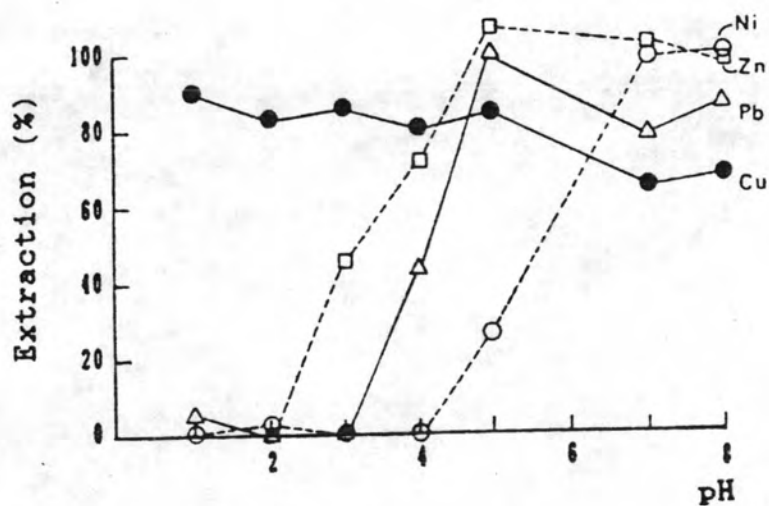


Fig. 4.12 Average percentage extraction of Cu, Ni, Pb and Zn from Dithizone-Chloroform Extraction System by varying pH of treated seawater from Experiment 12.

Table 4.12 The percentage extractions of Cu, Ni, Pb and Zn from Dithizone-Chloroform extraction system at various pH's from 1 to 8 (Experiment 12).

pH	Cu				Ni				Pb				Zn			
	Conc. (µg/l)	Ext. (%)	Average		Conc. (µg/l)	Ext. (%)	Average		Conc. (µg/l)	Ext. (%)	Average		Conc. (µg/l)	Ext. (%)	Average	
			Conc. (µg/l)	Ext. (%)			Conc. (µg/l)	Ext. (%)			Conc. (µg/l)	Ext. (%)			Conc. (µg/l)	Ext. (%)
1	4.536	90.72	4.536	90.72	0.138	2.76	0.069	1.38	0.429	8.58	0.286	5.72	ND	ND	ND	ND
	4.536	90.72			ND	ND			0.143	2.86			ND	ND		
2	4.143	82.86	4.161	83.22	0.231	4.62	0.155	2.31	ND	ND	0.360	0.72	ND	ND	ND	ND
	4.179	83.58			ND	ND			0.072	1.44			ND	ND		
3	4.465	89.30	4.322	86.44	ND	ND	ND	ND	ND	ND	ND	ND	2.100	42.00	2.300	46.50
	4.179	83.58			ND	ND			ND	ND			2.550	51.00		
4	3.607	72.14	4.071	81.43	ND	ND	ND	ND	2.072	41.44	2.214	44.29	3.750	75.00	3.630	72.50
	4.536	90.72			ND	ND			2.357	47.14			3.500	70.00		
5	4.107	82.14	4.297	85.35	1.805	36.10	1.389	27.77	4.786	95.72	5.000	100.00	5.950	117.00	5.470	107.50
	4.488	88.56			0.972	19.40			5.215	104.30			4.900	98.00		
7	3.071	61.42	3.267	65.35	4.675	93.50	4.953	99.06	3.501	70.02	3.965	79.30	4.750	93.00	5.250	103.00
	3.464	69.28			5.231	104.62			4.429	88.58			5.750	113.00		
8	3.785	75.70	3.428	68.56	5.508	110.16	5.045	100.91	5.072	101.44	4.358	87.16	5.750	113.00	4.990	99.89
	3.071	61.42			4.583	91.66			3.644	72.82			4.350	85.00		

ND : Nondetected.

Table 4.13 Results of validation for the Improved APDC-MIBK Extraction System and Dithizone-Chloroform Extraction System with the Certified Reference Materials.

Element	NASS-1		CASS-1		SLSS-1		
	Measured Values ($\mu\text{g/l}$)	Reported Values ($\mu\text{g/l}$)	Measured Values ($\mu\text{g/l}$)	Reported Values ($\mu\text{g/l}$)	Measured Values ($\mu\text{g/l}$)	Reported Values ($\mu\text{g/l}$)	
Cu	APDC-MIBK	0.012 (0.002)	0.288 (0.046)	2.60 (0.416)	0.099 \pm 0.010	0.291 \pm 0.027	3.58 \pm 0.30
	Dithi. - Chloro.	0.063 (0.010)	0.212 (0.033)	1.956 (0.313)			
Ni	APDC-MIBK	0.266 (0.004)	0.466 (0.028)	1.134 (0.068)	0.257 \pm 0.027	0.290 \pm 0.031	1.07 \pm 0.06
	Dithi. - Chloro.	0.05 (0.003)	0.183 (0.011)	0.400 (0.024)			
Pb	APDC-MIBK	0.067 (0.004)	0.250 (0.015)	0.417 (0.025)	0.039 \pm 0.006	0.251 \pm 0.027	0.106 \pm 0.011
	Dithi. - Chloro.	0.400 (0.024)	0.460 (0.028)	0.167 (0.010)			
Zn	APDC-MIBK	0.45	1.95	2.45	0.159 \pm 0.028	0.980 \pm 0.099	1.34 \pm 0.20
	Dithi. - Chloro.	*	0.70	1.65			

() : Absorbances. * : Contaminated.