

B. RAW DATA - POPULATION SAMPLING RESULTS

COMMUNITY LEAD STUDY - AIHL SUMMARY LAB RESULTS -

11/22/12

ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
BENICIA - ADULTS							
1001	12.	6	130.	2.4	0.32	QNS	ND
1002	16.	0	126.	< 0.4	< 0.10	1.007	22
1004	13.	6	77.	< 0.4	< 0.10	1.004	21
1011	10.	0	166.	NS	NS	NS	NS
1012	16.	0	118.	2.1	0.23	1.019	25
1013	11.	0	97.	1.0	0.58	1.028	25
1015	10.	0	133.	1.4	0.26	1.033	26
1016	20.	0	121.	2.0	0.15	1.020	26
1019	14.	9	115.	1.1	0.25	1.021	26
1021	12.	0	154.	QNS	0.22	QNS	ND
1039	12.	0	124.	< 0.4	0.10	1.013	20
1040	18.	0	81.	0.6	0.15	1.027	25
1047	13.	0	138.	1.1	0.09	1.014	22
1052	28.	6	43.	1.4	< 0.10	1.008	26
1067	11.	0	136.	1.7	0.27	1.032	25
1070	22.	0	27.	0.4	< 0.10	1.009	20
1071	13.	9	150.	< 0.4	0.21	1.023	26
1074	16.	0	74.	0.4	< 0.10	1.005	26
1092	16.	6	107.	4.3	0.24	1.028	26
1096	17.	0	43.	1.0	< 0.10	1.008	21
1101	10.	0	124.	0.6	< 0.10	1.013	25
1109	14.	0	142.	QNS	0.23	QNS	ND
1110	14.	6	NA	3.4	0.36	1.025	26
1112	19.	6	53.	0.8	0.09	1.016	21
1114	13.	0	127.	< 1.0	0.34	QNS	ND
1124	13.	6	119.	0.2	0.27	1.027	22

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
1127	12.	0	149.	1.7	0.30	1.022	26
1129	11.	6	131.	NS	NS	NS	NS
1131	11.	0	37.	< 0.8	0.22	QNS	ND
1132	14.	0	63.	0.6	0.40	1.027	21
1136	18.	0	111.	2.8	0.26	1.024	26
1151	10.	0	114.	0.8	0.20	QNS	ND
1152	12.	0	168.	1.4	0.17	1.017	26
1157	18.	0	88.	< 0.4	0.13	1.011	22
1164	12.	0	174.	0.9	0.34	1.037	26
1168	13.	0	147.	0.9	0.24	1.027	26
1169	10.	6	96.	1.8	0.31	1.030	26
1177	19.	0	52.	3.5	0.36	QNS	ND
1183	16.	0	128.	< 0.4	0.17	1.017	26
1184	14.	0	126.	1.0	0.09	1.014	26
1189	11.	0	187.	NS	NS	NS	NS
1191	11.	0	87.	< 0.4	0.09	1.016	26
1193	13.	0	80.	< 0.4	0.13	1.020	26
1199	26.	6	71.	1.7	< 0.10	QNS	ND
1201	13.	0	71.	1.5	0.08	1.018	26
1204	11.	0	98.	1.8	< 0.10	1.011	26
1205	14.	0	188.	0.6	< 0.10	1.012	26
1206	10.	0	126.	< 0.4	0.20	1.016	22
1210	9.	0	165.	1.0	0.17	1.019	22
1280	17.	9	133.	3.0	0.22	1.024	26
1281	12.	0	189.	2.6	0.31	1.033	26
1282	14.	0	99.	2.5	0.29	1.028	26

ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
<i>BENICIA CHILDREN</i>							
1304	12.	9	206.	1.8	0.62	1.037	26
1307	10.	0	101.	2.2	0.51	1.028	26
1308	18.	9	QNS	2.5	0.39	QNS	ND
1314	NS		NS	3.8	0.31	QNS	ND
1316	14.	9	133.	3.4	0.33	1.029	26
1317	15.	9	152.	1.9	0.35	1.028	26
1322	12.	9	QNS	4.2	< 0.10	QNS	ND
1328	15.	9	93.	2.9	0.34	1.031	26
1330	18.	9	98.	1.5	0.25	1.008	26
1335	14.	9	161.	NS	NS	NS	NS
1339	16.	0	110.	1.4	0.13	1.017	26
1342	13.	0	129.	3.1	0.26	QNS	ND
1344	NS		164.	2.2	0.17	1.030	ND
1358	NS		NS	2.2	0.27	1.025	26
1361	11.	0	NA	3.1	0.17	1.029	26
1362	NS		NS	4.1	0.39	1.035	26
1363	18.	9	73.	NS	NS	NS	NS
1365	11.	0	129.	1.8	0.31	1.033	26
1367	NS		NS	3.5	0.61	1.037	ND
1379	NS		NS	1.7	0.25	1.030	26
1384	18.	9	78.	0.7	< 0.10	1.007	26
1387	15.	0	86.	1.8	0.43	1.032	26
1388	10.	9	73.	NS	NS	NS	NS
1392	15.	0	95.	2.6	0.25	1.023	26
1393	10.	0	149.	NS	NS	NS	NS
1394	11.	0	94.	2.2	0.24	1.028	26

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
1395	13.	0	96.	2.9	0.28	1.032	26
1396	12.	0	106.	1.6	0.24	1.023	26
1397	9.	6	90.	QNS	0.15	QNS	ND
1398	16.	0	99.	3.7	0.54	1.028	26
1404	14.	0	117.	1.3	0.22	1.028	26
1409	NS		NS	2.6	0.30	1.034	26
1410	NS		NS	QNS	0.41	QNS	ND
1411	13.	0	127.	QNS	0.31	QNS	ND
1412	10.	0	102.	2.9	0.37	1.030	26
1413	11.	0	129.	QNS	0.19	QNS	ND
1415	11.	0	107.	2.2	0.33	1.030	26
1423	NS		NS	4.7	0.54	1.036	26
1425	13.	0	QNS	2.2	0.55	1.028	26
1429	21.	6	QNS	NS	NS	NS	NS
1430	13.	0	110.	NS	NS	NS	NS
1431	12.	0	94.	3.0	0.41	1.035	26
1437	12.	0	107.	2.4	0.31	1.029	26
CROCKETT ADULTS							
2003	20.	0	43.	1.4	0.14	1.023	25
2004	18.	6	77.	1.5	0.20	QNS	22
2006	16.	0	79.	3.4	< 0.10	1.023	26
2008	14.	0	139.	0.8	< 0.10	1.010	24
2009	35.	6	20.	1.5	< 0.10	1.009	25
2011	13.	0	74.	2.0	0.24	QNS	22
2012	13.	0	68.	1.4	0.24	1.022	22
2023	15.	9	91.	3.3	0.22	QNS	ND
2026	11.	0	159.	0.9	0.25	QNS	26

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
2027	18.	0	38.	3.3	0.18	1.016	22
2028	18.	6	107.	0.7	< 0.10	1.008	25
2029	21.	9	103.	1.2	< 0.10	1.011	24
2031	24.	6	72.	2.5	0.25	1.027	24
2035	17.	6	66.	3.4	0.27	1.032	22
2036	20.	9	85.	1.2	0.26	1.029	24
2038	12.	0	125.	1.4	0.19	1.026	24
2039	13.	0	78.	1.0	0.21	1.020	22
2040	15.	6	141.	1.8	< 0.10	1.023	24
2042	15.	0	117.	0.6	< 0.10	1.011	26
2045	15.	0	63.	1.3	0.26	1.025	25
2052	21.	0	48.	3.3	0.22	1.029	25
2053	12.	0	86.	1.7	0.25	1.027	24
2054	9.	0	154.	0.9	0.32	1.031	24
2059	48.	6	8.	4.3	0.18	1.018	22
2060	11.	0	106.	1.2	0.19	1.022	22
2061	22.	0	65.	0.9	< 0.10	1.007	24
2071	15.	0	90.	3.1	0.22	1.030	22
2073	18.	0	53.	2.1	0.16	1.025	25
2076	17.	9	94.	0.7	< 0.10	1.010	24
2081	43.	6	28.	4.4	0.20	1.025	25
2082	11.	0	116.	1.8	0.11	1.016	24
2083	13.	9	143.	1.7	0.20	QNS	ND
2086	16.	0	99.	2.1	0.28	1.019	24
2087	16.	9	126.	0.9	0.14	1.016	26
2089	15.	0	104.	0.9	< 0.10	1.009	24

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
2090	15.	6	248.	0.7	0.18	1.021	24
2092	14.	9	108.	1.0	0.19	1.016	24
2101	16.	0	73.	0.6	< 0.10	1.016	25
2104	13.	0	123.	1.2	0.14	1.022	24.
2105	9.	0	68.	0.9	0.15	1.013	24
2108	17.	9	91.	0.7	< 0.10	1.013	26
2112	14.	9	90.	QNS	0.34	QNS	ND
2115	14.	9	104.	2.2	0.20	1.026	24
2118	20.	0	86.	0.8	< 0.10	1.012	26
2121	12.	0	94.	1.9	0.27	1.030	24
2134	13.	9	120.	2.0	0.21	1.022	24
2142	17.	9	118.	1.2	0.11	1.020	24
2143	15.	0	127.	2.2	0.18	1.025	24
2148	11.	0	148.	0.8	< 0.10	1.010	24
2153	17.	6	89.	2.1	0.23	1.024	24
2154	11.	0	85.	1.7	0.20	1.025	22
<i>CROCKETT CHILDREN</i>							
2203	16.	9	52.	2.2	0.23	1.026	26
2205	19.	9	98.	3.9	0.44	1.033	26
2208	11.	0	114.	3.5	0.32	QNS	ND
2209	11.	6	117.	1.8	0.31	1.036	26
2211	15.	0	96.	1.2	0.35	1.034	26
2212	16.	0	69.	1.7	0.29	1.031	26
2213	11.	9	163.	1.8	0.34	QNS	26
2214	8.	0	157.	3.6	0.21	1.026	26
2216	11.	0	133.	0.6	0.35	1.029	26
2217	15.	9	110.	1.2	0.23	1.023	26

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
2218	17.	0	27.	2.7	0.35	1.027	26
2219	10.	0	129.	QNS	0.21	QNS	ND
2220	22.	6	60.	3.9	0.40	QNS	26
2221	25.	6	40.	2.6	0.34	1.027	26
2228	13.	9	82.	1.8	0.32	1.033	26
2229	20.	6	61.	QNS	0.29	QNS	ND
2230	14.	0	59.	3.6	0.40	1.026	26
2231	15.	9	87.	3.0	0.39	QNS	ND
2237	14.	0	87.	QNS	0.27	QNS	ND
2238	12.	0	103.	QNS	0.23	QNS	ND
2240	10.	0	73.	QNS	0.15	QNS	ND
2242	12.	0	147.	QNS	0.25	QNS	ND
2243	12.	0	145.	QNS	0.38	QNS	ND
2244	10.	0	116.	2.5	0.36	1.029	26
2245	15.	0	21.	2.7	0.15	1.047	26
2246	11.	0	117.	4.1	0.31	1.030	26
2248	20.	9	134.	1.7	0.38	1.029	26
2250	11.	0	111.	QNS	0.42	QNS	ND
MANHATTAN B. ADULTS 3004	17.	6	NA	1.7	0.14	1.018	20
3008	12.	0	NA	2.0	0.34	QNS	ND
3020	12.	0	NA	2.2	0.28	1.028	23
3021	22.	9	NA	1.8	0.44	1.031	22
3022	17.	0	NA	1.5	0.44	1.032	22
3030	18.	0	NA	2.1	0.32	1.033	22
3035	11.	0	NA	NS	NS	NS	NS
3040	16.	0	NA	1.3	< 0.10	1.012	22

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
3044	15.	0	NA	1.2	0.16	1.020	22
3052	17.	9	NA	1.5	0.53	1.031	24
3056	16.	0	NA	2.4	0.32	1.030	22
3058	10.	6	NA	1.5	0.28	1.031	24
3063	12.	6	NA	0.5	< 0.10	1.011	24
3067	16.	6	NA	1.1	0.28	1.025	24
3069	19.	9	NA	1.1	0.45	1.015	25
3081	NS		NS	1.0	< 0.10	1.018	23
3082	17.	6	NA	1.0	< 0.10	1.018	22
3089	16.	6	NA	0.8	< 0.10	1.007	20
3092	14.	9	NA	2.1	0.23	1.031	20
3095	14.	9	NA	2.4	0.39	1.029	23
3109	13.	6	NA	0.8	< 0.10	1.009	24
3111	18.	0	NA	1.4	0.12	1.023	22
3113	12.	0	NA	1.2	0.47	1.031	22
3117	11.	0	NA	2.5	0.24	1.023	24
3119	11.	0	NA	2.0	0.29	QNS	ND
3124	18.	6	NA	0.8	< 0.10	1.009	24
3126	11.	0	NA	1.1	0.25	1.029	24
3129	9.	0	NA	3.1	0.21	1.031	24
3133	11.	6	NA	QNS	0.29	QNS	ND
3134	9.	0	NA	1.0	0.20	1.030	20
3135	15.	0	NA	1.8	0.22	1.021	24
3146	14.	0	NA	2.1	0.32	1.032	20
3151	13.	6	NA	1.5	0.11	1.016	22
3160	19.	0	NA	1.2	0.21	1.028	24

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
3174	18.	0	NA	QNS	0.30	QNS	ND
3175	9.	0	NA	2.3	0.10	1.022	22
3179	10.	0	NA	QNS	0.14	QNS	ND
3184	25.	9	NA	0.9	< 0.10	1.007	23
3185	22.	6	NA	0.9	< 0.10	1.016	24
3186	11.	0	NA	1.0	< 0.10	1.014	24
3190	16.	0	NA	2.5	0.11	1.022	22
3202	13.	0	NA	0.8	< 0.10	1.011	25
MANHATTAN B. CHILDREN 3300	10.	6	NA	NS	NS	NS	NS
3307	11.	6	NA	NS	NS	NS	NS
3312	12.	6	NA	NS	NS	NS	NS
3313	11.	6	NA	NS	NS	NS	NS
3317	15.	9	NA	NS	NS	NS	NS
3320	17.	6	NA	NS	NS	NS	NS
3322	15.	9	NA	NS	NS	NS	NS
3323	18.	6	NA	NS	NS	NS	NS
3324	11.	6	NA	NS	NS	NS	NS
3328	14.	9	NA	NS	NS	NS	NS
3335	19.	9	NA	NS	NS	NS	NS
3341	18.	9	NA	NS	NS	NS	NS
3343	14.	9	NA	NS	NS	NS	NS
3349	24.	9	NA	NS	NS	NS	NS
3353	23.	9	NA	NS	NS	NS	NS
3360	18.	9	NA	NS	NS	NS	NS
3364	14.	9	NA	NS	NS	NS	NS
3367	21.	9	NA	NS	NS	NS	NS

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
3368	21.	9	NA	NS	NS	NS	NS
3372	17.	9	NA	NS	NS	NS	NS
3373	16.	9	NA	NS	NS	NS	NS
3374	18.	9	NA	NS	NS	NS	NS
3377	23.	9	NA	NS	NS	NS	NS
3380	11.	9	NA	NS	NS	NS	NS
3389	19.	9	NA	NS	NS	NS	NS
3398	17.	9	NA	NS	NS	NS	NS
3401	14.	9	NA	NS	NS	NS	NS
3407	22.	9	NA	NS	NS	NS	NS
3409	15.	9	NA	NS	NS	NS	NS
3410	16.	9	NA	NS	NS	NS	NS
3413	12.	9	NA	NS	NS	NS	NS
3414	13.	9	NA	NS	NS	NS	NS
3420	21.	9	NA	NS	NS	NS	NS
3424	14.	9	NA	NS	NS	NS	NS
3433	19.	9	NA	NS	NS	NS	NS
3438	25.	9	NA	NS	NS	NS	NS
3444	16.	9	NA	NS	NS	NS	NS
3446	25.	9	NA	NS	NS	NS	NS
3448	19.	9	NA	NS	NS	NS	NS
3451	19.	9	NA	NS	NS	NS	NS
BURBANK ADULTS 4002	11.	0	NA	1.6	0.27	1.030	26
4010	20.	0	NA	1.2	0.10	1.010	25
4013	29.	6	NA	2.9	< 0.10	1.008	25
4019	9.	0	NA	0.7	< 0.10	1.026	26

Moore Business Forms, Inc. 14

ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
4031	21.	6	NA	1.3	0.13	1.013	25
4038	17.	0	NA	QNS	0.20	QNS	ND
4043	14.	0	NA	2.5	0.24	1.033	26
4046	14.	0	NA	2.7	0.35	1.028	26
4049	17.	0	NA	1.9	0.10	1.015	26
4052	14.	0	NA	1.8	0.27	1.029	25
4053	15.	9	NA	1.0	0.18	1.018	25
4055	14.	0	NA	2.7	0.18	QNS	ND
4057	14.	0	NA	QNS	0.19	QNS	ND
4059	21.	6	NA	1.3	0.21	1.018	25
4062	17.	0	NA	NS	NS	NS	NS
4063	20.	6	NA	1.3	0.14	1.019	25
4072	12.	0	NA	0.7	< 0.10	1.008	26
4078	21.	0	NA	2.5	0.24	QNS	ND
4080	16.	6	NA	2.3	0.27	1.027	26
4097	15.	0	NA	1.2	< 0.10	1.015	25
4098	17.	0	NA	4.9	0.28	1.027	26
4107	18.	6	NA	2.3	0.25	QNS	ND
4109	15.	0	NA	1.8	0.14	1.020	26
4114	20.	0	NA	2.2	0.18	1.023	26
4120	19.	0	NA	QNS	0.13	QNS	ND
4123	18.	0	NA	2.9	0.19	QNS	ND
4124	13.	0	NA	2.6	0.29	1.028	26
4126	23.	9	NA	QNS	0.41	QNS	ND
4131	12.	0	NA	2.7	0.34	QNS	ND
4132	14.	0	NA	2.1	0.20	1.028	25

Moore Business Forms, Inc. 14

ID NO	BLOOD PB UG/100 G	CODE	ALAO UNITS	URINE PB UG/100ML	D-ALA UG/100ML	SP GRAV	TEMP DEG C
4137	11.	0	NA	2.2	0.33	1.030	25
4145	17.	0	NA	3.4	< 0.10	1.012	25
4156	19.	6	NA	1.4	0.17	1.028	26
4157	10.	0	NA	2.3	0.24	1.025	25
4162	15.	0	NA	2.0	0.50	1.035	25
4174	12.	0	NA	1.3	< 0.10	1.013	25
4175	22.	0	NA	QNS	0.37	QNS	ND
4182	11.	0	NA	QNS	0.54	QNS	ND
4183	9.	0	NA	QNS	0.38	QNS	ND
4185	17.	0	NA	0.5	< 0.10	1.007	26
4190	16.	0	NA	QNS	0.29	QNS	ND
4199	18.	0	NA	3.7	0.26	1.013	25
<i>BURBANK CHILDREN</i>							
4303	25.	9	NA	NS	NS	NS	NS
4304	23.	9	NA	NS	NS	NS	NS
4306	28.	9	NA	NS	NS	NS	NS
4308	26.	9	NA	NS	NS	NS	NS
4310	26.	9	NA	NS	NS	NS	NS
4313	17.	9	NA	NS	NS	NS	NS
4315	20.	9	NA	NS	NS	NS	NS
4316	25.	9	NA	NS	NS	NS	NS
4318	18.	9	NA	NS	NS	NS	NS
4319	21.	9	NA	NS	NS	NS	NS
4320	20.	9	NA	NS	NS	NS	NS
4322	21.	9	NA	NS	NS	NS	NS
4323	31.	9	NA	NS	NS	NS	NS
4324	13.	9	NA	NS	NS	NS	NS

Moore Business Forms, Inc. 14

ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA HG/100ML	SP GRAV	TEMP DEG C
4328	20.	9	NA	NS	NS	NS	NS
4330	19.	9	NA	NS	NS	NS	NS
4333	19.	9	NA	NS	NS	NS	NS
4336	18.	9	NA	NS	NS	NS	NS
4337	24.	9	NA	NS	NS	NS	NS
4342	31.	9	NA	NS	NS	NS	NS
4343	21.	9	NA	NS	NS	NS	NS
4345	21.	9	NA	NS	NS	NS	NS
4346	25.	9	NA	NS	NS	NS	NS
4347	18.	9	NA	NS	NS	NS	NS
4348	17.	9	NA	NS	NS	NS	NS
4350	26.	9	NA	NS	NS	NS	NS
4351	29.	9	NA	NS	NS	NS	NS
4352	18.	9	NA	NS	NS	NS	NS
4353	21.	9	NA	NS	NS	NS	NS
4355	21.	9	NA	NS	NS	NS	NS
4357	19.	9	NA	NS	NS	NS	NS
4358	20.	9	NA	NS	NS	NS	NS
4359	19.	9	NA	NS	NS	NS	NS
4363	20.	9	NA	NS	NS	NS	NS
4367	22.	9	NA	NS	NS	NS	NS
4368	21.	9	NA	NS	NS	NS	NS
5001	LABORATORY SAMPLES 23.	6	NA	QNS	0.22	QNS	ND
5002	14.	6	NA	2.3	0.24	1.032	25
ALPINE 6001	14.	6	NA	NS	NS	NS	NS
6002	9.	6	NA	NS	NS	NS	NS

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ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA 1G/100ML	SP GRAV	TEMP DEG C
6003	11.	6	NA	NS	NS	NS	NS
6004	11.	6	NA	NS	NS	NS	NS
6007	11.	6	NA	NS	NS	NS	NS
6008	53.	6	NA	NS	NS	NS	NS
6009	15.	6	NA	1.9	0.29	1.027	26
6010	12.	6	NA	NS	NS	NS	NS
6011	14.	6	NA	1.5	0.15	1.027	26
6012	14.	6	NA	NS	NS	NS	NS
6013	13.	6	NA	NS	NS	NS	NS
6014	13.	6	NA	NS	NS	NS	NS
6015	10.	6	NA	NS	NS	NS	NS
6018	10.	6	NA	QNS	0.24	QNS	ND
6021	14.	6	NA	NS	NS	NS	NS
6022	20.	6	NA	NS	NS	NS	NS
6023	18.	6	NA	NS	NS	NS	NS
6024	23.	6	NA	NS	NS	NS	NS
6028	23.	6	NA	NS	NS	NS	NS
6029	11.	6	NA	NS	NS	NS	NS
6030	21.	6	NA	NS	NS	NS	NS
6031	27.	6	NA	NS	NS	NS	NS
6032	13.	6	NA	0.9	< 0.10	1.013	26
6036	26.	6	NA	2.7	0.50	1.035	26
6037	< 5.	6	NA	1.7	0.51	1.023	26
6038	10.	6	NA	2.3	0.32	1.028	26
6040	14.	6	NA	NS	NS	NS	NS
6044	21.	6	NA	NS	NS	NS	NS

Moore Business Forms, Inc. 14

ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA MG/100ML	SP GRAV	TEMP DEG C
6050	17.	6	NA	NS	NS	NS	NS
6051	6.	6	NA	NS	NS	NS	NS
6052	6.	6	NA	2.2	0.16	1.015	26
6053	8.	6	NA	NS	NS	NS	NS
6054	24.	6	NA	2.2	0.23	1.026	26
6055	12.	6	NA	NS	NS	NS	NS
6056	19.	6	NA	2.0	0.13	1.029	26
6057	9.	6	NA	NS	NS	NS	NS
6061	14.	6	NA	NS	NS	NS	NS
6063	10.	6	NA	NS	NS	NS	NS
6064	7.	6	NA	1.2	0.17	1.025	26
6065	6.	6	NA	1.1	< 0.10	1.012	26
6066	NS		NS	1.5	0.20	1.028	26
6067	13.	6	NA	2.2	0.14	1.023	26
6068	15.	6	NA	1.7	0.29	1.027	25
6069	13.	6	NA	NS	NS	NS	NS
6071	11.	6	NA	2.3	0.33	1.034	25
6074	NS		NS	1.4	0.45	1.030	25
6075	9.	6	NA	0.4	0.35	1.024	25
6077	15.	6	NA	NS	NS	NS	NS
6078	< 5.	6	NA	NS	NS	NS	NS
6079	17.	6	NA	NS	NS	NS	NS
6082	8.	6	NA	1.0	0.20	1.028	25
6083	10.	6	NA	1.1	0.26	1.025	25
6084	9.	6	NA	NS	NS	NS	NS
6085	15.	6	NA	QNS	0.31	QNS	ND

ID NO	BLOOD PB UG/100 G	CODE	ALAD UNITS	URINE PB UG/100ML	D-ALA UG/100ML	SP GRAY	TEMP DEG C
6086	11.	6	NA	NS	NS	NS	NS
6088	14.	6	NA	NS	NS	NS	NS
6089	11.	6	NA	6.0	0.29	1.032	25
6090	8.	6	NA	NS	NS	NS	NS
6091	12.	6	NA	NS	NS	NS	NS
6092	11.	6	NA	NS	NS	NS	NS
6096	10.	6	NA	NS	NS	NS	NS
6097	9.	6	NA	NS	NS	NS	NS
6098	14.	6	NA	0.9	0.19	1.017	25
6099	< 5.	6	NA	NS	NS	NS	NS
6101	16.	6	NA	NS	NS	NS	NS
6102	19.	6	NA	NS	NS	NS	NS
6105	11.	6	NA	NS	NS	NS	NS
6106	12.	6	NA	NS	NS	NS	NS
6107	15.	6	NA	NS	NS	NS	NS

405 DATA CARDS READ AND PRINTED

NA = NOT APPLICABLE ND = NOT DETERMINED QNS = QUANTITY NOT SUFFICIENT FOR ANALYSIS NS =
NUMBER UNDER CODE COLUMN INDICATES TYPE OF BLOOD LEAD ANALYSIS
3 = DELVES RATIO
5 = DELVES STANDARD ADDITION
6 = MIBK EXTRACTION
9 = DELVES RATIO CORRECTED TO MIBK EXTRACTION BY FORMULA (RATIO + 3.1162)/(1.9696)
0 = DELVES RATIO CORRECTED TO MIBK EXTRACTION BY FORMULA (RATIO + 2.9394)/(1.130)

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20698	2	4/18/73	9.	1	K
20698	3	4/18/73	11.	1	K
20698	5	4/18/73	6.	1	K
20698	7	4/18/73	5.	1	K
20698	8	4/25/73	8.	1	K
20698	10	4/25/73	8.	1	K
20698	11	4/23/73	8.	1	K
20698	12	4/23/73	9.	1	K
20698	13	4/23/73	7.	1	K
20698	14	4/18/73	10.	1	K
20698	15	4/23/73	9.	1	K
20698	16	4/18/73	5.	1	K
20698	17	08/01/73	6.	6	U
20698	18	4/25/73	7.	1	K
20698	19	4/23/73	7.	1	K
20698	20	4/18/73	8.	1	K
20698	21	4/19/73	6.	1	K
20698	22	4/23/73	8.	1	K
20698	23	08/01/73	8.	6	U
20698	24	4/23/73	9.	1	K
20698	25	4/23/73	10.	1	K
20698	26	4/23/73	13.	1	K
20698	27	4/23/73	13.	1	K

METHOD

1 = Delves Ratio (adjusted)
6 = MIBK

SOURCE OF SAMPLES

Rokaw Blood--
Lab Nos. 20698-20790
San Diego--
Lab Nos. 30166

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20698	28	4/19/73	9.	1	K
20698	29	4/23/73	10.	1	K
20698	30	4/19/73	11.	1	K
20698	31	4/19/73	15.	1	K
20698	32	4/19/73	7.	1	K
20698	33	4/19/73	15.	1	K
20698	34	4/19/73	7.	1	K
20698	35	08/01/73	6.	6	U
20698	36	08/01/73	7.	6	U
20698	37	4/23/73	9.	1	K
20698	38	4/23/73	10.	1	K
20698	39	4/23/73	7.	1	K
20698	40	4/23/73	11.	1	K
20698	41	4/23/73	8.	1	K
20698	42	5/01/73	7.	1	K
20699	43	4/23/73	9.	1	K
20699	44	4/23/73	9.	1	K
20699	45	4/23/73	7.	1	K
20699	46	4/23/73	7.	1	K
20699	47	4/23/73	8.	1	K
20699	48	4/23/73	8.	1	K
20699	49	4/23/73	7.	1	K
20699	50	4/23/73	6.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20699	51	5/01/73	8.	1	K
20699	52	4/23/73	15.	1	K
20699	53	5/01/73	10.	1	K
20699	54	4/23/73	10.	1	K
20699	55	4/25/73	9.	1	K
20699	56	08/01/73	7.	6	U
20699	57	4/25/73	13.	1	K
20699	58	4/23/73	8.	1	K
20699	59	4/25/73	10.	1	K
20699	60	4/25/73	11.	1	K
20699	61	4/23/73	9.	1	K
20699	62	4/25/73	10.	1	K
20743	63	4/24/73	12.	1	K
20743	64	4/24/73	9.	1	K
20743	65	4/24/73	8.	1	K
20743	66	4/24/73	7.	1	K
20743	67	4/24/73	11.	1	K
20743	68	4/24/73	7.	1	K
20743	69	4/24/73	14.	1	K
20743	70	5/01/73	13.	1	K
20743	71	5/10/73	10.	1	K
20743	72	4/24/73	10.	1	K
20743	73	4/24/73	9.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20743	74	4/24/73	10.	1	K
20743	75	4/24/73	18.	1	K
20743	76	4/24/73	13.	1	K
20743	77	4/24/73	9.	1	K
20743	78	4/24/73	18.	1	K
20743	79	5/01/73	10.	1	K
20743	80	4/25/73	18.	1	K
20743	81	4/25/73	9.	1	K
20743	82	4/25/73	10.	1	K
20743	83	08/01/73	12.	6	U
20743	84	4/25/73	13.	1	K
20743	85	4/25/73	14.	1	K
20743	86	4/25/73	12.	1	K
20743	87	4/26/73	12.	1	K
20743	88	4/26/73	11.	1	K
20743	89	08/01/73	10.	6	U
20743	90	5/10/73	10.	1	K
20743	91	4/26/73	12.	1	K
20743	92	5/01/73	14.	1	K
20743	93	4/26/73	14.	1	K
20743	94	4/26/73	9.	1	K
20743	95	4/26/73	10.	1	K
20743	96	4/26/73	9.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20743	97	4/26/73	7.	1	K
20743	98	4/26/73	9.	1	K
20743	99	4/26/73	9.	1	K
20743	100	4/26/73	7.	1	K
20743	101	4/26/73	13.	1	K
20743	102	4/26/73	7.	1	K
20743	103	5/01/73	18.	1	K
20743	104	08/01/73	6.	6	U
20743	106	5/01/73	12.	1	K
20743	108	5/01/73	11.	1	K
20743	109	5/01/73	11.	1	K
20743	110	4/26/73	10.	1	K
20744	111	4/25/73	10.	1	K
20744	112	4/23/73	16.	1	K
20744	113	4/23/73	17.	1	K
20744	114	4/25/73	17.	1	K
20744	115	4/23/73	18.	1	K
20744	116	4/25/73	11.	1	K
20744	117	4/24/73	12.	1	K
20744	118	4/24/73	16.	1	K
20744	119	4/25/73	11.	1	K
20744	120	4/25/73	9.	1	K
20744	121	5/01/73	14.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20744	122	08/01/73	11.	6	U
20744	123	5/01/73	13.	1	K
20744	124	4/24/73	12.	1	K
20744	125	5/01/73	17.	1	K
20744	126	4/24/73	17.	1	K
20744	127	4/24/73	14.	1	K
20744	128	4/24/73	10.	1	K
20744	129	4/24/73	11.	1	K
20744	130	4/24/73	11.	1	K
20744	131	4/26/73	9.	1	K
20744	132	4/24/73	9.	1	K
20744	133	4/24/73	13.	1	K
20744	134	4/24/73	13.	1	K
20744	135	4/24/73	15.	1	K
20744	136	4/24/73	9.	1	K
20744	137	08/01/73	9.	6	U
20744	138	4/24/73	9.	1	K
20744	139	4/24/73	14.	1	K
20744	140	4/24/73	12.	1	K
20745	142	5/01/73	12.	1	K
20745	143	5/10/73	16.	1	K
20745	144	4/26/73	14.	1	K
20745	145	4/26/73	11.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20745	146	4/26/73	7.	1	K
20745	147	4/26/73	12.	1	K
20745	148	5/01/73	24.	1	K
20745	149	4/26/73	10.	1	K
20745	150	4/26/73	15.	1	K
20745	151	08/01/73	13.	6	U
20745	152	4/26/73	15.	1	K
20745	153	5/01/73	14.	1	K
20745	155	4/27/73	11.	1	K
20745	156	08/01/73	11.	6	U
20745	157	4/27/73	14.	1	K
20745	158	4/27/73	16.	1	K
20745	159	5/01/73	23.	1	K
20745	160	5/01/73	18.	1	K
20745	161	5/01/73	13.	1	K
20745	162	4/27/73	13.	1	K
20745	163	4/27/73	14.	1	K
20745	164	5/01/73	9.	1	K
20745	165	4/27/73	10.	1	K
20745	166	4/27/73	13.	1	K
20745	167	4/27/73	15.	1	K
20745	168	5/01/73	8.	1	K
20745	169	4/27/73	20.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20745	170	4/27/73	16.	1	K
20745	171	08/01/73	11.	6	U
20745	172	5/01/73	14.	1	K
20745	173	5/01/73	11.	1	K
20745	174	4/27/73	18.	1	K
20745	175	5/01/73	24.	1	K
20745	176	4/27/73	12.	1	K
20745	177	4/27/73	12.	1	K
20745	178	4/27/73	19.	1	K
20745	179	5/01/73	14.	1	K
20745	180	4/27/73	12.	1	K
20745	181	4/27/73	11.	1	K
20745	182	4/27/73	10.	1	K
20745	183	5/22/73	15.	1	K
20745	184	4/30/73	9.	1	K
20745	185	4/30/73	12.	1	K
20745	186	4/30/73	13.	1	K
20745	188	5/10/73	14.	1	K
20745	189	4/30/73	11.	1	K
20745	190	5/10/73	14.	1	K
20745	191	4/30/73	17.	1	K
20745	192	4/30/73	11.	1	K
20746	193	4/30/73	15.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20746	194	5/10/73	13.	1	K
20746	195	4/30/73	17.	1	K
20746	196	4/30/73	15.	1	K
20746	197	4/30/73	13.	1	K
20746	199	4/30/73	22.	1	K
20746	200	4/30/73	11.	1	K
20746	201	4/30/73	11.	1	K
20746	202	4/30/73	15.	1	K
20746	203	08/01/73	15.	6	U
20746	204	5/22/73	11.	1	K
20746	205	4/30/73	13.	1	K
20746	206	4/30/73	17.	1	K
20746	207	4/30/73	14.	1	K
20746	208	4/30/73	13.	1	K
20746	209	5/10/73	12.	1	K
20746	210	4/30/73	11.	1	K
20746	211	4/30/73	15.	1	K
20746	212	4/30/73	12.	1	K
20785	213	08/01/73	12.	6	U
20785	214	4/30/73	17.	1	K
20785	215	5/10/73	11.	1	K
20785	216	4/30/73	10.	1	K
20785	217	4/30/73	16.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20785	218	4/30/73	10.	1	K
20785	219	4/30/73	13.	1	K
20785	220	4/30/73	12.	1	K
20785	221	5/10/73	12.	1	K
20785	222	4/30/73	12.	1	K
20785	223	4/30/73	12.	1	K
20785	224	4/30/73	7.	1	K
20785	225	4/30/73	15.	1	K
20785	226	4/30/73	11.	1	K
20785	227	4/30/73	11.	1	K
20785	228	4/30/73	13.	1	K
20785	229	5/22/73	11.	1	K
20785	230	5/10/73	11.	1	K
20785	232	5/22/73	10.	1	K
20785	233	4/30/73	19.	1	K
20785	234	5/01/73	10.	1	K
20785	235	5/10/73	10.	1	K
20785	236	5/01/73	9.	1	K
20785	237	08/01/73	13.	6	U
20785	238	5/01/73	10.	1	K
20785	239	5/22/73	12.	1	K
20785	240	5/01/73	9.	1	K
20785	241	5/22/73	10.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20785	242	5/01/73	16.	1	K
20785	243	5/01/73	11.	1	K
20785	244	5/10/73	13.	1	K
20785	245	5/10/73	11.	1	K
20785	246	08/01/73	10.	6	U
20785	247	5/01/73	11.	1	K
20785	248	5/22/73	14.	1	K
20785	249	5/01/73	12.	1	K
20785	250	5/22/73	10.	1	K
20785	251	5/02/73	14.	1	K
20785	252	5/02/73	17.	1	K
20785	253	5/02/73	12.	1	K
20785	254	5/10/73	10.	1	K
20785	255	5/10/73	10.	1	K
20785	256	5/02/73	7.	1	K
20785	257	5/02/73	15.	1	K
20785	258	5/02/73	8.	1	K
20785	259	5/10/73	9.	1	K
20785	260	08/01/73	13.	6	U
20785	261	5/02/73	11.	1	K
20785	262	5/02/73	9.	1	K
20785	263	5/02/73	17.	1	K
20786	R1	5/03/73	23.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20786	264	5/10/73	8.	1	K
20786	265	5/22/73	9.	1	K
20786	266	5/02/73	12.	1	K
20786	267	5/02/73	11.	1	K
20786	268	5/10/73	8.	1	K
20786	269	5/02/73	10.	1	K
20786	270	5/02/73	6.	1	K
20786	271	5/02/73	10.	1	K
20786	272	5/11/73	23.	1	K
20786	273	5/02/73	15.	1	K
20786	274	5/03/73	16.	1	K
20786	275	5/11/73	14.	1	K
20786	276	5/03/73	11.	1	K
20786	277	5/22/73	15.	1	K
20786	278	5/03/73	11.	1	K
20786	279	5/03/73	16.	1	K
20786	280	5/03/73	11.	1	K
20787	281	5/03/73	14.	1	K
20787	282	5/03/73	16.	1	K
20787	283	5/03/73	12.	1	K
20787	284	5/03/73	19.	1	K
20787	285	5/03/73	10.	1	K
20787	286	5/03/73	14.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20787	287	5/03/73	11.	1	K
20787	288	5/03/73	15.	1	K
20787	289	5/11/73	17.	1	K
20787	290	5/22/73	18.	1	K
20787	291	5/11/73	14.	1	K
20787	292	5/03/73	12.	1	K
20787	293	08/01/73	16.	6	U
20787	294	5/03/73	12.	1	K
20787	295	5/03/73	12.	1	K
20787	296	5/03/73	16.	1	K
20787	297	5/11/73	16.	1	K
20787	298	5/24/73	12.	1	K
20787	299	5/11/73	11.	1	K
20787	300	5/22/73	14.	1	K
20787	301	5/22/73	15.	1	K
20787	302	5/22/73	15.	1	K
20787	303	5/14/73	24.	1	K
20788	304	5/14/73	13.	1	K
20788	305	5/22/73	17.	1	K
20788	306	5/24/73	11.	1	K
20788	307	5/14/73	8.	1	K
20788	308	5/14/73	11.	1	K
20788	309	08/01/73	19.	6	U

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20788	310	5/14/73	9.	1	K
20788	311	08/01/73	10.	6	U
20788	312	5/14/73	16.	1	K
20788	313	5/14/73	11.	1	K
20788	314	5/14/73	15.	1	K
20788	315	5/14/73	12.	1	K
20788	316	5/22/73	10.	1	K
20788	317	5/22/73	6.	1	K
20788	318	5/15/73	12.	1	K
20788	319	5/24/73	12.	1	K
20788	321	5/24/73	11.	1	K
20788	322	5/15/73	11.	1	K
20788	323	5/15/73	14.	1	K
20788	324	5/24/73	14.	1	K
20788	325	5/22/73	13.	1	K
20788	327	5/24/73	15.	1	K
20788	328	5/24/73	10.	1	K
20788	329	5/22/73	13.	1	K
20788	330	08/01/73	11.	6	U
20788	331	5/15/73	8.	1	K
20788	332	5/15/73	21.	1	K
20788	333	08/01/73	11.	6	U
20788	334	5/15/73	15.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20788	335	08/01/73	11.	6	U
20788	336	5/29/73	10.	1	K
20788	337	5/29/73	15.	1	K
20788	338	5/15/73	11.	1	K
20788	339	08/01/73	13.	6	U
20788	340	5/15/73	8.	1	K
20788	341	5/15/73	10.	1	K
20788	342	5/15/73	16.	1	K
20788	343	5/29/73	15.	1	K
20788	344	5/15/73	10.	1	K
20788	345	08/01/73	10.	6	U
20788	346	5/22/73	16.	1	K
20789	347	5/22/73	11.	1	K
20789	348	5/22/73	11.	1	K
20789	349	5/22/73	9.	1	K
20789	350	5/22/73	14.	1	K
20789	351	5/15/73	18.	1	K
20789	352	5/15/73	12.	1	K
20789	353	5/15/73	11.	1	K
20789	354	5/15/73	10.	1	K
20789	355	5/22/73	13.	1	K
20789	356	5/15/73	11.	1	K
20789	357	5/29/73	8.	1	K

B L O O D · L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20789	358	5/15/73	8.	1	K
20789	359	5/15/73	10.	1	K
20789	360	5/16/73	9.	1	K
20789	361	5/22/73	7.	1	K
20789	362	5/16/73	16.	1	K
20789	363	5/29/73	9.	1	K
20789	364	5/22/73	12.	1	K
20789	365	5/16/73	12.	1	K
20789	367	5/29/73	13.	1	K
20789	368	5/16/73	11.	1	K
20789	369	5/22/73	9.	1	K
20789	370	5/16/73	8.	1	K
20789	372	5/22/73	12.	1	K
20789	374	5/16/73	8.	1	K
20789	375	08/01/73	13.	6	U
20789	376	5/16/73	10.	1	K
20789	377	5/29/73	11.	1	K
20789	378	5/16/73	6.	1	K
20789	379	08/01/73	9.	6	U
20789	380	5/29/73	11.	1	K
20789	381	5/23/73	9.	1	K
20789	382	5/29/73	8.	1	K
20789	383	5/16/73	11.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20789	384	5/29/73	9.	1	K
20789	385	5/23/73	7.	1	K
20789	386	5/16/73	9.	1	K
20789	387	08/01/73	14.	6	U
20789	388	5/23/73	9.	1	K
20789	389	5/29/73	9.	1	K
20789	390	5/23/73	12.	1	K
20789	391	5/30/73	8.	1	K
20789	392	5/30/73	8.	1	K
20790	393	5/23/73	12.	1	K
20790	394	5/23/73	9.	1	K
20790	395	5/23/73	11.	1	K
20790	396	5/23/73	15.	1	K
20790	397	5/23/73	12.	1	K
20790	398	5/23/73	11.	1	K
20790	399	5/30/73	8.	1	K
20790	400	5/30/73	9.	1	K
20790	401	5/30/73	7.	1	K
20790	402	5/30/73	14.	1	K
20790	403	5/23/73	8.	1	K
20790	404	5/23/73	10.	1	K
20790	405	5/23/73	19.	1	K
20790	406	08/01/73	11.	6	U

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
20790	407	5/23/73	12.	1	K
20790	408	5/30/73	6.	1	K
20790	409	5/30/73	7.	1	K
20790	410	5/23/73	9.	1	K
20790	411	08/01/73	11.	6	U
20790	412	5/24/73	12.	1	K
20790	413	5/30/73	8.	1	K
20790	414	5/30/73	8.	1	K
20790	415	5/24/73	8.	1	K
20790	416	5/24/73	10.	1	K
20790	417	5/24/73	8.	1	K
20790	418	5/30/73	8.	1	K

30166	3	6/13/73	19.	1	K
30166	7	6/13/73	21.	1	K
30166	18	6/13/73	24.	1	K
30166	23	08/01/73	17.	6	U
30166	28	08/01/73	31.	6	U
30166	30	6/07/73	16.	1	K
30166	40	6/07/73	18.	1	K
30166	41	6/14/73	23.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
30166	51	6/07/73	24.	1	K
30166	60	6/13/73	14.	1	K
30166	65	6/07/73	17.	1	K
30166	80	6/06/73	14.	1	K
30166	84	6/18/73	10.	1	K
30166	98	6/13/73	18.	1	K
30166	103	6/18/73	13.	1	K
30166	110	6/07/73	18.	1	K
30166	119	6/18/73	16.	1	K
30166	130	6/13/73	23.	1	K
30166	133	6/06/73	9.	1	K
30166	146	6/18/73	16.	1	K
30166	220	6/13/73	24.	1	K
30166	231	6/07/73	8.	1	K
30166	234	6/07/73	24.	1	K
30166	249	6/14/73	16.	1	K
30166	251	6/06/73	15.	1	K
30166	312	6/13/73	16.	1	K
30166	313	6/13/73	17.	1	K
30166	322	6/07/73	9.	1	K
30166	403	6/07/73	11.	1	K
30166	405	08/01/73	21.	6	U
30166	407	6/07/73	22.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
30166	412	6/18/73	8.	1	K
30166	424	6/14/73	16.	1	K
30166	426	6/07/73	13.	1	K
30166	501	6/07/73	12.	1	K
30166	506	6/13/73	14.	1	K
30166	507	6/13/73	15.	1	K
30166	511	6/13/73	18.	1	K
30166	513	6/13/73	18.	1	K
30166	514	6/13/73	18.	1	K
30166	517	6/07/73	15.	1	K
30166	519	6/18/73	11.	1	K
30166	523	6/06/73	10.	1	K
30166	525	6/07/73	14.	1	K
30166	527	6/18/73	19.	1	K
30166	530	6/13/73	15.	1	K
30166	533	6/07/73	12.	1	K
30166	601	08/01/73	17.	6	U
30166	603	6/15/73	20.	1	K
30166	612	6/13/73	20.	1	K
30166	613	6/13/73	21.	1	K
30166	615	6/13/73	20.	1	K
30166	720	6/18/73	10.	1	K
30166	721	6/18/73	12.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
30166	805	6/13/73	19.	1	K
30166	902	6/07/73	11.	1	K
30166	907	08/01/73	22.	6	U
30166	910	6/07/73	11.	1	K
30166	911	6/18/73	10.	1	K
30166	912	6/07/73	14.	1	K
30166	920	08/01/73	24.	6	U
30166	922	6/18/73	13.	1	K
30166	925	6/18/73	13.	1	K
30166	926	08/01/73	20.	6	U
30166	1003	6/18/73	12.	1	K
30166	1004	6/07/73	13.	1	K
30166	1009	6/07/73	14.	1	K
30166	1013	6/07/73	11.	1	K
30166	1014	6/18/73	13.	1	K
30166	1101	6/07/73	19.	1	K
30166	1108	6/15/73	12.	1	K
30166	1111	6/13/73	21.	1	K
30166	1112	6/15/73	18.	1	K
30166	1202	6/07/73	8.	1	K
30166	1309	6/07/73	14.	1	K
30166	1403	6/15/73	15.	1	K
30166	1501	6/18/73	11.	1	K

B L O O D L E A D A N A L Y S E S

LAB NUMBER	SAMPLE NUMBER	DATE ANALYZED	LEAD UG/100G	METHOD	ANALYST
30166	1503	6/13/73	20.	1	K
30166	1504	6/07/73	11.	1	K
30166	1508	6/18/73	9.	1	K
30166	1509	6/15/73	10.	1	K
30166	1601	6/13/73	17.	1	K
30166	1602	6/07/73	9.	1	K
30166	1604	6/07/73	8.	1	K
30166	1605	6/18/73	11.	1	K
30166	1702	6/06/73	6.	1	K

C. LABORATORY METHODOLOGY

D. MANUSCRIPT

Appendices C and D were not reproducible due to insufficient contrast.

Details of the work, which is listed on page 3, may be obtained from the Air and Industrial Hygiene Laboratory, Department of Health, 2151 Berkeley Way, Berkeley, California 94704.

DELTA-AMINOLEVULINIC ACID IN URINE*

I SCOPE

Delta-aminolevulinic acid (d-ALA) is a precursor in the biosynthesis of porphyrins and is normally found in urine. Many investigators have demonstrated that urinary excretion of d-ALA is consistently elevated in cases of clinical lead poisoning and in workers exposed to lead. The lead appears to affect porphyrin synthesis by inhibiting the formation of porphobilinogen (PBG) resulting in an accumulation of its immediate precursor d-ALA. Consequently, the concentration of d-ALA appears as elevated levels in the urine.

II PRINCIPLE

A sensitive colorimetric method for d-ALA has been described by Mauzerall and Granick¹ where two types of ion-exchange resins are used to remove interfering substances present in normal urine, namely, PBG and urea. The isolated d-ALA is determined by condensing it with acetylacetone to form a pyrrole which can then be reacted with a modified Ehrlich's reagent. This reaction produces a red colored solution whose color intensity is measured in a spectrophotometer. Davis and Andelman² have modified this method using disposable ion-exchange chromatography columns making possible the rapid isolation of d-ALA from a large number of urine samples.

III EQUIPMENT

- A. Tomac 10 cc disposable plastic syringes from American Hospital Supply, Evanston, Illinois.

*Prepared by staff of the Air and Industrial Hygiene Laboratory, State of California Department of Public Health, Berkeley, May 1972.

- B. Wooden support racks
- C. Drain trough
- D. Boiling water bath
- E. Spectrophotometer capable for measuring color intensity at 553 m μ
- F. One cm optical light path cells.

IV REAGENTS

- A. All reagents shall be A.C.S. reagent grade
 - 1. Acetylacetone: $\text{CH}_3\text{COCH}_2\text{COCH}_3$; 2,4-pentanedione
Eastman Organic Chemicals
 - 2. Delta-aminolevulinic Acid Hydrochloride: $\text{NH}_2\text{CH}_2\text{COCH}_2\text{CH}_2\text{COOH}\cdot\text{HCl}$
Baker grade, J. T. Baker Chemical Co.
 - 3. p-Dimethylaminobenzaldehyde: $(\text{CH}_3)_2\text{NC}_6\text{H}_4\text{CHO}$
Baker grade, J. T. Baker Chemical Co. Recrystallized from aqueous methanol. M.P. 73-74 $^\circ\text{C}$ or Eastman Kodak, Cat. No. 95, without recrystallization.
 - 4. Ion-exchange Resins:
 - Anion exchange resins. Analytical grade AG 1-X8, 100 to 200 mesh, acetate form, Bio-Rad Laboratories
 - Cation exchange resins. Analytical grade AG 50 W-X8, 100 to 200 mesh, hydrogen form, Bio-Rad Laboratories
 - 5. Acetate Buffer, pH 4.7:
Add 57 ml of glacial acetic acid to 136 g of sodium acetate trihydrate and dilute with distilled water to 1000 ml.
 - 6. Modified Ehrlich-Hg Reagent:
Add 20 ml of concentrated (70%) perchloric acid to 84 ml of glacial acetic acid. Then add 2.0 g of recrystallized p-dimethyl-

aminobenzaldehyde (DMAB) and 0.35 g of mercuric chloride. Dilute with distilled water to 110 ml. Prepare fresh daily.

7. 1.0 M Sodium Acetate Solution:

Dissolve 136 g of sodium acetate trihydrate in 1000 ml of distilled water.

8. Standard Delta-aminolevulinic Acid (d-ALA) Solution:

Stock ALA solution. Weight 12.8 mg of d-ALA·HCl which is equivalent to 10 mg of d-ALA via the Cahn Electrobalance using the 0 to 20 mg range. Dissolve this quantity in 100 ml of pH 4.7 acetate buffer solution.

One ml = 100 µg d-ALA

Working ALA solution. Ten ml of the stock solution are diluted to 100 ml with pH 4.7 acetate buffer solution.

One ml = 10 µg d-ALA.

Both solutions are stable for about a month if kept in dark and refrigerated.

9. Preparation of Disposable Chromatography Columns:

A 1.6 cm diameter glass fiber filter disc is placed at the bottom of an empty Tomac 10 cc disposable plastic syringe. A 5 ml portion of a slurry made of 1.5 g resin and 3.5 ml water is pipetted into each syringe. The resin is then topped with a second glass fiber disc to stabilize the resin bed. The result is a resin column which measures 1.0 cm in height and 1.6 cm in diameter equivalent to a resin volume of 2 ml.

V PROCEDURE

A. Separating d-ALA from Urine

1. Insert a dual disposable chromatographic column setup in tandem position in a support rack above a drain trough with the column containing the anionic resin (AG-1) on top and the column containing the cationic resin (AG 50 W) on the bottom. See Fig 1.
2. Wash the top column with 10 ml of distilled water and allow to drain through both columns into the drain trough.
3. Apply a 1.0 ml aliquot of urine at pH 5 to 7 to the top column and allow to drain through both columns into the drain trough.
4. Wash the top column twice with 4 ml of distilled water and allow to drain through both columns into the drain trough. See Fig 1,A.
5. Remove the top column and wash the bottom column three times with 10 ml of distilled water and allow to drain into the trough. Test for urea on a spot plate during the third wash with Ehrlich's reagent which gives a yellow color with urea. See Fig 1,B.
6. Remove the drain trough and place a 10 ml volumetric flask under the bottom column.
7. Elute the d-ALA from the bottom column with 7.0 ml of 1.0 M sodium acetate solution and collect in the 10 ml volumetric flask. See Fig 1,C.

B. Colorimetric Analysis of d-ALA

1. Add 0.2 ml of acetylacetone to the volumetric flask containing the 1.0 M sodium acetate eluate from the bottom cationic resin column.
2. Dilute to the 10.0 ml mark with pH 4.7 acetate buffer solution.
3. Place the volumetric flask in a boiling water bath for 10 minutes and cool to room temperature.

4. Take a 2.0 ml aliquot into a 10 ml Erlenmeyer flask and add 2.0 ml of modified Ehrlich-Hg reagent.
5. Read the absorbance at 553 m μ after 15 minutes using the 1 cm cells. The red color is stable for about 15 minutes after the 15 minutes developing time.

C. ALA Standards

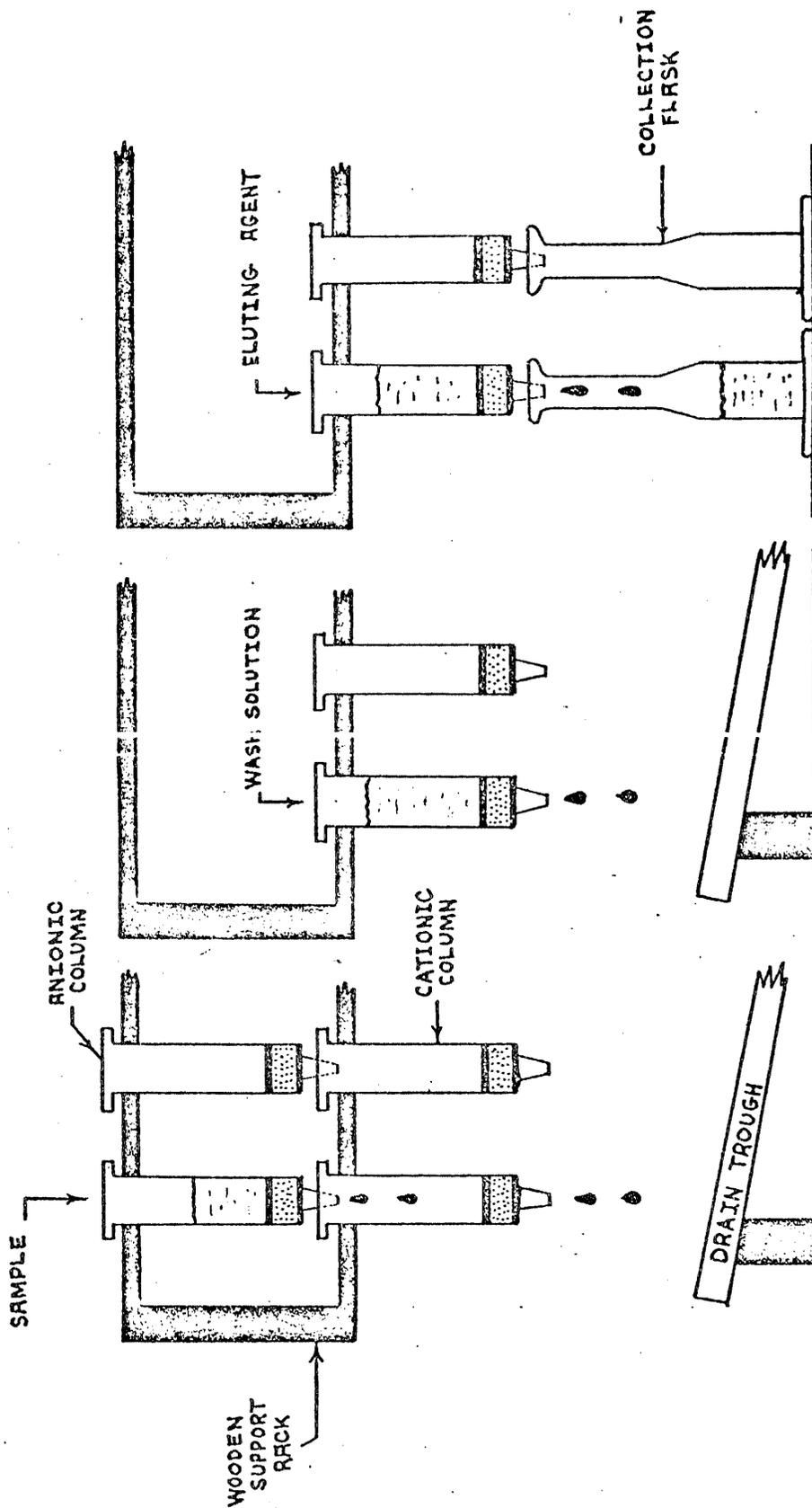
1. Add 0, 1, 3, 5, 10, 20 and 30 μ g of d-ALA respectively in 10 ml volumetric flasks.
2. Add sufficient distilled water to a volume of about 7 ml.
3. Follow the above procedure for the colorimetric analysis of ALA.
4. The zero standard is used as the photometer reference and the absorbance values are plotted against micrograms of d-ALA per ml of urine.

VI PRECISION, RECOVERY AND NORMAL VALUES

- A. The standard ALA curve obeys Beer's Law and is linear up to 50 μ g d-ALA per ml of urine. The average slope of the standard curve is 0.020 ± 0.001 .
- B. The limit of detection (absorbance of 0.01 for a 1 cm light path) in a 1 ml sample of urine is 0.5 μ g of d-ALA. The relative standard deviation between identical samples is less than 1%.
- C. Average recovery of d-ALA from spiked urine samples is $93 \pm 6\%$. This recovery efficiency is effective through the range of 1 μ g to 30 μ g of d-ALA per ml of urine.
- D. An average of 2.5 mg d-ALA is excreted per day by a normal individual. The upper limit of the normal range is about 5 mg d-ALA per day. In terms of mg% or mg of d-ALA per 100 ml of urine, the average value is 0.22 ± 0.16 mg/100 ml urine and the upper limit of the normal range is about 0.6 mg/100 ml of urine.

VII REFERENCES

1. Mauzerall, D. and Granick, S., "The Occurrence and Determination of Delta-Aminolevulinic Acid and Porphobilinogen in Urine". J. Biol. Chem. 219, 435-446 (1956).
2. Davis, Joseph R. and Andelman, Samuel L., "Urinary Delta-Aminolevulinic Acid Levels in Lead Poisoning. I. A Modified Method for the Rapid Determination of Urinary Delta-Aminolevulinic Acid Using Disposable Ion-exchange Chromatography Columns". Arch. Environ. Health 15, 53-59 (1967).

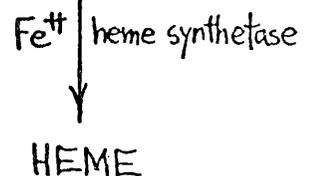
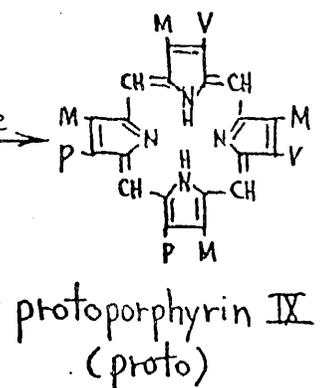
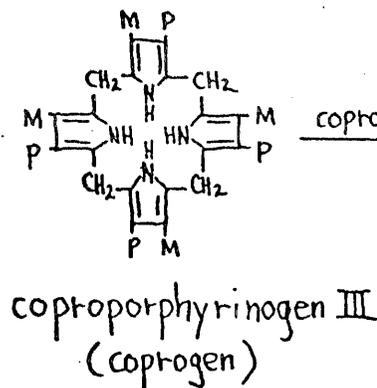
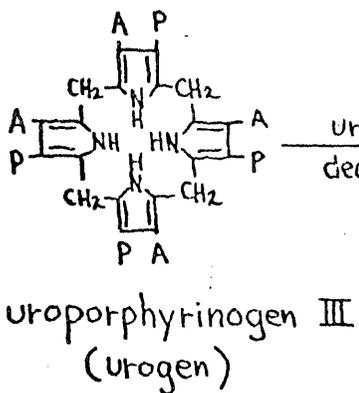
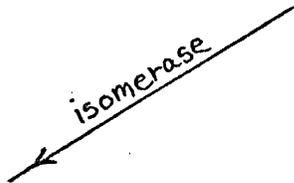
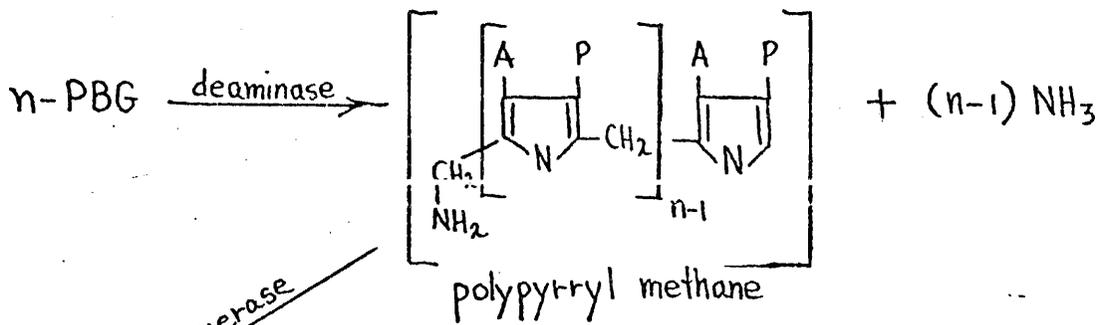
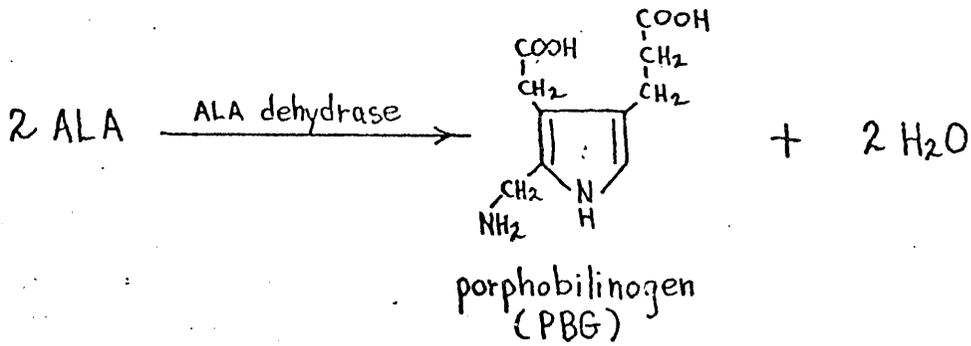
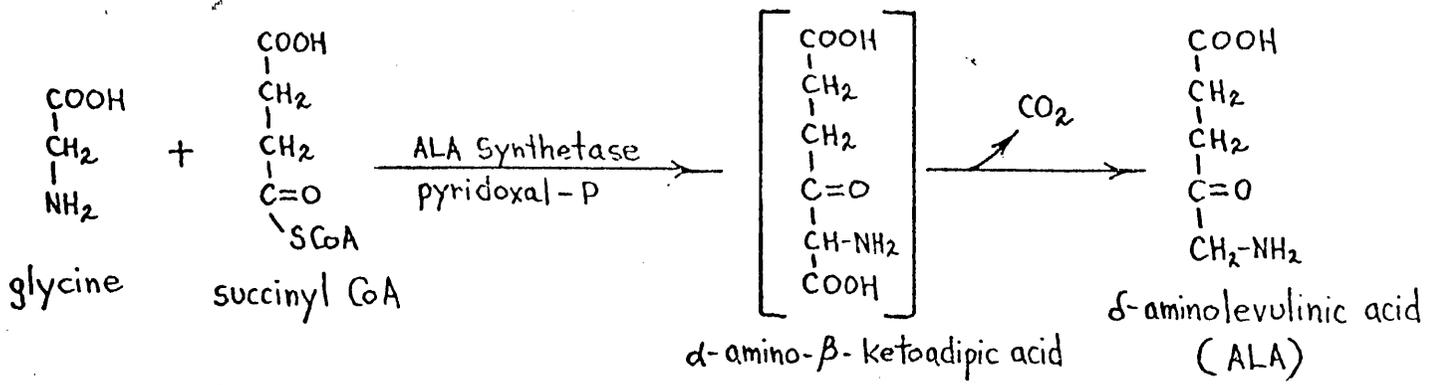


C

B

A

FIG 1. CHROMATOGRAPHIC SYSTEM FOR THE ISOLATION OF URINARY δ -ALA



ABBREVIATIONS	
M	= -CH ₃
V	= -CH=CH ₂
P	= -CH ₂ CH ₂ COOH
A	= -CH ₂ COOH

FIG. 2. BIOSYNTHESIS OF HEME

NORMAL HUMAN URINARY 3-AMINO LEVULINIC ACID (ALA) VALUES

REFERENCE	SAMPLE NUMBER	NORMAL URINARY 3-AMINO LEVULINIC ACID - CONC.	
		mg. ALA/100 ml. urine	mg. ALA/24 hrs.
MAZZERALL & GRANICK (1956)	10		\bar{x} 2.5
STITCH (1958)	20		m = 2.13 S.D. = 0.42
TISKOFF et al (1958)	7	m = 0.411 S.D. = 0.071	
HAEGER-ARONSEN (1960)	50 ♂ 50 ♀ 20-65 yrs.	m = 0.29 S.D. = 0.14	m = 1.52 S.D. = 0.59
GUTNIAK & KRANCZYK (1962)	-	0.33	
SAITA & MOREO (1964)	-		1.3 to 2.8
DE ZORZI (1964)	-	0.293 max.	
GATTNER (1965)	-	m = 0.290 S.D. = 0.14	2.1 to 4.0
BALBO et al (1965)	30 ♂	\bar{x} 0.235	
DJURIC et al (1966)	40	m = 0.453 S.D. = 0.254	
IDEL'SON (1966)	20 ♂ + ♀ 16-50 yrs.		0.52-2.5
DAVIS & ANDELMAN (1967)	100 children 9 mo. - 5 yrs.	m = 0.22 S.D. = 0.16	

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DELTA-AMINOLEVULINIC ACID

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DETERMINATION OF PARTICULATE LEAD

1. Principle and Applicability of Method
 - 1.1 Samples containing particulate lead are wet-ashed with nitric and perchloric acids. The resulting digestion mixture is diluted, filtered, and the lead determined by atomic absorption spectroscopy.
 - 1.2 The method is applicable to the determination of lead in airborne particulates, or any other sample matrix in which the $\text{HNO}_3\text{-HClO}_4$ digestion mixture completely dissolves lead, destroys any organic matter present, and allows lead to be quantitatively transferred from the diluted digestion mixture to a filtrate which can be analyzed by atomic absorption spectroscopy.
2. Range and Sensitivity
 - 2.1 The range and sensitivity depends upon the atomic absorption spectrophotometer used. For an instrument which follows Beer's Law for concentrations from $0.5 \mu\text{g/ml}$ to $50 \mu\text{g/ml}$, the range for lead is $25 \mu\text{g}$ to $2,500 \mu\text{g}$ in the aliquot taken for analysis. This is equivalent to a range of $0.05 \mu\text{g Pb/m}^3$ to $5 \mu\text{g Pb/m}^3$ based on the analysis of 25% of a $2,000 \text{ m}^3$ air sample. The upper end of the range may be extended by diluting the sample solution. The lower end of the range may be extended by sampling a greater air volume or taking a larger aliquot of the sample.
3. Interferences: None
4. Precision and Accuracy
 - 4.1 No data is available for high volume collection of particulate matter on cellulose filters. Particulate matter sampling, based on collaborative testing using a standard high volume collection method and glass fiber filters, gives a relative standard deviation (coefficient of variation) of 3.7% for multilaboratory variation, although sampling error in some cases may exceed $\pm 50\%$ (1).
 - 4.2 The mean recovery of $50 \mu\text{g}$ of lead (near the lower detectable limit for most atomic absorption spectrophotometers) on one-fourth sheet of TFA 810 filter paper is 101% with a relative standard deviation of 12%. The mean recovery of $500 \mu\text{g}$ of lead on one-fourth sheet of TFA 810 filter paper is 98% with a relative standard deviation of 0.80%.

* Prepared by staff of the Air and Industrial Hygiene Laboratory, State of California Department of Public Health, Berkeley, California, January 1973

5. Apparatus

- 5.1 Staplex TFA 810 filter paper or any other low blank filters which can be dissolved by the $\text{HNO}_3\text{-HClO}_4$ digestion, plus appropriate sampling equipment for collecting the particulate lead on the filter.
- 5.2 Atomic absorption spectrophotometer and associated equipment capable of analyzing lead in a perchloric acid solution.
- 5.3 Phillips beakers, 125 ml, and reflux-finger caps or watch glasses to be used as covers for the beakers. All glassware is Pyrex or equivalent quality, washed with detergent, rinsed, acid washed with 2N nitric acid and then rinsed with de-ionized water.
- 5.4 Plastic-tipped forceps
- 5.5 Stainless steel scissors

6. Reagents

- 6.1 De-ionized water
- 6.2 Nitric Acid: B&A, 70.0-71.0%, specific gravity 1.42
- 6.3 Dilute nitric acid (1 + 99): Prepared by adding 1 ml of nitric acid to 99 ml of de-ionized water.
- 6.4 Perchloric acid: J. T. Baker Analyzed Reagent, 70-72%, No. 9652
- 6.5 Lead nitrate (Crystal): J. T. Baker Analyzed Reagent, No. 2322

7. Procedure

- 7.1 Sample collection. Samples are collected on Staplex TFA 810 or other equivalent cellulose filter media by a standard high volume collection method (1)
- 7.2 Sample preparation
 - 7.2.1 One-fourth of an eight inch by ten inch filter containing the particulate sample is cut with stainless steel scissors and transferred with plastic-tipped forceps to a 125 ml Phillips beaker and 10 ml of nitric acid is added.
 - 7.2.2 A reagent blank is prepared by placing 10 ml of nitric acid in a Phillips beaker.
 - 7.2.3 Standards are prepared as prescribed in the procedure for calibration, paragraph 8.2.1. A set of standards is run with each set of samples.

- 7.2.4 Beakers containing the blank, standards and samples are covered with reflux-finger caps and heated gently on a hot plate until the filters partially dissolve (approximately one hour).
- 7.2.5 Beakers are removed from the hot plate and 5 ml of perchloric acid added to each. The reflux fingers are replaced and the contents of the beakers boiled gently until clear and fuming with copious vapors of perchloric acid. The ashing requires approximately 6 hours and is complete when the volume is 1 to 3 ml. WARNING. The digestion mixture is not allowed to go to dryness.
- 7.2.6 Approximately 15 ml of deionized water is added to the digestion mixture. The mixture is brought to a boil and filtered through a Whatman No. 541 filter paper into a 50 ml volumetric flask. Any remaining silica is washed with small portions of hot water and the washings passed through the filter. The filtrate is allowed to cool and then diluted to volume. The solution is now ready for atomic absorption analysis.

7.3 Atomic absorption analysis

- 7.3.1 The atomic absorption spectrophotometer is set up according to the manufacturer's recommendations for the determination of lead.
- 7.3.2 Deionized water is aspirated into the instrument and the baseline set. The reagent blank, standards, and samples are aspirated into the instrument and the absorbance for each solution recorded. The reagents are unsatisfactory if lead is detected in the reagent blank. If the instrument reads in percent absorption, the readings must be converted to absorbance.
- 7.3.3 Any sample reading outside the linear range of the instrument is diluted with dilute nitric acid and re-run.

8. Standards and Calibrations

8.1 Standard lead solutions

- 8.1.1 Stock standard, 1,000 $\mu\text{g Pb/ml}$. Exactly 1.5980 g of dry lead nitrate is dissolved in sufficient dilute nitric acid to make one liter of solution.
- 8.1.2 Working standard, 250 $\mu\text{g Pb/ml}$. This solution is prepared weekly by appropriate dilution of the stock standard with dilute nitric acid, and is used to prepare the calibration standards.

8.2 Calibration

- 8.2.1 A minimum of six standards are prepared to cover the range of the method. Into each of six Phillips beakers is placed a quarter of an unused filter. Lead from the working standard is pipetted into the beakers so that the total lead in each beaker is as indicated below, and sufficient dilute nitric acid is added to bring the total nitric acid in each beaker to 10 ml.

Beaker No.	Total Lead in Beaker μg	Equivalent Lead in Filtrate $\mu\text{g/ml}$
1	0	0
2	250	5
3	500	10
4	1000	20
5	1500	30
6	2500	50

- 8.2.2 The standards are taken through the procedure starting at paragraph 7.2.4 and a calibration line of absorbance versus concentration is fit by the least squares method from the absorbances obtained on the standards. A new calibration line is prepared for each set of determinations.

- 8.2.3 The equation of the calibration line is determined in the form:

$$A = a + b C_f$$

or

$$C_f = (A-a)/b$$

where

A = absorbance

a = intercept of calibration line

b = slope of calibration line

C_f = micrograms of lead per ml of solution

- 8.2.4 An alternate calibration procedure is given in the Appendix I.

9. Calculations

- 9.1 Particulate lead concentration, C, in micrograms per cubic meter of air is:

$$C = C_f \times \frac{50 \times 4}{V}$$

or

$$C = 200 C_f / V$$

where

50 = total volume of solution in ml

4 = factor for calculating lead on total filter

V = sample air volume in cubic meters

10. Effects of storage

10.1 Filter samples protected from contamination may be stored indefinitely.

11. References

1. Federal Register 36(84), Friday, April 30, 1971, Part II, Appendix B, Reference method for the determination of suspended particulates in the atmosphere (high-volume method).

APPENDIX I
Alternate Calibration Method

When the amount of lead in the reagent blank and filter blank (zero standard, paragraph 8.2.1) is below the limit of detection and there are no matrix effects, as is normally the case for the determination of airborne particulate lead by this method, an alternative method may be used to prepare the calibration line. A minimum of six standards are used to cover the range of the method. The dilute nitric acid solution serves as one standard. Five other lead in nitric acid standards are prepared by diluting the working standard with dilute nitric acid so that the final solutions contain 0, 5, 10, 20, 30 and 50 μg of lead per ml. These standards are aspirated into the atomic absorption spectrophotometer and the resulting absorbancies used to prepare the calibration line.

When the calibration line is prepared by this method, it is necessary to carry a filter blank and recovery standard through the procedure. The reagent blank is used to indicate lead contamination in the reagents, the filter blank to indicate lead contamination in the filter and the recovery standard to indicate any gross error in the procedure.

A statistical analysis was made on a calibration line prepared from standards made by the alternate method and one prepared from standards made as described in paragraph 8.2.1 where the standards are taken through the procedure. It was found that neither the slopes nor the intercepts of the two lines were different at the 95% level of significance.

APPENDIX II
Method of Standard Additions

Burnham, et al (Environ Sci Tech 3:5, 472-5, May 1969) and Hwang (Can Spectrosc 16:2, 43-5, 53, March 1971), observed matrix effects and found it necessary to use the method of standard additions when using atomic absorption to determine lead in air particulate samples. Thompson, et al (At Absorption Newslett 9:3, 53-7, May-June 1970), reduced matrix effects by diluting the sample.

In order to determine whether the standard additions technique gives significantly different results from the direct method, we chose a group of representative samples and determined lead by both methods. The data and a plot of direct versus standard additions method are given below:

<u>Filter No.</u>	<u>Location</u>	<u>Lead in Filtrate, $\mu\text{g/ml}$</u>	
		<u>Direct</u>	<u>Standard Additions</u>
3	Los Angeles	9.19	9.60
7	Los Angeles	4.43	5.26
15	Los Angeles	41.84	49.69
124	Los Angeles	108.29	107.65
405	Redding	3.05	3.17
793	Vallejo	5.40	5.94
861	San Luis Obispo	3.34	3.32
1023	Bakersfield	4.12	4.90
1066	Mariposa	1.06	0.85
1083	Merced	4.10	4.64
1102	Santa Barbara	8.59	8.28
1108	Sacramento	3.96	3.74
1263	Ukiah	3.70	3.88

A statistical analysis of the data shows the methods to be in close agreement. The correlation is high (Spearman's $\rho = 0.99$) and the Wilcoxon matched pair signed rank test indicates the distributions are not significantly different ($\rho = 0.16$).

The graph shows the linear relation between the direct and standard additions methods. The line best fitting the data is:

$$\text{Direct} = 0.98 \times \text{Standard addition}$$

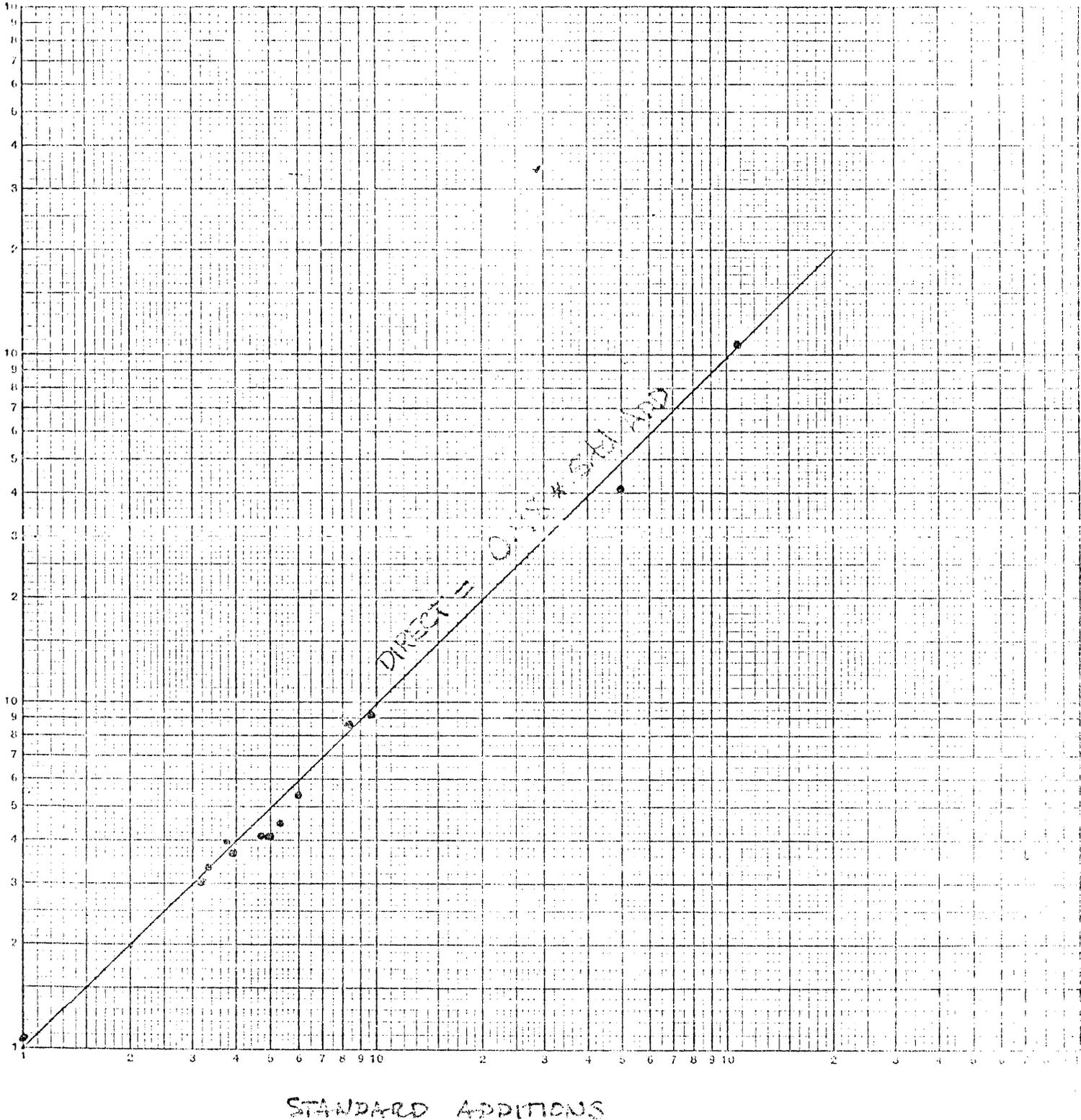
It is our conclusion that results obtained by the direct method is not sufficiently different from results obtained by the standard additions method to warrant analyzing samples by the standard additions method.

LEAD IN FILTRATE, $\mu\text{g}/\text{ml}$

BY TWO METHODS

DIRECT

MODEL LOGARITHMIC 467400
 3 X 3 CYCLES
 KEFFEL & ESSER CO.



DETERMINATION OF LEAD IN BIOLOGICAL FLUIDS, FOODSTUFFS
AND RELATED MATERIALS *

1.0 PRINCIPLE

- 1.1 The lead in solution is chelated with ammonium pyrrolidine dithio-carbamate at pH 8.5 and extracted into methyl isobutyl ketone for detection and analysis by atomic absorption spectroscopy (AAS).
- 1.2 This procedure may be applied to the analysis of lead in biological materials and foodstuffs after the sample has been dry or wet ashed.

2.0 SENSITIVITY AND RANGE

- 2.1 A working range of 0.2 μg - 12 μg /total sample is detected with a 10X scale expansion; whereas, a level of 100 μg /total sample is determined without scale expansion.

3.0 INTERFERENCES

- 3.1 Large quantities of bismuth cause a yellow precipitate in MIBK which is eliminated by determining lead directly, without chelating and extracting.
- 3.2 Large quantities of cadmium cause a white precipitate in MIBK. This is eliminated by using a smaller amount of sample.
- 3.3 Iron, zinc, and copper are masked by potassium cyanide.

4.0 PRECISION AND ACCURACY

4.1 Blood

The precision of the wet ash technique was assessed in two ways.

- 4.1.1 A unit of outdated blood was spiked with known quantities of lead. The results are presented in Table I. The coefficient of variation for the unspiked blood and for the blood + 15 μg Pb/100 g agree with that reported by Yeager for bloods in the same concentration range.

*Prepared by staff of the Air and Industrial Hygiene Laboratory, State of California Department of Public Health, Berkeley, March 1973.

4.1.2 Comparison of results with the dithizone method, AIHL Recommended Method No. 22.

The AAS method for determining blood in the concentration range of 10-20 $\mu\text{g}/100\text{ g}$ is more reproducible than the dithizone method. See Table II. Only one out of five replicate values in blood DR 293 fell within the detection limits of the dithizone method.

Table III lists the results obtained on individual specimens using the AAS and dithizone techniques.

4.2 Foodstuffs

The precision and accuracy of the dry ash technique was obtained by analyzing orchard leaves available from the National Bureau of Standards. In 44 observations, the mean lead value and one standard deviation was $43.3 \pm 4\ \mu\text{g}/\text{g}$. This value is substantiated by the NBS values obtained by other methods as indicated in Table IV. The nondestructive photon activation method is considered as the absolute method.

5.0 APPARATUS AND SPECIAL EQUIPMENT

- 5.1 Perkin-Elmer 306 Atomic Absorption Spectrophotometer equipped with a Perkin-Elmer Model 56 strip chart recorder to analyze the organic extracts.
- 5.2 Tipets to dispense the 5 ml of ammonium citrate buffer and 10 ml of digestion mixture.
- 5.3 Oxford pipettor or any automatic pipettor to dispense accurately 4 ml of water-saturated methyl isobutyl ketone.
- 5.4 Infrared heat lamp to pre-ash food samples.
- 5.5 Glazed silica (vitreosil) crucibles of 40 ml capacity for ashing foods.
- 5.6 Platinum crucibles of 50-100 ml capacity for ashing foods high in sugar or fat content.
- 5.7 Magnetic stirrer and stirring bar to prepare the ammonium citrate buffer.
- 5.8 Muffle furnace capable of attaining 450°C to ash the food samples.
- 5.9 Acid-washed glassware and sample containers for collection and analysis of samples.

6.0 REAGENTS

- 6.1 All reagents are of analytical grade and in the amounts used usually yielded 0.05 μg or less Pb/sample.

- 6.1.1 Ammonium Hydroxide, 28%-30%, Mallinckrodt
- 6.1.2 Ammonium Pyrrolidine dithiocarbamate, Fisher A-182
- 6.1.3 Acid, Citric, 98% min., Eastman Kodak, 588
- 6.1.4 Acid, Nitric, 70-71%, Baker and Adamson, 1120
- 6.1.5 Acid, Perchloric, 70-72%, Baker Analyzed, 9653
- 6.1.6 Acid, Sulfuric, 95.5-96.5%, Baker and Adamson, 1130
- 6.1.7 Lead Nitrate, Baker Analyzed, 2322
- 6.1.8 4-Methyl-2-pentanone (MIBK), Matheson, Coleman and Bell, 5617
- 6.1.9 Phenol Red, USP X 111, National Aniline Division, Allied Chemical, 317
- 6.1.10 Potassium Cyanide, Baker and Adamson, granular, 2107
- 6.1.11 Potassium Sulfate, Baker Analyzed Crystal, 3278
- 6.1.12 Chloroform, Baker Analyzed, 9180
- 6.1.13 Diphenylthiocarbazone (dithizone), Eastman Organic Chemicals, 3092
- 6.1.14 Sodium Hydroxide, Baker and Adamson, 2255

6.2 Working Reagents

6.2.1 Ammonium citrate buffer - pH 8.5

Use a teflon-covered magnetic stirring bar and Thermo-stir magnetic stirrer to dissolve 400 grams of citric acid in 100 ml distilled water and 400 ml of ammonium hydroxide. When cool, adjust to pH 8.5 with phenol red indicator (0.4% in 0.012 N NaOH). Dilute to 1 liter with distilled water. Purify by extracting with repeated portions of dithizone (16 mg/1 CHCl₃) in a 2-liter separatory funnel until the dithizone solution retains its original green color. Remove excess dithizone by repeated chloroform extractions.

6.2.2 Nitric acid - 1% w/v

Prepare a 1% solution 1:99 in deionized water.

6.2.3 Potassium cyanide - 10% w/v

Prepare a 10% w/v solution by dissolving 100 grams of KCN in a small amount of deionized water. Bring to a volume of 1 liter with deionized water. Keep refrigerated.

6.2.4 Ammonium pyrrolidine dithiocarbamate - 2% w/v

Prepare daily. Dissolve APDC in a small amount of deionized water and bring to volume.

6.2.5 4-Methyl-2-pentanone-(MIBK) - water saturated

Store the MIBK in a glass stopper bottle containing enough water to saturate it. Transfer the organic phase to the Oxford pipettor prior to delivery into the sample.

6.2.6 Lead Standards

Prepare a stock of 0.1598 gram of lead nitrate in 1% HNO₃ in a 100 ml volumetric flask. This yields a 1000 µg/ml solution. Prepare working solutions of 0.5, 1.0, 10 and 20 µg/ml by diluting with 1% nitric acid. Prepare the following total sample concentrations for constructing the standard curve: 0.0, 0.2, 0.5, 1, 2, 4, 8, and 12 µg per sample from the working solutions and 1% HNO₃. A standard containing 24 µg/sample is added to the curve when the sample analyzed exceeds 12 µg/sample.

6.2.7 Ashing aid - for dry ashing technique

Prepare a 25% solution of K₂SO₄ by dissolving 250 grams of K₂SO₄ in concentrated nitric acid. Allow two days for the K₂SO₄ to go into solution.

6.2.8 Digestion mixture - for wet ashing technique

15 parts concentrated nitric acid
5 parts concentrated perchloric acid
5 parts concentrated sulfuric acid

7.0 PROCEDURE

7.1 Sample Collection

7.1.1 Blood

Collect the blood in lead-free heparinized vacutainer tubes (BD L-3200XF313) using a vacutainer holder and Monoject 210 20GA x 1½" needles.

7.1.2 Urine

Collect spot specimens in acid-washed 250 ml tri-pour beakers. Transfer samples to the 4 oz acid-washed amber bottle containing 2.5 ml of 5N HCl. Keep samples cold during shipment to the laboratory.

7.1.3 Market Samples

Place each type of fresh produce and each package of meat in a plastic bag to prevent cross-contamination, and seal with a wire tie. Retain bottled, canned, dried and packaged items in their original containers. If travel time between the store and laboratory is greater than an hour, keep perishable items in an ice chest containing frozen refrigerant or bags of ice to minimize moisture loss in transit. Upon arrival at the laboratory, store these items in the refrigerator until they are processed for more permanent storage in a dried or frozen state. Process food within three days to maintain sample integrity and to minimize sample deterioration.

7.1.4 Garden Vegetables

Place each type of vegetable in a plastic bag and store in a cool ice chest enroute to the laboratory. Refrigerate until processed for dry storage.

7.1.5 Hospital Diets

Each hospital participating in the radiological survey submitted food samples representing 21 consecutive meals. These were ground to form a composite sample for shipment to the laboratory and were refrigerated until a portion was processed for dry storage.

7.2 Sample Preparation and Storage

7.2.1 Biological Fluids

Blood - Refrigerate until ready for analysis. At that time, empty the total content of a vacutainer tube into a tared Phillips beaker to obtain the amount used. Cover with a reflux finger cap. The sample size has a range from 5-15 grams.

Urine - Keep frozen until thawed in refrigerator prior to the day of analysis. Measure in an acid-washed graduated cylinder and record the volume, specific gravity, and temperature of the sample. Transfer the sample into a 125 ml Phillips beaker and cover with a reflux finger cap. A volume of 100 ml is desired in the normal population.

7.2.2 Foods

Produce and Processed Foods - Wash and dice produce specimens into smaller sections discarding non-edible portions (pits, cores, stems, rinds, etc.). Blend canned goods in their own juices. Thaw frozen vegetables. Cut bread into smaller pieces. Use at least 100 grams of each hospital diet sample. Place samples in tared beakers. Weigh and oven dry sample for at least 3 days at 170°F. (High carbohydrate containing foods require a longer drying time.) Allow the beaker and contents to cool to room temperature and reweigh to obtain the dry

weight. Break down sample physically with a lead-free mortar and pestle or a Spex mixer-mill to attain a more uniform and homogenous material. Store the ground material in Spex 11" by 3" plastic vials at room temperature (20°C - 24°C).

Meats - Debone and cut meats into smaller chunks for homogenization in a blender. Weigh and add water equivalent to 10% of the weight. Blend other less fibrous foods, shellfish, soups, organs, without any additional water. Retain approximately 100 ml of the blended mixture, store in the freezer at -15°C in 4 oz plastic vials.

Unprocessed Foods - Crush and portion out dried or other homogeneous foods before storage at room temperature in Spex plastic vials. These include grains, pasta, crackers, peanut butter, oils, sugar and related items, tomato by-products, dry dairy products, coffee grounds and tea leaves. Transfer approximately 100 ml of the following and store frozen in plastic vials: dairy products, luncheon meats, cat food, dog food, and beverages. Drain canned tuna and anchovy and store frozen.

7.3 Sample Analysis

7.3.1 Biological Fluids

Add ten ml of digestion mixture to all samples and reagent blank and allow to sit at room temperature until actively digested. When warmed on a hot plate, brown fumes of nitrogen oxides appear. Continue digestion until copious HClO₄ fumes are visible. At this point the digest is yellowish-white and approximately 2-3 ml in volume. (The digestion of urine requires 2-3 days, whereas blood is digested in 1 day.) Allow the beaker to cool to room temperature. Rinse the reflux finger cap with deionized water into the acid digest. Transfer the contents quantitatively into a 50 ml volumetric flask with deionized water and store until extracted into APDC and MIBK for detection and analysis by atomic absorption.

7.3.2 Foods

Dry ash foods in a muffle furnace in vitreosil silica dishes of 40 ml capacity or platinum dishes of 50-100 ml capacity. The quantity used for analysis depends on the nature of the food.

Use 1 to 10 grams of sample for foods kept in dry storage.

A homogenous 10-50 gram portion of the thawed samples may be used after dehydration in the oven at 75°C for a minimum of two days.

Analyze an orchard leaves sample as a standard reference material with each group of 17 samples.

Pre-ash all samples with 2 ml of ashing aid under an infrared lamp. For high fat- or high sugar-containing foods, char slowly in a platinum crucible on a hot plate. Cover crucible with a watch glass during this

process. When completely charred, small amounts of concentrated HNO_3 (~ 0.5 ml) is added to release the CO_2 . This is continued until little CO_2 or foaming is produced.

When pre-ashing is completed, the crucible is placed in a 180°C furnace. The temperature is raised at 50°C intervals every 15 minutes until a temperature of 450°C is reached.

Ash samples for 3 hours. When the residue is cool, 2 ml of concentrated HNO_3 is run down the sides of the crucible to wet the ash. Dry the sample under the infrared lamp before returning it to the muffle for a second time. Raise the temperature 100°C every 15 minutes until 450°C is attained. Continue the ashing for 3 hours. This treatment is usually sufficient to oxidize all organic materials in produce and low protein foods.

Most meat and protein-like foods require a third ashing period before the black specks of carbon are no longer present. The ashes are of varying shades of color due to the presence of other minerals.

Transfer the ash quantitatively into a 50 ml volumetric flask by warming a 2 ml portion of concentrated HNO_3 in the crucible. Use a stirring rod to loosen the residue and rinse with deionized water. Use two additional acid rinses of 1.5 and 1 ml. High concentrations of calcium and phosphorus cause difficulty in the transfer of the sample. This is resolved by further acid rinses. Store the digest and solution in the volumetric flask until it is extracted with APDC and MIBK for atomic absorption detection and analysis.

7.4 Atomic Absorption Determination

Start standards and reagent blank here. Add 2 drops phenol red to samples, 5 ml of ammonium citrate buffer with tipet dispenser and NH_4OH dropwise until a red color is obtained (purplish if iron is present). Add 1 ml of 10% w/v KCN, 1 ml APDC reagent, followed by 4 ml water-saturated MIBK solution dispensed with the Oxford pipettor. Stopper the flask and shake vigorously for 30 seconds. Add deionized water to bring the MIBK layer to the neck of the flask. Let stand for a few minutes and analyze the organic phase at 2833 nm using a scale expansion of 10X and an integration time of 10 seconds. The resulting absorbances are recorded on the strip chart of Perkin-Elmer model 56 recorder. If the total concentration of the sample exceeds $12 \mu\text{g}$, a scale expansion of 1X, with a 2-second integration, is used on the remainder of the extract. Using the manufacturer's guidelines, the flowmeter for air pressure is set at 10 and the acetylene flow at 5. Aspirate the aqueous saturated MIBK to establish a base line on the recorder strip chart. Analyze the reagent blank, the standards, and samples. Run a set of standards for every 18 samples.

8.0 CALIBRATION

Prepare a working curve from standards containing $0.0 \mu\text{g}$ - $12 \mu\text{g}$ in the total sample. Construct a curve by using the least square method. The curve for the extracted lead standards is linear up to at least $24 \mu\text{g}/\text{sample}$.

9.0 CALCULATION

Subtract the lead concentration in the reagent blank from the lead concentration in the sample. Calculate the concentration by using the slope and intercept obtained from the standard curve as follows:

$$\text{concentration in blank} = \frac{\text{reagent blank absorption} - \text{intercept}}{\text{slope}}$$

$$\text{concentration in sample} = \frac{\text{sample absorption} - \text{intercept}}{\text{slope}}$$

9.1 Biologicals

$$\text{Urine } \mu\text{g}/100 \text{ ml} = \frac{(\text{conc. in sample} - \text{conc. in blank}) \times 100}{\text{volume used}}$$

$$\text{Blood } \mu\text{g}/100 \text{ g} = \frac{(\text{conc. in sample} - \text{conc. in blank}) \times 100}{\text{amount used g}}$$

9.2 Food

$$\text{concentration } \mu\text{g}/\text{g as purchased} = \frac{\text{conc. in sample} - \text{conc. in blank}}{\text{amount used g} \frac{(\text{wet wt g})}{(\text{dry wt g})}}$$

10.0 REFERENCE

Yeager, D.W., J. Cholak and E. W. Henderson. Determination of lead in biological and related material by atomic absorption spectrophotometry. *Envr Sci & Tech* 5:1020, 1971

VL:ibnl-8

TABLE I

Analysis of Replicate Samples of Outdated Spiked and Unspiked Blood

	<u>Blood $\mu\text{g Pb}/100 \text{ g}$</u>	<u>Blood + 15 $\mu\text{g Pb}/100 \text{ g}$</u>	<u>Blood + 30 $\mu\text{g Pb}/100 \text{ g}$</u>
	18.6	32.8	48.7
	19.6	33.3	47.5
	19.3	32.6	49.2
	17.8	33.4	49.3
	19.2	30.9	47.8
Mean	18.9	32.6	48.5
S.D.	± 0.731	± 1.07	± 0.841
C.V.	3.7%	3.1%	1.7%

TABLE II

Analysis of Replicate Blood Samples by AAS and Dithizone

	<u>Blood DR 293</u> <u>$\mu\text{g Pb}/100 \text{ g}$</u>		<u>Blood DR 300</u> <u>$\mu\text{g Pb}/100 \text{ g}$</u>	
	<u>AAS</u>	<u>Dithizone</u>	<u>AAS</u>	<u>Dithizone</u>
	8.7	12.7	16.8	13.5
	9.9	3.9*	17.5	15.4
	7.7	6.5*	15.9	17.6
	11.6	2.2*	17.4	9.9
	8.5	6.5*	18.5	15.8
Mean	9.3	6.4	17.2	14.4
S.D.	± 1.5	± 4.0	± 1.0	± 2.9
C.V.	16.0%	62.0%	5.1%	20.1%

* Below detection limit of 1 $\mu\text{g Pb}/100 \text{ g}$

TABLE III

Comparison of Results on Specimens Analyzed by AAS and Dithizone

<u>Sample</u>	<u>AAS $\mu\text{g Pb}/100\text{ g}$</u>	<u>Dithizone $\mu\text{g Pb}/100\text{ g}$</u>
1	7	13
2	19	16
3	10	14
4	14	13
5	29	28

TABLE IV

Comparison of NBS Orchard Leaves
Analysis by Different Methods

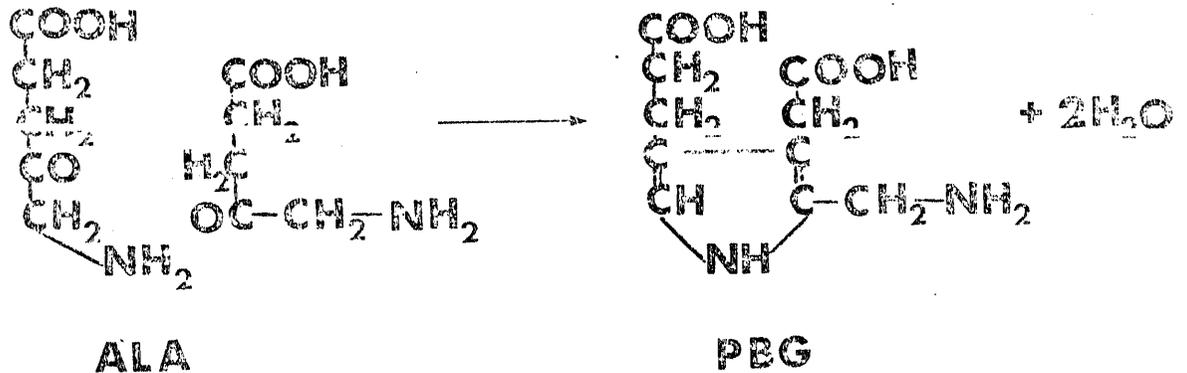
Analytical Method	Mean $\mu\text{gPb/g}$	S.D. $\mu\text{Pb/g}$	C.V. %
AAS (This method)	43.3	± 4.0	9.2
Photon Activation	45	± 2	4.4
Polarography ^a	44.6	± 1.8	4.0
Polarography ^b	44.0	± 3.8	8.6
Isotope Dilution - Spark Source Mass Spectrometry	43.0	± 4	9.3

^a Digested in HCl, HNO₃, HClO₄^b Digested in HCl, HNO₃, HClO₄, HF

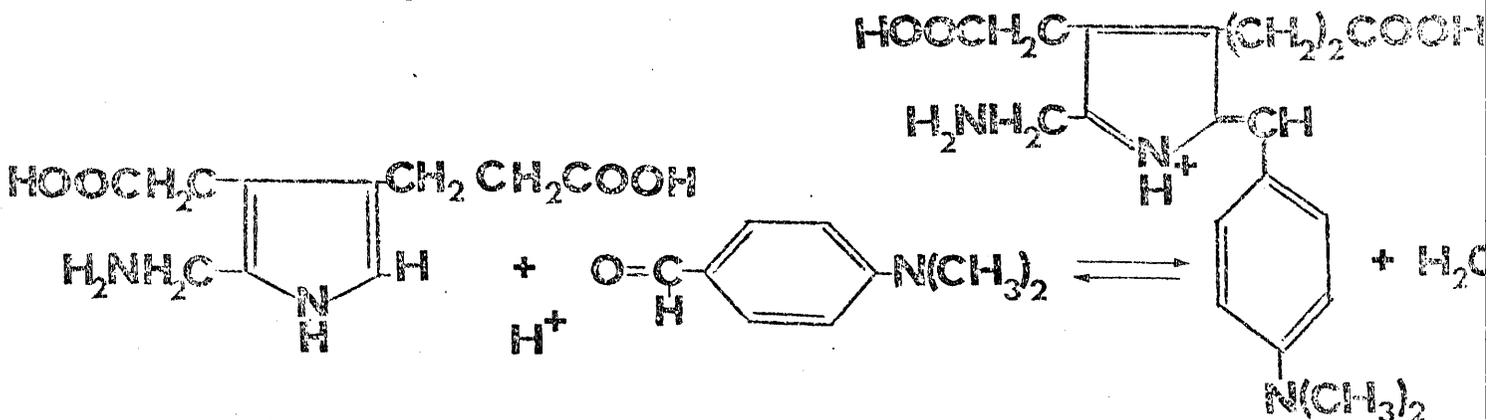
METHOD
 δ -AMINOLEVULINIC DEHYDRATASE (ALAD) IN BLOOD*

Method for the determination of δ -aminolevulinic acid dehydratase (ALAD), based on the method of Bonsignore, D., Calissano, P. and Cartasegna, C., Med. Lavoro, 56, 199 (1965).

Principle. The method is based on the formation of porphobilinogen (PBG) from δ -aminolevulinic acid under influence of ALAD in blood. Two molecules of ALA combine into the ring structure of porphobilinogen (PBG) with the loss of two molecules of water:



The resulting PBG is determined by production of a red color with p-dimethylamino-benzaldehyde (modified Ehrlich's reagent), which is then read in a spectrophotometer at 553 nm.



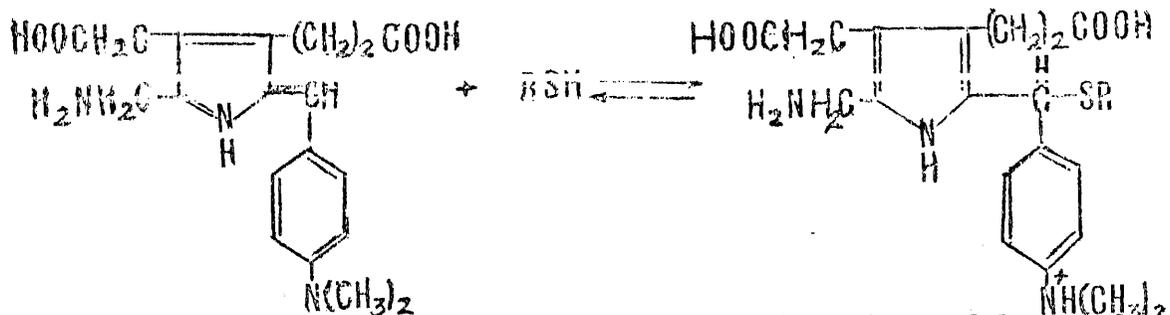
*Prepared by staff of the Air and Industrial Hygiene Laboratory, State of California Department of Public Health, Berkeley, June 1971.

Reagents. All water should be lead free (deionized) and all glassware must be also lead free (prewashed with dilute nitric acid followed by a wash with deionized water).

1. δ -aminolevulinic acid HCl (ALA) 0.01 M - 0.0419 g/25 ml
(MW 167.59, available J. T. Baker, Cal Biochem., Fluka Chem. Co.)
Final pH should be adjusted to 6.7 with 1% NaHCO_3 .

This solution should be prepared fresh daily.

2. Trichloroacetic acid (TCA) 10% which contains 0.1 M HgCl_2 , 10 g TCA/100 ml and 2.715 g HgCl_2 /100 ml. The function of Hg^{++} is to bind thiol groups which decolorize the red Ehrlich color compound:



Slight precipitation standing does not affect the usefulness of this reagent.

3. Modified Ehrlich reagent, 2% p-dimethylamino-benzaldehyde in HAC and HClO_4 mixture: 1 g p-dimethylamino-benzaldehyde is dissolved in 30 ml of glacial acetic acid; then 16 ml of HClO_4 is added and makes to final volume of 50 cc with glacial acetic acid. This solution must be prepared fresh daily.

Procedure. Collect blood in heparinized, lead-free containers (vacu-tainers). Analyze as soon as possible after drawing (within 30 min.). During the time prior to analysis, samples must be refrigerated at 0°C or held in ice water.

Measure exactly 0.40 ml blood into 2.60 ml D.I. water in a 15 ml test tube and add 2.0 ml ALA solution.

Transfer 2.0 ml to a 15 ml centrifuge tube (Blank tube) which contains 2.0 ml TCA solution. Immediately another 2.0 ml is transferred to another centrifuge tube (Reaction tube) without TCA solution. Incubate both tubes for 1 hour at 37°C. (TCA blocks the enzyme reaction in the blank tube, while the enzyme-ALA reaction proceeds in the reaction tube.)

During this period, the hematocrit value of the sample blood is determined by the standard method (1). After the incubation, add 2.0 ml TCA mixture to the reaction tube. (This prevents the reaction from proceeding further.)

Both tubes are now centrifuged 10 minutes at 10,000 gravities. In order to remove floating materials, it may be necessary to transfer the liquid to smaller tubes and recentrifuge 15 minutes at 500 gravities. The final solution must be completely clear. (Suspended matter gives high results.)

From each of the two tubes, transfer 2.0 ml of the clear supernatant liquid to two 15 ml test tubes. To each add 2.0 ml modified Ehrlich reagent. Shake well and let stand 3 minutes. Read immediately in a

spectrophotometer at 553 nm (after 5 minutes the color begins to bleach). The spectrophotometer should be zeroed versus the blank tube. The net reading is then the absorbance of the reaction tube.

Calculation. ALAD activity units are defined as the difference in absorbance in a 1 cm cell between the reaction tube and the blank tube, corrected for the sample dilution and the percent hematocrit:

$$\frac{(A_R - A_B) \times \frac{5 \text{ ml}}{0.4 \text{ ml}} (\text{dilution factor}) \times 1,000}{\% \text{ hematocrit}} = \text{enzyme units per ml erythrocytes}$$

- 1) Maxwell M. Wintrobe: Clinical Hematology, pp. 413-418, 6th Edition, Lea L. Febiger, Philadelphia 1967.

DPM:dk1-4

EVALUATION OF LABORATORY METHODS FOR LEAD IN BLOOD

AIHL REPORT NO. 161

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EVALUATION OF LABORATORY METHODS FOR LEAD IN BLOOD

ABSTRACT

Two Delves Cup techniques are compared to the methyl isobutyl ketone (MIBK) extraction procedure. The Delves Cup Ratio determinations, adjusted by a proportionality factor, were found to be equivalent to MIBK determinations. Unacceptably high variability was observed in the Delves Cup Standard additions determinations. Thus, this technique cannot be considered equivalent to MIBK.

INTRODUCTION

AIHL currently has the capability to determine blood lead levels by several atomic absorption methods. These include the MIBK (methyl isobutyl ketone) extraction procedure, the Delves Cup Ratio method, and the Delves Cup Standard Additions technique.

MIBK extraction is the reference method. As the ratio and standard additions methods are less time consuming, a study was undertaken to determine if these two methods were equivalent to the MIBK extraction procedure.

ANALYTICAL METHODS

Samples analyzed by MIBK Extraction¹ are wet-ashed with a mixture of nitric, perchloric and sulfuric acids. Lead is chelated with ammonium pyrrolidine dithiocarbamate (APDC) at pH 8.5, extracted in MIBK, aspirated into the burner of an atomic absorption spectrophotometer and the lead determined by comparing the absorbance of the sample to the absorbance of lead standards analyzed in the same manner.

When using the Delves Cup technique², a number of standardization procedures can be used. Two common ones are the Delves Cup Ratio method³ and the Delves Cup Standard Additions method³. For the Delves Cup Ratio method, one 10 μ l sample of heparinized blood is pipetted into a nickel crucible and 10 μ l of standard blood with known lead content is pipetted into another nickel crucible. The blood in the crucible is partially oxidized with hydrogen peroxide, the crucible inserted into the burner flame of the atomic absorption spectrophotometer and the absorbance of each blood recorded. The lead content of the sample is calculated by comparing the absorbance of the sample blood with that of the standard blood. For the Delves Cup Standard Additions method, standardization is accomplished by addition of known concentrations of lead to aliquots of blood samples.

STUDY DESIGN

Blood was obtained from the Alameda County Blood Bank. Five samples were analyzed by the reference method, MIBK, another set of five by the ratio method, and a third set of five by standard additions. Three more sets of five were spiked with 15 $\mu\text{g Pb}/100\text{g}$ blood and run by the three methods to compare results at the upper limit of normality. Three more sets were spiked with 30 $\mu\text{g Pb}/100\text{g}$. The results of these analyses are shown in Table I.

RESULTS, MIBK vs STANDARD ADDITIONS

The comparison between the standard additions and MIBK results are shown in Figure 1. Considerable variability in the standard additions data is evident. The precision is poor with the coefficient of variation ranging from 41% in the unspiked blood to 15% in the spiked sample determinations. Although statistically there are no differences in the means of the determinations ($\alpha = 0.2$ and 0.3 by the Wilcoxon two sample test), the high variability in the standard additions method is unacceptable and the method cannot at this time be considered equivalent to MIBK.

RESULTS, MIBK vs RATIO

In Figure 2, is plotted the MIBK - ratio comparison. The precision of the ratio method is acceptable. The coefficient of variation is 6% at the lower levels and 4% at the highest level (blood spiked with 30 $\mu\text{g Pb}/100\text{g}$). The ratio method however, yielded results consistently lower than the MIBK method.

For the ratio method to be equivalent to MIBK, a proportionality factor must be applied to adjust the ratio determinations. In order to adjust ratio determinations for blood in the normal range a least squares line was fitted to the blood and blood plus 15 $\mu\text{g}/100\text{g}$ data. The line so determined is show in Figure 2:

$$\text{Ratio} = -3.1 \mu\text{g}/100\text{g} + 0.97 \times \text{MIBK}$$

when this equation is used to relate the ratio to the MIBK determinations the MIBK levels can be estimated within a close range. Typical confidence intervals for these estimates are shown in Table II. At each level, the 95% confidence interval for the MIBK estimate is within 1 $\mu\text{g Pb}/100\text{g}$.

ADJUSTING THE RATIO DETERMINATIONS

Based on the least squares line, the factor by which the ratio determinations must be adjusted is:

$$f = \frac{\text{ratio} + 3.1 \text{ } \mu\text{g}/100\text{g}}{0.97}$$

Prior to this evaluation, eight blood specimens had been analyzed by AIHL using both the ratio and MIBK methods. As in the laboratory evaluation, the ratio results tended to be lower than MIBK. The original and adjusted ratio results are listed in Table III. Adjusting by the proportionality factor brings the ratio results more in line with the MIBK determinations. (See Figure 3)

CONCLUSIONS

The ratio method, when determinations are adjusted by the appropriate proportionality factor, is equivalent to MIBK. Although standard additions yields average results close to MIBK averages, precision is poor for standard additions determinations in the normal blood lead range.

RECOMMENDATION

Use of the Delves Cup Ratio Method is acceptable. However, it is necessary that we routinely adjust the ratio determination as described above. Because the ratio method is based on a standard blood, the proportionality factor may vary as a new standard blood is employed. The adjustment may then be specific for a given set of data. For each series of results to be adjusted, a subsample of the analyses could be re-run by MIBK. The ratio - MIBK comparison would determine the proportionality factor for that set of results.

REFERENCES

1. Yeager DW, Cholak J, Henderson EW: Determination of lead in biological and related material by atomic absorption spectrophotometry. *Env Sci Tech* 5:10, 1020-1022, October 1971
2. Delves HT: A micro-sampling method for the rapid determination of lead in blood by atomic absorption spectrophotometry. *Analyst* 95:431-438, May 1970
3. Fernandez FJ, Kahn HL: The determination of lead in whole blood by atomic absorption spectrophotometry with the "Delves Sampling Cup" technique. *Atomic Absorption Newsletter* 10:1, 1-5, Jan-Feb 1971

TABLE I
BLOOD LEAD DETERMINATIONS BY THREE METHODS

	<u>MIBK</u> <u>μg/100 g</u>	<u>Standard</u> <u>Additions</u> <u>μg/100 g</u>	<u>Ratio</u> <u>Method</u> <u>μg/100 g</u>
DELVES CUP			
<u>Blood</u>	18.57	35.3	16.0
	19.58	22.9	16.0
	19.27	23.5	15.5
	17.75	12.2	14.7
	<u>19.23</u>	<u>15.1</u>	<u>13.7</u>
Mean	18.88	21.80	15.18
Coeff. of variation	4%	41%	6%
<u>Blood +</u> <u>15 μg Pb</u>	32.79	39.2	29.0
	33.33	31.8	28.0
	32.60	43.1	27.7
	33.39	39.8	31.2
	<u>30.91</u>	<u>30.4</u>	<u>26.6</u>
Mean	32.60	36.86	28.50
Coeff. of variation	3%	15%	6%
<u>Blood +</u> <u>30 μg Pb</u>	48.70	46.5	39.6
	47.46	41.9	39.1
	49.20	45.2	41.8
	49.31	49.3	39.1
	<u>47.75</u>	<u>60.7</u>	<u>42.3</u>
Mean	48.48	48.72	40.38
Coeff. of variation	2%	15%	4%

TABLE II

95% CONFIDENCE INTERVAL FOR MIBK LEVELS
 ESTIMATED FROM THE RATIO METHOD DETERMINATION

$$\text{RATIO} = - 3.1 \mu\text{g}/100 \text{ g} + 0.97 \times \text{MIBK}$$

	<u>Ratio Determination</u> $\mu\text{g}/100 \text{ g}$	<u>Estimated MIBK</u> $\mu\text{g}/100 \text{ g}$	<u>95% Conf. Intv. on MIBK Estimate</u> $\mu\text{g}/100 \text{ g}$
Concentration	15	18.7	(17.7, 19.6)
	20	23.8	(23.6, 24.1)
	30	34.1	(33.0, 35.3)

TABLE III
 RATIO METHOD DETERMINATIONS
 ADJUSTED BY THE PROPORTIONALITY FACTOR

$$f = \frac{\text{RATIO} + 3.1 \mu\text{g}/100 \text{ g}}{0.97}$$

	<u>MIBK</u> <u>μg/100 g</u>	<u>Ratio</u> <u>μg/100 g</u>	<u>Ratio Adjusted</u> <u>μg/100 g</u>
	16	13	17
	16	12	16
	10	12	16
	11	9	12
	12	10	14
	11	9	12
	18	14	18
	11	9	12
	<hr/>	<hr/>	<hr/>
Mean	13.1	11.0	14.6

Figure 1

LEAD IN BLOOD DETERMINATIONS
BY THE STANDARD ADDITIONS AND MIBK METHODS

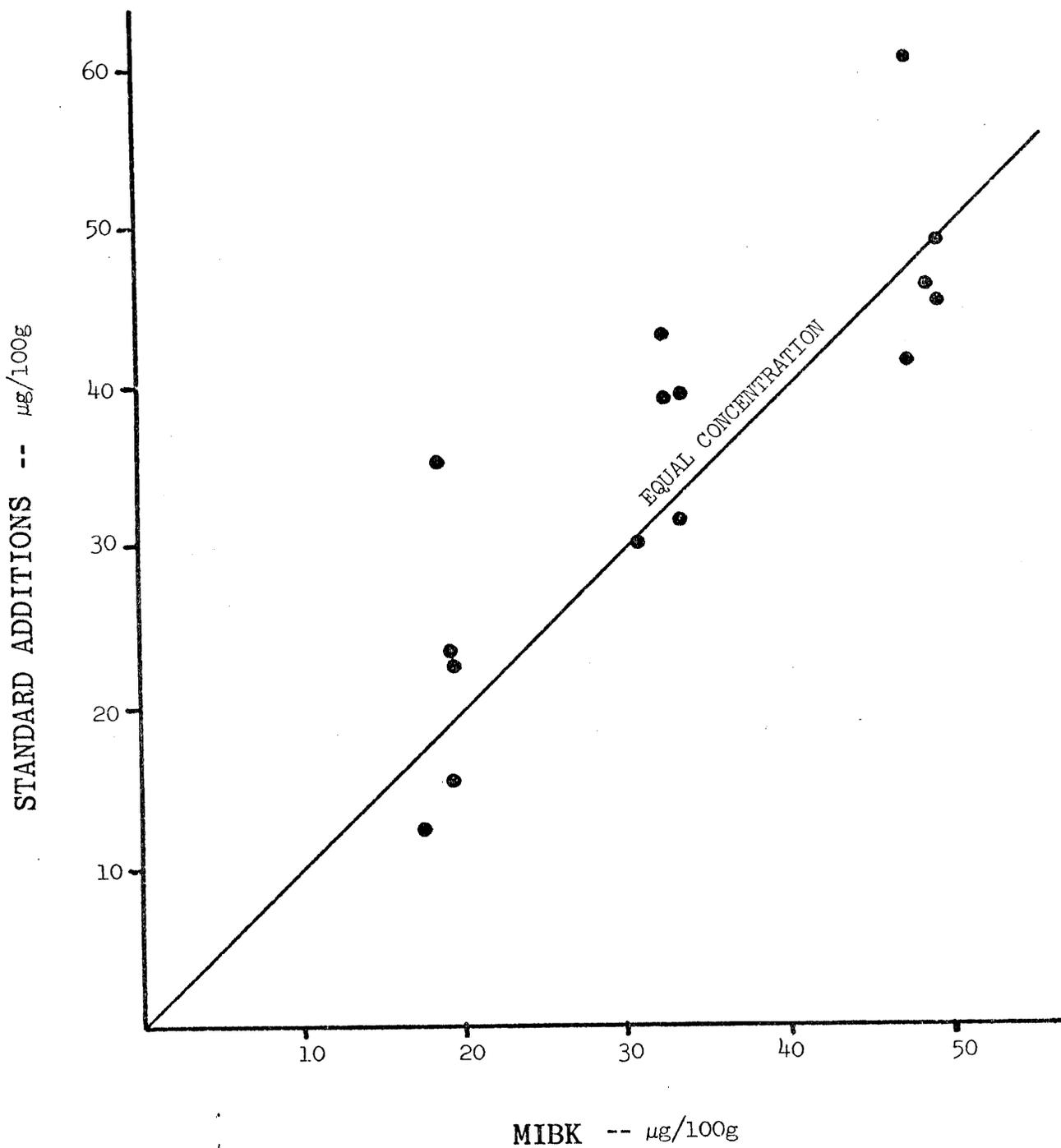


Figure 2

LEAD IN BLOOD DETERMINATIONS
BY THE RATIO AND MIBK METHODS

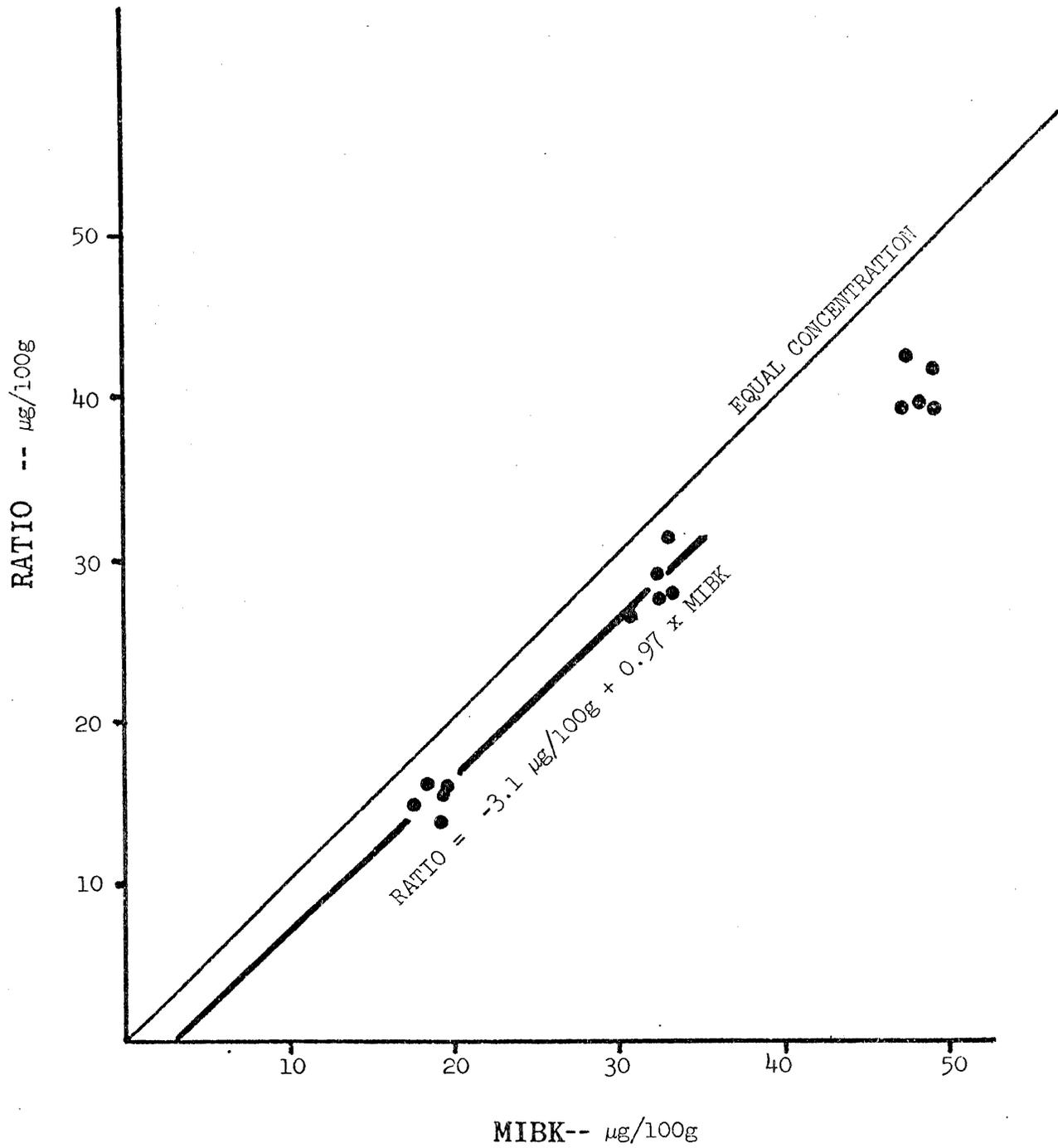
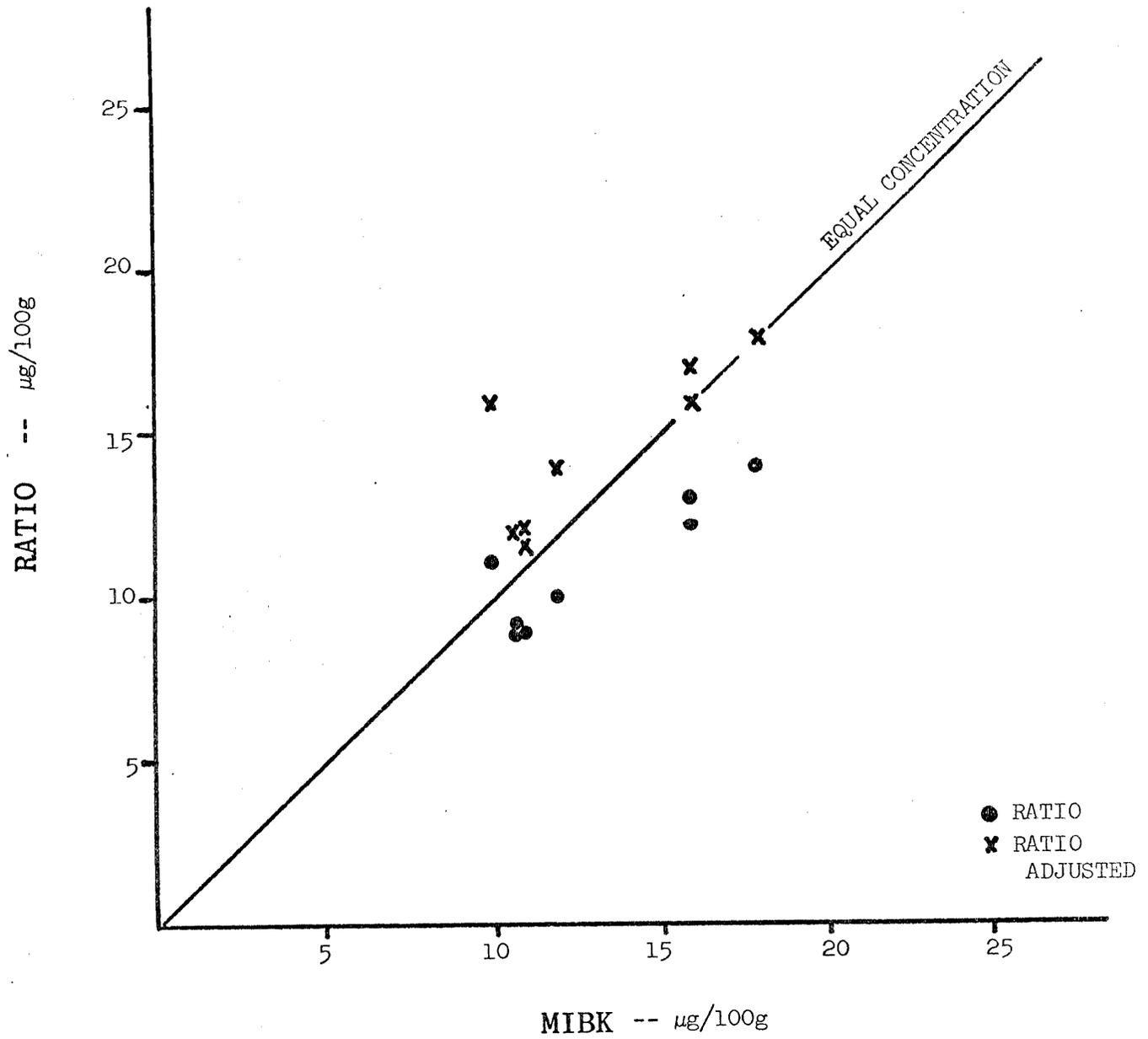


Figure 3
LEAD DETERMINATIONS BY THE RATIO METHOD
BEFORE AND AFTER ADJUSTMENT, COMPARED TO MIBK



δ -Aminolevulinic Acid Dehydratase (ALAD) Stability in Human Blood

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The determination of δ -aminolevulinic acid dehydratase in blood appears to be a useful test for diagnosing the effect of exposure to inorganic lead compounds. When applying this test in epidemiological studies, allowable boundaries concerning the time interval and storage temperature between collection of the blood and the actual enzyme assay become important design criteria. These have been evaluated and established.

SINCE THE DETERMINATION OF δ -aminolevulinic acid dehydratase (ALAD) in blood became a useful test in the diagnosis of lead exposure in people,¹⁻¹¹ only the papers published since 1970 have mentioned the elapsed time between the collection of blood and the ALAD assay itself. Hernberg *et al.*¹¹ did all their ALAD determinations within 3 hours, and they found no significant change in the ALAD activity during 5 hours of storage at 3°, 25°, or 30°C. Miller *et al.*⁶ performed all ALAD analyses within 1 hour, while Weissberg *et al.*⁹ analyzed blood samples for ALAD within 24 hours of the time of collection.

In field work, the blood is usually collected far from the place of analysis. Therefore, it is important to know how long the enzyme is stable and within what period of time the analysis has to be performed without losing a significant amount of activity. Nikkanen *et al.*¹² recently described the loss of activity during storage at 5°C over periods of 1 to 7 days. Especially in bloods from occupationally exposed sub-

jects, the loss of activity was quite unpredictable. We have now obtained data to determine what latitudes in specimen handling are permissible within 24 hours of storage and at temperatures between 1° and 37°C.

Materials and Methods

Experiments were done on human blood obtained from ten volunteers (five males and five females) with no history of occupational lead exposure. The ALAD was determined according to the method of Bonsignore *et al.*⁷ at pH 6.7. The original method was applied, and the only change was in the volume of reagents, which was increased to twice the original amount. The activity of ALAD was expressed in units, one unit being defined as the difference in absorbance in matched 1-cm cells between the reacted specimen and the blank tube, corrected for the sample dilution and the percent of hematocrit. The hematocrit was determined in duplicate.

The blood of each donor (collected in two 10-cc vacutainer heparinized lead-free tubes) was divided into twelve equal volumes of 1.2 cc within 15 minutes of collection. The tubes were covered with parafilm and divided into two sets of six. One series was kept at 1°C (Dewar flask surrounded with

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ice), and the second series was kept at 25°C (room temperature). About 5 minutes after both tubes of blood were collected, the activity of ALAD was determined, and the result of this analysis provided the value at "zero" time. Samples from the two sets were analyzed for ALAD on 0.4 cc of blood at 2, 4, 6, 8, 10, and 24 hours after the blood drawing.

The variability of the ALAD method was determined on one blood sample from donor D.M. Eight ALAD tests run simultaneously by two analysts yielded a range of 176 to

184 units with a mean of 181. Sums of squares were pooled to estimate the standard deviation, 2.45 units. The coefficient of variation for these analyses is 1.4%, with 95% confidence interval covering the range 0.8 to 2.0%. The variability attributed to the method is therefore considered to be within $\pm 2\%$.

Specimen Storage

The results obtained after storage at 1° and 25°C are presented in Table I. Individual ALAD values and the group means are

TABLE I
ALAD Stability in Human Blood

Subjects	ALAD Activity (units)						
	Time Elapsed between Blood Drawing and Analysis (hours)						
	0	2	4	6	8	10	24
	Temperature = 1°C						
C.N.	104	95	90	87	89	91	89
B.A.	152	145	144	142	140	136	137 ^a
L.S.	88	79	79	76	76	76	73
B.H.	123	123	121	117	118	115	111
H.M.	199	199	184	186	180	174	185 ^a
P.M.	105	107	97	95	90	88	91
E.I.	118	110	105	104	109	129	117
D.M.	171	168	170	167	170	162	152
M.D.	171	164	160	175	170	168	163
A.A.	123	122	117	109	116	101	117 ^a
Group mean	135.4	131.2	126.7	125.8	125.8	124.0	123.5
Significance ^b of decrease from initial value	$p =$	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Temperature = 25°C						
C.N.	104	98	90	88	81	83	85
B.A.	152	146	142	134	141	137	134
L.S.	88	78	77	75	72	73	64
B.H.	123	116	120	117	115	111	99
H.M.	199	199	177	183	197	171	174
P.M.	105	106	97	94	84	91	86
E.I.	118	117	110	99	110	111	101
D.M.	171	177	168	177	175	159	153
M.D.	171	161	170	167	162	168	166
A.A.	123	127	115	117	119	109	110
Group mean	135.4	132.5	126.6	125.1	125.6	121.3	117.2
Significance ^b of decrease from initial value	$p =$	0.06	<0.01	<0.01	<0.01	<0.01	<0.01

^aThe sample was partly hemolyzed.

^bWilcoxon signed rank test.

shown. It is clear from these data that there is a significant decrease in activity at either storage temperature within 4 hours. Preliminary experiments included stability tests at 37°C. The activity decreased so rapidly that a storage temperature of 25°C should never be exceeded. Samples cannot be preserved in dry ice because the erythrocytes are hemolyzed, in which case an hematocrit could not be obtained. It may be possible to utilize frozen storage when the hematocrit is replaced by determination of the hemoglobin content. The validity of such a modification was not investigated. Substantial hemolysis was observed upon the 24-hour storage at 1°C (Table I). Thus, it seems wise to begin analyses of samples within 10 hours.

Within these limitations, the data in Table I, when plotted as percentages of the initial value in Figures 1 and 2, suggest that the decay in activity during specimen storage might be expressed by a functional relationship of the form

$$P = A + B \cdot R^t$$

where P is the predicted percent of the initial value to which the enzyme activity has decreased. This exponential equation assumes as constant the rate of decay (R) per unit increase in storage time (t , in hours). The function approaches the value A asymptotically. The constant B is the difference between A and the initial value. The exponential curves best fitting the data are:

$$P = 84.8 + 15.4(0.88^t) \quad \text{at } 25^\circ\text{C}$$

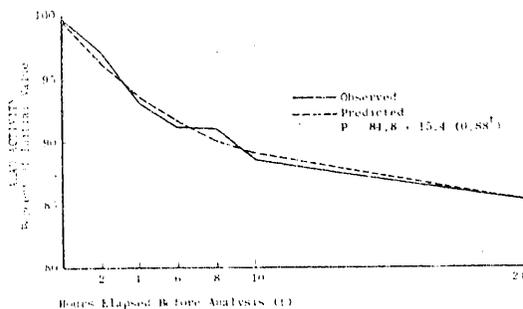


Figure 1. ALAD stability in human blood. Samples were held at 25°C. For each elapsed time, the observed and predicted percentages of initial value are shown as the mean of ten samples.

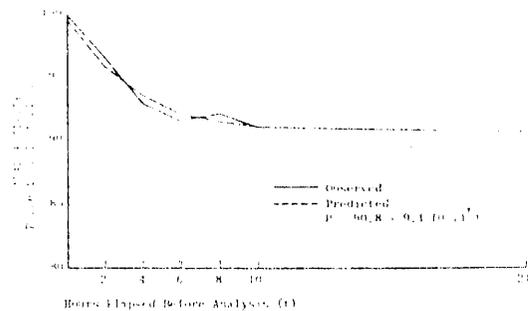


Figure 2. ALAD stability in human blood. Samples were held at 1°C. For each elapsed time, the observed and predicted percentages of initial value are shown as the mean of ten samples.

$$P = 90.8 + 9.4(0.74^t) \quad \text{at } 1^\circ\text{C}$$

Figures 1 and 2, which present the mean observed for the ten samples and the percent predicted by the equations, illustrate how closely the decrease follows the exponential function. The ALAD activity decrease occurring during storage could therefore be predicted, and the initial value estimated for samples held at 1° or 25°C for up to 24 hours.

For examples, for samples held 10 hours at 1°C:

$$\begin{aligned} P &= 90.8 + 9.4(0.74^{10}) \\ &= 91.24\% \end{aligned}$$

The ALAD value determined after 10 hours would be multiplied by $1/0.9124$ to estimate the initial ALAD value.

Correction factors determined in this manner have been applied to adjust the results for samples held at 1°C. The corrected and uncorrected results for five of the ten individuals are shown in Figure 3.

Without correction, deviations from the initial value ranging from -12 to -25 ALAD units occur throughout the 24-hour period. After correction, the range narrows to within 9 ALAD units. In each case, applying the correction brings the ALAD determination closer to the initial value.

Discussion

Our results differ significantly from those of Weissberg *et al.*,⁹ who found that blood retains maximum ALAD activity up to 24

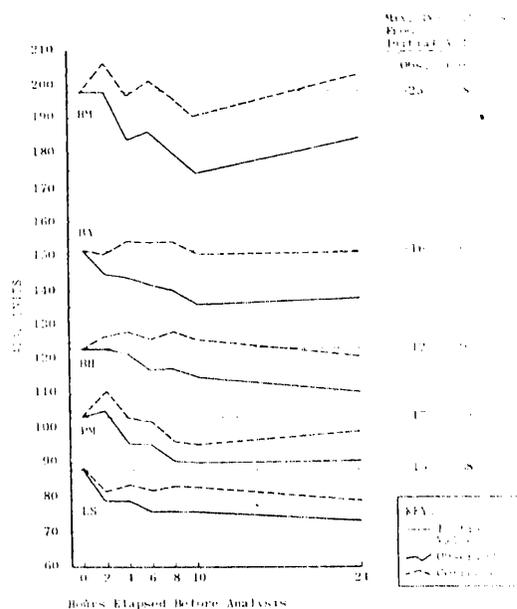


Figure 3. Corrected and observed ALAD levels for five individuals. Samples were held at 1°C. The maximum deviations from the initial value are listed in the columns on the right.

hours, when the blood was kept under refrigeration.

Our results differ also from those of Hernberg *et al.*,⁷ who found the enzyme to remain stable within 5 hours after blood collection. Actually, our findings do not affect the interpretation of their work, as all their ALAD tests were made within 3 hours. Ideally, the ALAD test should be started within 2 hours after the blood collection. When circumstances prevent this, samples should be kept preferably at 1°C, but never at more than 25°C, and the "initial value" should be calculated from a statistically estimated decay function.

Although the decrease in activity upon storage is significant for analytical reasons, the results of this work confirm the remarkable stability of this enzyme in blood. Calissano *et al.*¹³ isolated ALAD from human erythrocytes and found the enzyme more unstable the purer it was. This means that some substances naturally present in the blood probably protect the enzyme from destruction. Calissano *et al.*¹³ have already

found that reducing agents such as cysteine, glutathione, and mercaptoethanol, which would be expected to protect the enzyme from oxidation, have no marked effect on the stability of the purified enzyme. It would be interesting to determine the nature of these stabilizing mechanisms.

Summary

The stability of δ -aminolevulinic acid dehydratase (ALAD) in human blood was examined in relationship to the storage of the sample (for 0, 2, 4, 6, 8, 10, and 24 hours) at 1°C and 25°C. It was found that the enzyme is stable for 2 hours. After 4 hours, the activity decreased significantly; after 24 hours 91% of the initial activity remained at 1°C, and 87% at 25°C. Thus, the enzyme assay is best done within 2 hours of blood sampling. When the analysis cannot be done in this period, then it is possible to correct the results for the decrease in activity. Samples can be stored at 1° to 25°C up to 8 hours, but when longer storage is anticipated, specimens must be stored at 1°C. Owing to the possible hemolysis of blood, an elapsed time not exceeding 10 hours is recommended between the blood drawing and the ALAD assay. In any case, storage time of more than 24 hours and storage temperatures in excess of 25°C would invalidate any test result. If the hematocrit test could be replaced by a hemoglobin determination, specimens could be stored frozen and thereby greatly facilitate population surveys. This possibility is subject to further research.

Acknowledgments

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Fuel Gas from Unmined Coal

Additional equipment is being installed and stepped-up experiments are being planned in the Bureau of Mines research on producing clean-burning fuel gas from coal by gasifying it underground. A site near Hanna, Wyoming, was prepared for the experiments last fall when boreholes were drilled 400 feet down from the surface into a 30-foot-thick deposit of low-sulfur coal owned by the Rocky Mountain Energy Company. The coal was ignited in March 1973 to provide heat for the gasification process. Combustion and gasification have been controlled since by regulating the flow of air pumped down boreholes. Produced gas is withdrawn through other boreholes. After three months of injecting air, gas started flowing to the surface at a rate of about 0.75 million cubic feet per day.

Main fuel constituent of the gas is carbon monoxide, therefore its energy content is relatively low compared to natural and "bottled" gases that are used in household appliances. The gas is good as a fuel for electric power generating plants and other industrial purposes.

The Bureau plans to "enrich" the injected air by the addition of oxygen to see if the reaction can be accelerated. Attempts will be made to increase the gas flow through the coal bed by drilling horizontal holes with an adaptation of equipment for directional drilling of oil wells. Findings from the Bureau's experiments will be used to determine how underground gasification can be used to the best economic and environmental advantage over conventional technology for obtaining energy from coal.

VEGETATION MONITORING FOR AIRBORNE
HEAVY METAL POLLUTION

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Abstract

In a location where horses died from lead poisoning, Avena fatua (wild oat) was used as a simple, passive system for monitoring airborne lead and cadmium. Conventional air sampling did not show increased levels, but levels in Avena samples identified the major source. Sampling site selection employed a multiple source diffusion model. Results are displayed using computer mapping techniques.

INTRODUCTION

During 1969 and 1970, over forty sudden deaths of horses occurred in portions of Solano and Contra Costa Counties bordering on the Carquinez Strait, approximately 20 miles northeast of San Francisco. A joint study was undertaken by the California Air Resources Board, University of California at Davis and Berkeley, State Department of Agriculture, and the State Department of Public Health (1). The illness of some horses and the cause of death of others were diagnosed as lead poisoning. Several point sources and vehicular traffic were possible lead sources.

Forty-eight-hour averages of airborne particulate lead (approximately $1 \mu\text{g}/\text{m}^3$) in the central study area were lower in concentration than normally found in San Francisco and similar urban atmospheres. However, lead levels in the soils and pasture grasses where the horses grazed year-round were far in excess of reported background levels of $10 \mu\text{g}/\text{g}$ dry weight lead in the soil (2). Aerial transport of small lead particles over long distances has been well documented (7-12).

Vegetation has been used as an indicator of airborne lead by several investigators (3-6). We, therefore, designed a vegetation sampling program which could demonstrate, if successful, that passive vegetation sampling for trace metals would be an important supplement to conventional air pollution monitoring.

Description of Area

The area studied includes Vallejo (pop. 67,905), Benicia (pop. 7,180), Martinez (pop. 15,656), and Crockett (pop. 3,698). The land is predominantly rural grasslands, supporting horses, cattle and sheep.

The horses graze year-round, and their supplemental feed during the winter months, if any, is usually locally grown volunteer hay, harvested the previous summer from the nearby fields.

From March to October the prevailing wind is westerly. Marine air from the Pacific Ocean passes over San Francisco Bay, through the gap above the Carquinez Strait, into the California Central Valley. The westerly wind funnels through the Strait at speeds often in excess of 25 mph and averaging 13 mph. During the months of October through March, the prevailing wind direction is easterly with an average velocity of 8 mph.

Source Inventory

Emission estimates were compiled from data of the Bay Area Air Pollution Control District and the California Air Resources Board; major lead sources were local and Bay Area automotive emissions, lead smelting operations at Selby, boxcar scavenger operations and tetraethyl lead production.

Plan and Rationale of Study

Estimates of the deposition of lead and other heavy metals in the study were developed from a multiple source diffusion model using limited meteorological data.

Our model assumed the whole study area to be subjected to automotive lead from motor vehicles in the San Francisco Bay Area. On a typical summer day, this pollution was assumed to be well mixed and diluted within the lowest thousand feet, providing a background level, augmented by other sources, of lead pollution. Emissions from the 600-foot stack at Selby, which has effective stack height due to thermal buoyancy of about 1,000 feet, were predicted to fall out on surfaces as far away as 60 miles downwind. The high hills in the plume line, should be especially affected by the emissions from the tall stack. Horse deaths occurred on these high hills. This area is also across the road from an oil refinery which has a stack height similar to the pasture elevation.

Cadmium analysis was also performed because it was specifically associated with smelting operations, but not with automotive or oil refinery emissions. Cadmium is of interest, also, because of its toxicity to kidney tissues.

Selection of Plant Species

The plant species was selected according to the following criteria:

- (1) palatability to grazing animals and possible food chain implications

- (2) prevalence - availability throughout the study area and the state
- (3) pollutant capturing ability - complex, hairy surface
- (4) exposure - ease of recognition of the age of tissue sampled in relation to duration of exposure; this maximizes sample comparability.

The tissue which best fulfilled the above criteria was the top 4 to 6 inches of the head of the annual grass Avena fatua (wild oat). Horses, sheep and cattle graze the hairy, green leaves, consume the branched heads and seeds, and unless given supplementary feed, will continue to graze the dry yellow stubble down to the bare ground during the fall and winter months. The stem tissue and seeds, having a low surface-area-to-mass ratio, were eliminated from the collected sample prior to analysis. The panicle tissue, having a high surface area-to-mass ratio, was thus exposed to atmospheric sources of lead and cadmium from March until the samples were collected in August.

Sample Collection

In the middle two weeks of August, 1970, over 300 samples of Avena and the top 1/4-inch of soil in which they grew were taken, 134 of which were from the central study area. No samples were located on recently plowed ground, nor within 500 feet from any road. Additional samples were collected on east-to-west transects extending 60 miles downwind

of the Strait, and on north-to-south arcs crossing these transects. Remote locations throughout the state were also sampled.

Methods of Analysis

The Avena samples were oven dried at 70°C in a forced-air oven to constant weight, and wet-ashed with a mixture of nitric (HNO₃) and perchloric (HClO₄) acids. The soils were air dried and lead and cadmium extracted with hot nitric acid. The digests were diluted, filtered, and the lead and cadmium determined in the filtrate by atomic absorption spectroscopy. Further specification of methods may be found in reference (1).

Washing of the vegetation prior to analysis was not done, since washing cannot conclusively differentiate surface deposited metals from those absorbed systemically, and the grazing animals consume Avena in its unwashed state. Rains (13) indicates that rainwater does not leach the lead from the Avena in its unwashed state.

Precision of the method is ±5% for lead and ±20% for cadmium in Avena and about ±10% for lead and ±20% for cadmium in the soil. The limit of detection is about 10 µg Pb/g and 1 µg Cd/g in Avena and 5 µg Pb/g and 0.5 µg Cd/g in soil.

Results

The results of the vegetation sampling are summarized in Figures 1 and 2. The figures display contours of lead and cadmium concentrations

produced by computer mapping at 134 sampling locations in the central study area. The locations of the horse deaths lie within areas containing greater than 800 $\mu\text{g Pb/g}$ and 10 $\mu\text{g Cd/g}$ dry weight in Avena tops. The similar pattern of lead and cadmium contamination implies the same source for these two pollutants. A plot of concentrations of lead in soil reveals a similar pattern.

In field and greenhouse experiments we have shown negligible translocation of lead from soil to grass tops. In these experiments, vegetation growing on study area field soils of greatly differing metal concentrations was exposed to filtered and unfiltered rural and urban atmospheres.

Lead levels in excess of 50 $\mu\text{g Pb/g}$ dry weight Avena were found as far as 60 miles downwind of the Strait.

The lead concentrations at the 18 statewide locations, which ranged from 50 to 210 $\mu\text{g Pb/g}$ dry weight Avena, revealed a general background pattern of lead in the 1970 Avena tops which was above 50 $\mu\text{g Pb/g}$ except in very remote areas. Cadmium values for the statewide survey range from none detected to 3.2 $\mu\text{g Cd/g}$ dry weight Avena tops.

The smelter ceased operations in March 1971. Samples of Avena from the same sample locations in 1971 were much lower in lead and cadmium than in 1970.

In the joint study (1), lead pollution from the smelter was found to be the major cause of lead poisoning in horses. This occurred as the result of the uptake of lead from pasture grasses, of which Avena was a major component.

Conclusions

We have demonstrated that vegetation sampling describes the pattern of airborne lead pollution in relation to several sources, which in this study included primarily a lead smelter and automotive emissions.

Customary high-volume sampling indicated no unusual amounts of lead in the air.

In using vegetation as a passive air pollution monitor in any area or time of year, it is important that the exposure of the sample be easily established, i.e., the same plant tissues of the same species are harvested, and all samples are taken within a specified stage of plant growth, with the weather patterns established under these conditions.

We conclude that vegetation sampling for airborne metallic pollutants can be a simple, useful, and a practical procedure.

The lead and cadmium patterns demonstrated by such vegetation sampling have been useful in further selection of air sampling sites, in planning epidemiological studies, in searching for further environmental effects in the study area, and in identifying smelter emissions as the major source of vegetation contamination which caused lead poisoning in horses.

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List of Figures

Fig. 1 Lead concentration pattern in Avena, August 1970.

Fig. 2 Cadmium concentration pattern in Avena, August 1970.

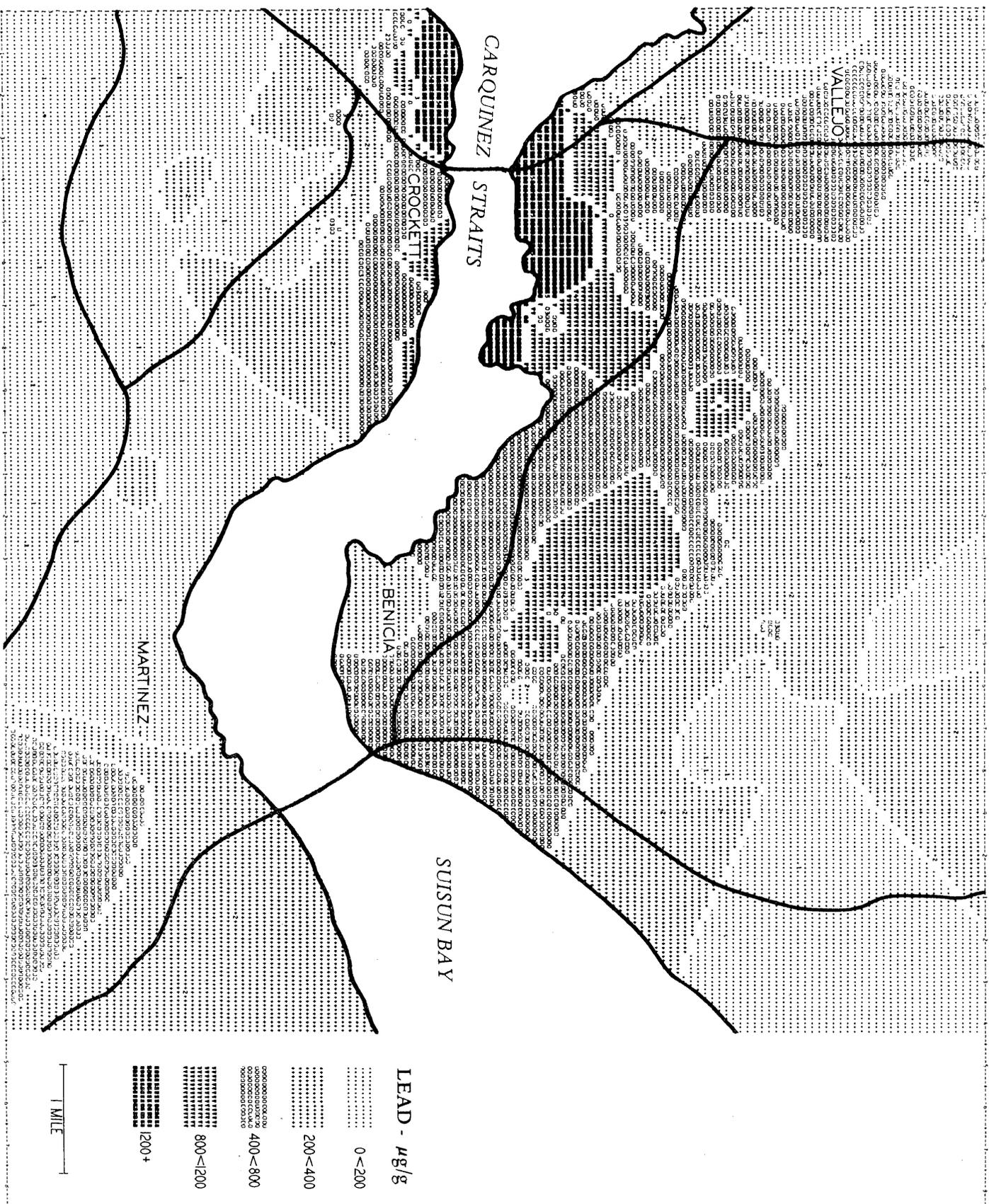
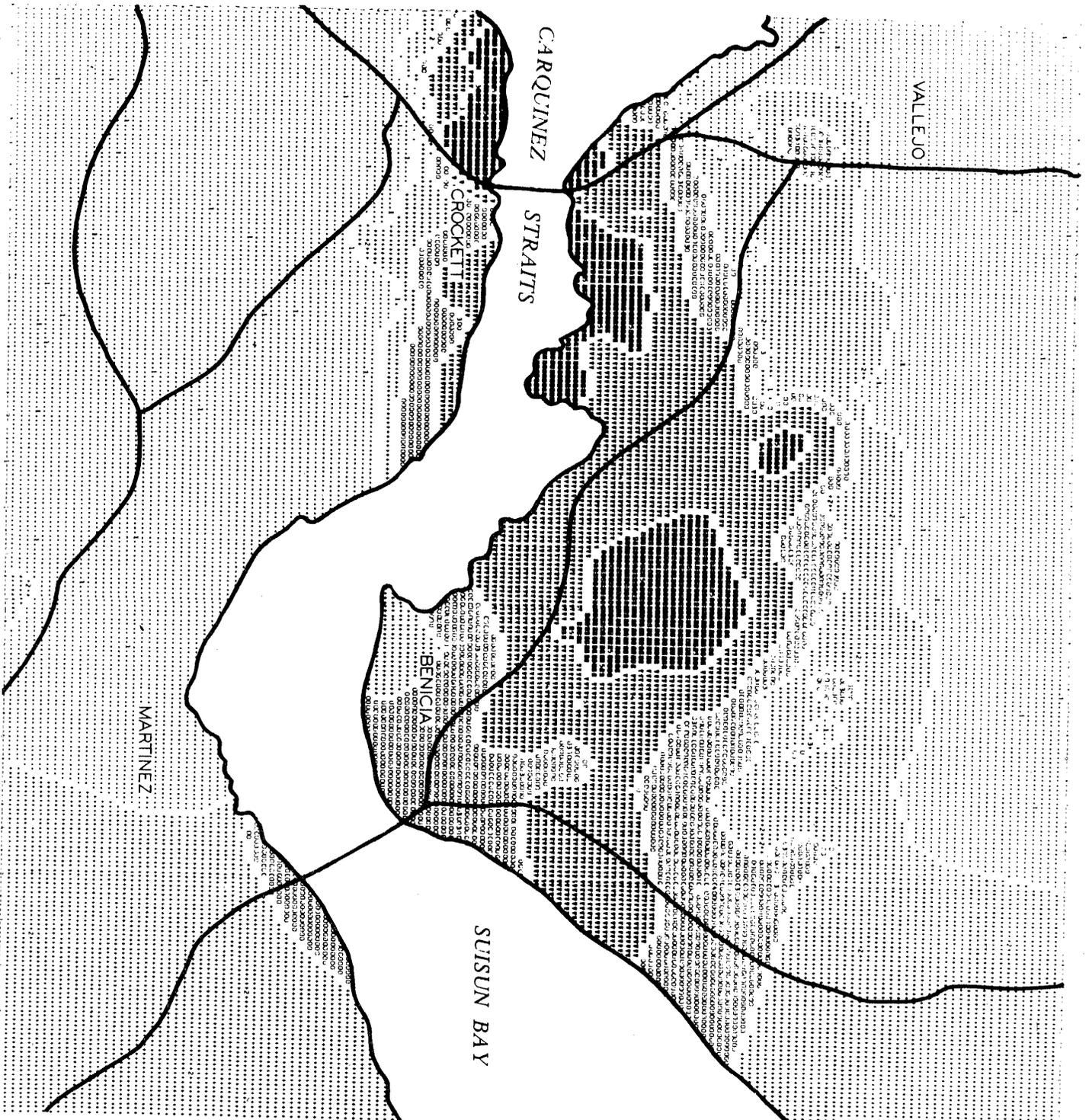


Figure 1



CADMIUM - µg/l

- 0 < 2
- ===== 2 < 5
- ||||| 5 < 10
- \\\\\\\\ 10 < 25
- ||||| 25+

1 MILE

Figure 2 189.