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Effect of Alkali Water on Dairy Cows

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EFFECT OF ALKALI WATER ON DAIRY COWS

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THE EFFECT OF ALKALI WATER ON DAIRY COWS

EFFECT OF ALKALI WATER ON DAIRY COWS

By C. Larsen and D. E. Bailey

INTRODUCTION

While alkali water is not general in South Dakota, it is prevalent in certain sections of the semiarid portions of the state. In some places the water is so charged with soluble minerals that it has been a question whether cows and other stock could drink it without being injured. In some of these sections the cows became "alkalied." By many this disease was laid to drinking the alkali water.

In a previous bulletin (Bul. 132) the results of the experiments on the effects of alkali water on dairy products are reported. The effects of this kind of water on cows are reported in this bulletin.

The experiment was conducted chiefly with two purposes in view: First, to find out whether strong alkali water would produce the so-called "alkali disease;" and second, to find how the excess of minerals in the alkali water was eliminated from the cow's body.

PLAN OF THE EXPERIMENT

Three barren, healthy, young cows, Nos. 1, 2 and 3, were used for the experiment. On account of the large amount of analytical work, and on account of the necessary strict control, more cows could not be used in the

experiment. These cows were kept in stalls in the barn throughout the investigations.

Weighing and Sampling Intake

Cows 1 and 2 were given alkali water and cow 3 received soft water. The alkali water used was the strongest of any that was analyzed from the wells in the state. Such water as may collect in partially dried up ponds was not considered.

The cows were fed a definite ration of grain and silage. They were fed daily 7 pounds of grain (3 pounds of bran, 3 pounds of oats, and 1 pound of oil meal), 25 pounds of corn silage, and 1 ounce of salt in two equal portions, morning and night. They were given all the hay they would eat, and all the water they would drink three times a day. Enough hay was weighed out for 12 hours, and at the end of this period, that not eaten was weighed back. All water drank was carefully weighed. A detailed record was kept of all the intake.

TABLE NO. I.

Amount, in pounds, of materials taken in by each cow during 10-day periods.

COW I

Period	Preliminary	Experimental I	Experimental II
Date	Dec. 20 to 30, 1911	Jan. 27 to Feb. 6, 1912	Oct. 6 to 16, 1912
Kind of water drank	Normal well	Alkali	Alkali
Water	703.5	665.5	634.0
Hay	186.5	157.5	145.5
Grain	70.0	70.0	70.0
Silage	250.0	250.0	250.0
Salt	0.6	0.6	0.6
Total	1210.6	1143.6	1100.1

TABLE NO. I—Continued

Amount, in pounds, of materials taken in by each cow during 10-day periods

COW II

Period	Preliminary	Experimental I	Experimental II
Date	Dec. 20 to 30, 1911	Jan. 27 to Feb. 6, 1912	Oct. 6 to 16, 1912
Kind of water drank	Normal well	Alkali	Alkali
Water	910.0	652.0	779.0
Hay	187.0	162.5	153.5
Grain	70.0	70.0	70.0
Silage	250.0	250.0	250.0
Salt	0.6	0.6	0.6
Total	1417.6	1135.1	1253 .1

COW III

Period	Preliminary	Experimental I	Experimental II
Date	Dec. 20 to 30, 1911	Jan. 27 to Feb. 6, 1912	Oct. 6 to 16, 1912
Kind of water drank	Normal well	Soft	Soft
Water	553.0	509.0	353.0
Hay	145.0	144.0	96.5
Grain	70.0	70.0	70.0
Silage	250.0	250.0	250.0
Salt	0.6	0.6	0.6
Total	1018.6	978.6	770.1

The intake was carefully sampled for analysis. The grain for all of the cows during the whole experiment was thoroughly mixed and sampled. The hay used was selected, wild, upland hay of uniform quality, and was piled to one side separately. Samples for analysis were taken from different parts of the pile.

The corn silage was of uniform quality. A representative composite sample was obtained by sampling the silage every other day during the 10 day period.

The salt given the cows was the best obtainable butter salt. It was accurately weighed out in small packages, mixed, and fed with the grain morning and night.

The soft water was rain water from the roof of the barn, and was collected in a cistern near the barn.

The alkali water was shipped from a well at Midland. From the table of analyses it will be noticed that its strength varied somewhat. This variation in the per cent of minerals was due to a variation in the amount of rainfall. Small showers did not affect the composition of the water. Only one rainfall during the experiment materially decreased the per cent of minerals. In the latter part of the summer there was a heavy rainfall which flooded the creek near the well. This reduced the total minerals in the water from 7,369 parts per million to 4,546 parts per million. During the following two months the total minerals gradually increased to the normal amount.

Collecting, Weighing, and Sampling the Outgo

The determined outgo consisted of milk, urine and feces. No account was taken of the transudation through the skin, and to losses incident to body changes.

The milk was obtained and weighed in the usual way. To obtain the urine and feces a man was stationed, night and day, behind the cows with necessary pails and other receptacles. At the time of voiding the urine was caught in a broad bucket, and then transferred to the collecting pail. These pails were kept covered, and were weighed, sampled and emptied twice a day. The total weight of the voidings was checked with the sum of the different voidings. The feces were caught, weighed and kept in a similar manner.

TABLE NO. II.

Amounts, in pounds, of materials given off by each cow during 10-day periods

COW I

Period	Preliminary	Experimental I	Experimental II
Date	Dec. 20 to 30, 1911	Jan. 27 to Feb. 6, 1912	Oct. 6 to 16, 1912
Kind of water drank	Normal well	Alkali	Alkali
Milk	165.9	165.1	123.8
Urine	127.2	151.0	146.7
Feces	695.7	631.4	560.9
Total	988.8	947.5	831.4

COW II

Period	Preliminary	Experimental I	Experimental II
Date	Dec. 20 to 30, 1911	Jan. 27 to Feb. 6, 1912	Oct. 6 to 16, 1912
Kind of water drank	Normal well	Alkali	Alkali
Milk	257.6	245.9	135.2
Urine	102.0	151.8	169.0
Feces	870.5	529.3	657.3
Total	1230.1	927.0	961.5

COW III

Period	Preliminary	Experimental I	Experimental II
Date	Dec. 20 to 30, 1911	Jan. 27 to Feb. 6, 1912	Oct. 6 to 16, 1912
Kind of water drank	Normal well	Soft	Soft
Milk	159.6	121.2	26.3
Urine	113.4	112.9	122.6
Feces	565.7	573.7	408.2
Total	838.7	807.8	557.1

Composite samples were taken of the outgo at the time of weighing, or each 12 hours. In the case of milk and urine a number of cubic centimeters, corresponding to the number of pounds, and representing an average quality, were placed in glass-stoppered bottles and preserved with formaldehyde. The feces were transfered to

a box each 12 hours, thoroughly mixed, and a number of grams taken, corresponding to the number of pounds excreted. These composite samples were preserved with Thymol, in wide-mouthed air-tight glass bottles.

Records of intake and outgo from these cows were kept for 10 day periods.

Careful analyses were made of all the samples. The methods of A. O. A. C. were used as far as possible. The chlorine was determined by the provisional method on page 24 of A. O. A. C.; the phosphorus was determined by digesting the sample with a mixture of sulphuric and nitric acids; the sulphur was determined by the sodium peroxide method. In the case of the milk and urine, the sulphur was determined by evaporating 15 gram samples with sodium carbonate, and analysis then completed as described in the methods of A. O. A. C. Nearly four times as much sulphur was obtained in the milk by this method as was obtained by the usual method of ashing.

TABLE NO. III

Composition of intake and outgo of the cows during the different periods.

FEED AND WATER

	Period	PER CENT: Water	Ash	Crude Protein	Ether Extract	Crude Fiber	Starch	PARTS PER MILLION: Sulphur (S)	Chlorine (Cl)	Phosphorus (P)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Iron (Fe)	Aluminum (Al)	Silica (SiO_2)
Grain.....	Preliminary and I	10.35	4.00	19.48	4.31	8.06	37.22	2645.0	763.0	6174.0	1301.0	2950.0	275.0	6831.0	11.0	14.0	7340.0
	II	10.74	4.49	18.35	5.37	8.52	24.80	2480.0	891.0	7442.0	1145.0	3299.0	283.0	8340.0	11.0	13.0	7161.0
Hay	Preliminary and I	6.11	11.20	6.44	2.96	28.14	16.38	2315.0	1518.0	803.0	5401.0	2495.0	236.0	4927.0	9.0	18 0	75320.0
	II	7.52	7.78	5.33	2.41	28.99	20.92	1245.0	1097.0	752.0	5080.0	1954.0	303.0	8271.0	13.0	27.0	45685.0
Silage	Preliminary and I	75.60	1.80	2.57	0.81	5.92	5.62	429.0	729.0	578.0	534.0	1031.0	59.0	2875.0	4.0	11.0	8094.0
	II	77.71	1.77	2.01	0.39	8.62	5.35	388.0	463.0	383.0	602.0	762.0	92.0	3608.0	7.0	11.0	7746.0
Normal water	Preliminary	Total Solids	750.0	Loss on Ignit'n	148.0			44.0	13.3	432.2*	107.4	54.0	29.6	4.3	2.0	2.3	28.9
Alkali water.	I		7369.0		460.0			1327.2	316.2	589.3*	387.5	132.8	1683.7	61.4	19.2	10.6	99.9
	II		6596.0		512.0			1212.0	249.0	587.0*	432.0	138.0	1403.0	64.0	6.0	3.0	58.0
Soft water	I and II		155.0		59.0			5.8	3.6	85.0*	19.4	1.7	10.4	4.5	0.6	1.6	7.5

*Bicarbonates

MILK

	Period	Water	Ash	Protein	Casein	Fat	Lactose	Sulphur (S)	Chlorine (Cl)	Phosphorus (P)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Iron (Fe)		
COW I	Preliminary Dec. 20 to 30, 1911	85.73	0.746	4.22	3.05	4.65	4.65	388.0	795.0	1060.0	1211.0	138.0	446.0	1396.0	0.7		
	I. Jan. 27-Feb. 6. 1912	85.53	0.749	4.15	3.38	4.83	4.74	402.0	854.0	1028.0	1213.0	141.0	408.0	1419.0	0.6		
	II. Oct. 6 to 16, 1912	85.71	0.756	3.83	3.03	4.79	4.91	373.0	885.0	1002.0	1190.0	152.0	450.0	1388.0	0.8		
COW II	Preliminary Dec. 20 to 30. 1911	87.41	0.767	3.39	2.33	3.75	4.68	320.0	783.0	1008.0	1129.0	128.0	368.0	1693.0	0.6		
	I. Jan 27 to Feb 6. 1912	87.04	0.778	3.49	2.85	4.07	4.62	316.0	868.0	935.0	1129.0	133.0	370.0	1721.0	0.8		
	II. Oct. 6 to 16. 1912	87.14	0.807	3.56	2.84	3.90	4.59	372.0	1042.0	941.0	1094.0	158.0	589.0	1593.0	0.8		
COW III	Preliminary Dec. 20 to 30. 1911	85.61	0.763	4.20	2.97	4.60	4.85	387.0	837.0	1104.0	1324.0	125.0	433.0	1243.0	2.0		
	I. Jan 27 to Feb 6. 1912	85.30	0.781	4.04	3.23	5.07	4.82	401.0	977.0	1079.0	1358.0	135.0	478.0	1281.0	1.8		
	II. Oct. 6 to 16. 1912	85.68	0.745	3.91	2.87	4.88	4.78	409.0	1079.0	1040.0	1191.0	133.0	566.0	1185.0	1.4		

TABLE NO. III (Continued)

URINE

	Period	Water	Ash	Total Nitrogen	Urea	Uric Acid	Creatinine	Sulphur (S)	Chlorine (Cl)	Phorphorus (P)	Calcium (Ca)	Magnesium(Mg)	Sodium (Na)	Potassinm (K)	Iron (Fe)	Silica (SiO_2)
COW I	Preliminary Dec 20-30. 1911	89.68	3.12	1. 28	1.88	0.036	0.55	2117.0	1739.0	68.0	312.0	1483.0	854.0	14211.0	2.0	
	I. Jan 27-Feb 6, 1911	89.90	4.17	1.15	1.80	0.028	0.59	5946.0	1702.0	75.0	436.0	1151.0	5210.0	11611.0	0.7	134.0
	II. Oct 6 to 16, 1911	90.45	3.95	0.93	1.36	0.041	0.34	4434.0	2463.0	72.0	280.0	1058.0	3987.0	13264.0	0.8	112.0
COW II	Preliminary Dec 20 to 30. 1911	88.57	3.18	1.39	1.86	0.060	0.57	2635.0	1164.0	34.0	643.0	1528.0	390.0	13637.0	2.0	
	I. Jan 27 to Feb 6 1912	90.10	3.93	1.11	1.73	0.025	0.52	5565.0	2537.0	58.0	502.0	1020.0	5406.0	10286.0	0.7	238.0
	II. Oct. 6 to 16, 1912	91.10	3.87	0.81	1.17	0.032	0.41	4418.0	2045.0	55.0	259.0	845.0	4788.0	11717.0	1.4	124.0
COW III	Perliminary Dec 2. to 30. 1912	89.76	3.04	1.41	2.03	0.030	0.50	1899.0	2124.0	80.0	300.0	1431.0	822.0	13599.0	1.7	
	I. Jan 27 to Feb 6. 1912	89.48	2.93	1.58	2.33	0.032	0.40	1994.0	1971.0	92.0	260.0	1328.0	275.0	13168.0	0.9	144.0
	II. Oct 6 to 16. 1912	90.64	2.73	1.43	2.69	0.053	0.70	1061.0	3414.0	120.0	116.0	1124.0	803.0	12550.0	0.4	92.0

FECES

	Period	Water	Ash	Crude Protein	Ether Extract	Crude Fiber	Starch	Sulphur (S)	Chlorine (Cl)	Prosphorus (P)	Calcium (Ca)	Magnesium(Mg)	Sodium (Na)	Potassium(K)	Iron (Fe)	Aluminum(Al)	Silica (SiO_2)
COW I	Preliminary Dec 20-30. 1911	82.98	3.07	1.66	0.50	4.69	3.80	447.0	449.0	629.0	1717.0	1160.0	113.0	506.0	8.0	11.0	21762.0
	I. Jan 27 to Feb 6. 1911	84.05	2.61	1.92	0.37	4.09	3.56	673.0	529.0	794.0	1386.0	940.0	485.0	400.0	5.0	16.0	18280.0
	II. Oct 6 to 16, 1912	83.67	2.58	1.72	0.39	4.28	3.59	689.0	579.0	1007.0	1876.0	997.0	574.0	575.0	10.0	16.0	13004.0
COW II	Preliminary Dec 20 to 30. 1911	84.53	2.78	1.43	0.35	4.17	3.50	434.0	458.0	510.0	1431.0	1000.0	148.0	660.0	8.0	10.0	20593.0
	I. Jan 27 to Feb 6, 1912	80.55	3.38	2.11	0.44	5.05	4.38	956.0	402.0	900.0	1500.0	1241.0	422.0	613.0	10.0	17.0	23435.0
	II. Oct 6 to 16, 1912	84.34	2.43	1.51	0.39	4.23	3.28	670.0	474.0	874.0	1847.0	959.0	537.0	653.0	9.0	19.0	12907.0
COW III	Preliminary Dec 20 to 30. 1911	82.37	3.11	1.71	0.53	4.30	3.65	490.0	375.0	871.0	1503.0	1162.0	108.0	434.0	10.0	14.0	22375.0
	I. Jan 27 to Feb 6. 1962	83.03	2.74	1.68	0.41	4.43	2.69	540.0	374.0	920.0	1190.0	1018.0	151.0	896.0	6.0	13.0	19916.0
	II. Oct 6 to 16, 1912	81.86	2.77	1.84	0.43	4.46	3.69	482.0	335.0	1511.0	1745.0	1058.0	350.0	1058.0	10.0	15.0	15589.0

TABLE NO. IV.

Showing total amounts, in pounds, of intake and outgo of each cow during the three periods.

Preliminary period on normal well water.

			Total Weights	Total Ash	Composition of Ash							
					Sulphur (S)	Chlorine (Cl)	Phosphorus (P)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Silica (SiO_2)
Cow I	Intake	Water	703.5	0.528	0.031	0.009		0.076	0.038	0.021	0.003	0.020
		Hay	186.5	20.888	0.432	0.283	0.150	1.007	0.465	0.044	0.919	14.047
		Grain	70 0	2.800	0.185	0.053	0.432	0.091	0.207	0.019	0.478	0.514
		Silage	250.0	4.500	0.107	0.182	0.145	0.134	0.258	0.015	0.719	2.024
		Salt	0.6	0.625		0.379				0.246		
		Total intake	1210.6	29.341	0.755	0.906	0.727	1.308	0.968	0.345	2.119	16.605
	Outgo	Milk	165.9	1.235	0.064	0.132	0.176	0.201	0.023	0.074	0.232	
		Urine	127.2	3.968	0.269	0.221	0.009	0.039	0.189	0.109	1.808	
		Feces	695.7	21.358	0.311	0.312	0.438	1.195	0.807	0.079	0.352	15.145
		Total outgo	988.8	26.561	0.644	0.665	0.623	1.435	1.019	0.262	2.392	15.145
Cow II	Intake	Water	910.0	0.682	0.040	0.012		0.098	0.049	0.027	0.004	0.026
		Hay	187.0	20.944	0.433	0.284	0.150	1.010	0.466	0.044	0.921	14.085
		Grain	70.0	2.800	0.185	0.053	0.432	0.091	0.207	0.019	0.478	0.514
		Silage	250.0	4.500	0.107	0.182	0.145	0.134	0.258	0.015	0.719	2.024
		Salt	0.6	0.625		0.379				0.246		
		Total intake	1417.6	29.551	0.765	0.910	0.727	1.333	0.980	0.351	2.122	16.649
	Outgo	Milk	257.6	1.976	0.082	0.201	0.259	0.291	0.033	0.095	0.436	
		Urine	102.0	3.244	0.269	0.119	0.004	0.066	0.156	0.040	1.391	
		Feces	870.5	24.190	0.378	0.399	0.444	1.246	0.870	0.128	0.574	17.930
		Total outgo	1230.1	29.410	0.729	0.719	0.707	1.603	1.059	0.263	2.401	17.930
Cow III	Intake	Water	553.0	0.415	0.025	0.007		0.059	0.030	0.016	0.002	0.016
		Hay	145.0	16.240	0.336	0.220	0.116	0.783	0.361	0.034	0.714	10.921
		Grain	70.0	2.800	0.185	0.053	0.432	0.091	0.206	0.019	0.478	0.514
		Silage	250.0	4.500	0.107	0.182	0.145	0.134	0.258	0.015	0.719	2.024
		Salt	0.6	0.625		0.379				0.246		
		Total intake	1018.6	24.580	0.653	0.841	0.693	1.067	0.855	0.330	1.913	13.475
	Outgo	Milk	159.6	1.217	0.062	0.134	0.176	0.211	0.020	0.069	0.199	
		Urine	113.4	3.447	0.215	0.241	0.009	0.034	0.162	0.093	1.542	
		Feces	565.7	17.593	0.277	0.212	0.492	0.850	0.657	0.061	0.245	12.660
		Total outgo	838.7	22.257	0.554	0.587	0.677	1.095	0.839	0.223	1.986	12.660

TABLE NO. IV. (Continued)
Showing total amounts, in pounds, of intake and outgo of each cow during the three periods.
Experimental period I on alkali water.

			Total Weights	Total Ash	Composition of Ash							
					Sulphur (S)	Chlorine (Cl)	Phosphorus (P)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Silica (SiO_2)
		Water	665.5	4.904	0.883	0.210		0.258	0.088	1.121	0.041	0.067
		Hay	157.5	17.640	0.365	0.239	0.127	0.851	0.393	0.037	0.776	11.870
		Grain	70.0	2.800	0.185	0.053	0.432	0.091	0.207	0.019	0.478	0.514
	Intake	Silage	250.0	4.500	0.107	0.182	0.145	0.134	0.258	0.015	0.719	2.024
		Salt	0.6	0.625		0.379				0.246		
Cow I		Total intake	1143.6	30.469	1.540	1.063	0.704	1.344	0.946	1.438	2.014	14.475
		Milk	165.1	1.237	0.066	0.141	0.170	0.200	0.023	0.067	0.234	
	Outgo	Urine	151.0	6.297	0.898	0.257	0.011	0.066	0.174	0.787	1.753	0.020
		Feces	631.4	16.480	0.425	0.334	0.501	0.875	0.593	0.306	0.253	11.540
		Total outgo	947.5	24.014	1.389	0.732	0.682	1.141	0.790	1.160	2.240	11.560
		Water	652.0	4.805	0.865	0.206		0.253	0.087	1.098	0.040	0.065
		Hay	162.5	18.200	0.376	0.247	0.131	0.877	0.405	0.038	0.801	12.240
		Grain	70.0	2.800	0.185	0.053	0.432	0.091	0.207	0.019	0.478	0.514
	Intake	Silage	250.0	4.500	0.107	0.182	0.145	0.134	0.258	0.015	0.719	2.024
		Salt	0.6	0.625		0.379				0.246		
Cow II		Total intake	1135.1	30.930	1.533	1.067	0.708	1.355	0.957	1.416	2.038	14.843
		Milk	245.9	1.913	0.078	0.213	0.230	0.278	0.033	0.091	0.423	
	Outgo	Urine	151.8	5.966	0.845	0.385	0.009	0.076	0.155	0.821	1.561	0.036
		Feces	529.3	17.890	0.506	0.213	0.476	0.794	0.657	0.223	0.325	12.404
		Total outgo	927.0	25.769	1.429	0.811	0.715	1.148	0.845	1.135	2.309	12.440
		Water	509.0	0.079	0.003	0.002		0.010	0.001	0.005	0.002	0.004
		Hay	144.0	16.128	0.333	0.219	0.116	0.778	0.359	0.024	0.710	10.846
		Grain	70.0	2.800	0.185	0.053	0.432	0.091	0.207	0.019	0.478	0.514
	Intake	Silage	250.0	4.500	0.107	0.182	0.145	0.134	0.258	0.015	0.719	2.024
		Salt	0.6	0.625		0.379				0.246		
Cow III		Total intake	973.6	24.132	0.628	0.835	0.693	1.013	0.825	0.319	1.909	13.388
		Milk	121.2	0.947	0.049	0.118	0.131	0.165	0.016	0.058	0.155	
	Outgo	Urine	112.9	3.368	0.225	0.223	0.010	0.029	0.150	0.031	1.487	0.016
		Feces	573.7	15.719	0.310	0.215	0.528	0.683	0.584	0.087	0.514	11.426
		Total outgo	807.8	19.974	0.584	0.556	0.669	0.877	0.750	0.176	2.156	11.442

TABLE NO. IV. (Continued)
Showing total amounts, in pounds, of intake and outgo of each cow during the three periods.
Experimental period II on alkali water.

			Total Weights	Total Ash	Composition of Ash							
					Sulphur (S)	Chlorine (Cl)	Phosphorus (P)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Silica (SiO_2)
		Water	634.0	3.857	0.768	0.158		0.274	0.088	0.890	0.041	0.037
		Hay	145.5	11.320	0.181	0.160	0.109	0.739	0.284	0.044	1.203	6.647
		Grain	70.0	3.143	0.174	0.062	0.521	0.080	0.231	0.020	0.584	0.501
	Intake	Silage	250.0	4.425	0.097	0.116	0.096	0.151	0.191	0.023	0.902	1.937
		Salt	0.6	0.625		0.379				0.246		
Cow I		Total outgo	1100.1	23.370	1.220	0.875	0.726	1.244	0.794	1.223	2.730	9.122
		Milk	123.8	0.936	0.046	0.110	0.124	0.147	0.019	0.056	0.172	
	Outgo	Urine	146.7	5.795	0.651	0.361	0.011	0.041	0.155	0.585	1.946	0.016
		Feces	560.9	14.471	0.387	0.325	0.565	1.052	0.559	0.322	0.323	7.294
		Total intake	831.4	21.202	1.084	0.796	0.700	1.240	0.733	0.963	2.441	7.310
		Water	779.0	4.739	0.944	0.194		0.337	0.108	1.093	0.050	0.045
		Hay	153.5	11.942	0.191	0.168	0.115	0.780	0.300	0.047	1.270	7.013
		Grain	70.0	3.143	0.174	0.062	0.521	0.080	0.231	0.020	0.584	0.501
	Intake	Silage	250.0	4.425	0.097	0.116	0.096	0.151	0.191	0.023	0.902	1.937
		Salt	0.6	0.625		0.379				0.246		
Cow II		Total intake	1253.1	24.874	1.406	0.919	0.732	1.348	0.830	1.429	2.806	9.496
		Milk	135.2	1.091	0.050	0.141	0.127	0.148	0.021	0.080	0.215	
	Outgo	Urine	169.0	6.540	0.747	0.346	0.009	0.044	0.143	0.809	1.980	0.021
		Feces	657.3	15.972	0.440	0.312	0.575	1.214	0.630	0.353	0.429	8.484
		Total outgo	961.5	23.603	1.237	0.799	0.711	1.406	0.794	1.242	2.624	8.505
		Water	353.0	0.036	0.002	0.001		0.007	0.001	0.004	0.002	0.003
		Hay	96.5	7.508	0.120	0.106	0.073	0.490	0.189	0.029	0.798	4.409
		Grain	70.0	3.143	0.174	0.062	0.521	0.080	0.231	0.020	0.584	0.501
	Intake	Silage	250.0	4.425	0.097	0.116	0.096	0.151	0.191	0.023	0.902	1.937
		Salt	0.6	0.625		0.379				0.246		
Cow III		Total intake	770.1	15.737	0.393	0.664	0.690	0.728	0.612	0.322	2.286	6.850
		Milk	26.3	0.196	0.011	0.028	0.027	0.031	0.004	0.015	0.031	
	Outgo	Urine	122.6	3.347	0.130	0.419	0.015	0.014	0.138	0.098	1.539	0.011
		Feces	408.2	11.307	0.197	0.137	0.617	0.712	0.432	0.143	0.432	6.363
		Total outgo	557.1	14.850	0.338	0.584	0.659	0.757	0.574	0.256	2.002	6.374

ELIMINATION OF MINERALS FROM COWS RECEIVING NORMAL WELL WATER DURING PRELIMINARY PERIOD.

During the 10 day preliminary period when the cows received the ordinary normal well water, each, on the average, consumed 27.824 pounds of minerals, or a total of 83.47 pounds for the three cows. Of these 1.9 per cent were in the water, 69.6 per cent were in the hay, 10.1 per cent were in the grain, 16.2 per cent were in the silage, and 2.2 per cent were in the salt.

As shown in the tables, complete analyses were made of the outgo from the cows, (milk, urine and feces). Of all the mineral consumed during this preliminary period, 93.7 per cent were recovered in these three outgoes. This is the average from the three cows.

Per Cent Minerals Recovered in Milk

During the preliminary period of 10 days when the three cows were on the normal college well water, 1.48 pounds, or 5.3 per cent of the total consumed minerals, were eliminated through the milk. This is the average from the three cows.

The per cent of consumed minerals going from the cow's body into the milk corresponds with the amount of milk given by the cow. For instance cow No. 1 gave 165.9 pounds of milk during the 10 days, and 4.2 per cent of the consumed minerals were in the milk. Cow No. 2 produced 257.6 pounds of milk during the same time and 6.7 per cent of the consumed minerals were in the milk. Cow No. 3 produced 159.6 pounds of milk, and 5.0 per cent of the total consumed minerals were recovered in the milk. The greater the flow of milk, the greater was the per cent of the total consumed minerals which were eliminated in the milk.

The per cent of each of the ash constituents, on the basis of the total consumed minerals, recovered in the milk during this preliminary period is as follows: sulphur 0.25-, chlorine 0.56, phosphorus 0.73+, calcium 0.84+, magnesium 0.09+, sodium 0.29-, and potassium 1.04-.

Per Cent Minerals in Urine

During the same ten day preliminary period 3.55 pounds, or 12.8 per cent of the consumed minerals were recovered in the urine. This is the average for the three cows.

The per cent of each of the ash constituents, on the basis of the total consumed minerals eliminated in the urine, is as follows: sulphur 0.90+, chlorine 0.70+, phosphorus 0.03+, calcium 0.17-, magnesium 0.29-, and potassium 5.68-.

Cow 1 voided 127.2 pounds of urine containing 3.97 pounds of ash, which is 13.5 per cent of the total ash consumed.

Cow 2 voided 102.0 pounds of urine containing 3.24 pounds of minerals, which equal 11.0 per cent of the total consumed minerals.

Cow No. 3 voided 113.4 pounds of urine containing 3.45 pounds of minerals, which is 14.0 per cent of the total minerals consumed.

Per Cent Minerals in Feces

During this ten day period when the three cows received the normal well water, 21.05 pounds, or 75.6 per cent of the total minerals consumed were recovered in the feces. This is the average from the three cows.

The per cent of each of the ash constituents, on the basis of the total consumed minerals, eliminated in the

feces is as follows: sulphur 1.16-, chlorine 1.11-, phosphorus 1.65-, calcium 3.94+, magnesium 2.80-, sodium, 0.32+, potassium 1.40+, and silica 54.79+. It will be noticed that silica composes by far the largest proportion of minerals found in the feces.

Cow No. 1 voided 695.7 pounds of feces which contained 21.36 pounds of minerals. This is 72.8 per cent of the total consumed minerals.

Cow No. 2 voided 870.5 pounds of feces which contained 24.19 pounds of minerals. This is 81.9 per cent of the total consumed minerals.

Cow No. 3 voided 565.7 pounds of feces which contained 17.59 pounds of minerals. This is 71.6 per cent of the total consumed minerals.

The composition of the ash from the milk, feces, and urine from each of these cows is practically the same as the averages already given and therefore shall not be considered separately here.

ELIMINATION OF MINERALS FROM COWS RECEIVING ALKALI WATER AND SOFT WATER DURING EXPERIMENTAL PERIOD I.

As soon as the preliminary determinations reported above, had been made cows Nos. 1 and 2 were given alkali water, and cow No. 3 was given soft or rain water. No determinations were made until the cows were used to the new kinds of water. Thirty days elapsed before the ten day experimental period began. The same strict control over intake and outgo was exercised and the same analyses as were reported from the experimental period were carried out.

The same quality of food and the same amount, with the exception of hay which was fed ad libitum, were fed to these three cows. The kind of water was the only factor that was changed.

It will be seen that the two cows on alkali water consumed on an average 1.25 pounds more ash constituents during the ten days than they did during the same length of time while receiving the normal well water. Cow No. 3 receiving the soft water consumed 0.45 pounds less than she did in the preliminary period on normal water. The alkali water drank, during this ten day experimental period, by cows Nos. 1 and 2, contained 4.26 pounds more ash constituents than did the normal water drank by the same cows in the preliminary period.

The increase in ash constituents from the alkali water consisted chiefly of sodium, sulphur, chlorine and calcium. The alkali water contained about six hundred times more sodium, about thirty times more sulphur, about twenty-five times more chlorine, and about four times more calcium, than did the normal well water. Potassium, though present only in small quantities, was increased about fifteen times over that of the normal well water.

Cow 1, receiving alkali water, drank 38 pounds of water less than she did during the preliminary period. Cow No. 2 drank 258 pounds less water than she did in the preliminary period. Cow No. 3, on soft water, consumed 44 pounds less water than during the preliminary period. This variation may reasonably be ascribed to a difference in the kind of water, to a difference in barn humidity and temperature, and to a correspondingly lower temperature of the water drank. The temperature was five degrees F. lower during the experimental period in February than it was during the preliminary period in the latter part of December.

The weights of the cows before entering this experimental period were as follows:

Cow No. 1 1,010 pounds.
Cow No. 2 1,168 pounds.
Cow No. 3 1,107 pounds.

At the close of the experimental period their weights were as follows:

Cow No. 1 on alkali water, 1,032 pounds.
Cow No. 2 on alkali water, 1,207 pounds.
Cow No. 3 on soft water, 1,142 pounds.

The average weight before entering the alkali water period of cows 1 and 2 was 1,089 pounds. The average weight of these same two cows after the alkali water period was 1,120 pounds.

The amount of hay consumed was less during the alkali water period than during the time they received normal water. Cow No. 1 ate 29 pounds less hay during the 10 day period on alkali water than she did during the preliminary 10 day period while receiving the normal well water. Cow No. 2 ate 24.5 pounds less. Cow No. 3, receiving soft water, ate only one pound less hay in the experimental period than she did during the preliminary period.

Minerals Recovered in Milk

During this 10 day experimental period, when cows Nos. 1 and 2 received alkali water, 1.58 pounds, or 5.1 per cent of the consumed minerals were recovered in the milk. This is the average of the two cows. In the preliminary period while receiving normal water 1.61 pounds, or 5.5 per cent of the total consumed minerals were recovered in the milk from these cows.

In case of cow No. 3, receiving soft water, 0.95 pounds or 3.9 per cent of the consumed minerals were recovered in the milk. In the preliminary period when she drank normal water, 1.22 pounds or 5.0 per cent were obtained in the milk.

The decrease in the ash constituents recovered in the milk while the cows received alkali water may be laid to a decrease in the amount of milk.

It will thus be seen that the minerals in the milk remain remarkably constant. The excess of soluble minerals in the alkali water did not materially affect the composition of the milk, or the total outgo through this channel. The dairy cow evidently is well supplied with organs to protect the constancy of milk composition.

The per cent of each of the different ash constituents, on the basis of the total consumed minerals, eliminated in the milk during the first experimental period is as follows: Sulphur 0.23, chlorine 0.58, phosphorus 0.65, calcium 0.78, magnesium 0.09, sodium 0.26, and potassium 1.07. This is the average of cows Nos. 1 and 2.

Minerals Recovered in Urine

On an average 6.13 pounds or 20 per cent of the total consumed minerals were recovered in the urine, during the time the two cows were on alkali water. Only 3.61 pounds or 12.2 per cent were found in the urine when the same cows were on normal water.

By feeding alkali water to the cows the amount of minerals in the urine was materially increased. The urine contained about three times more sulphur and about ten times as much sodium, as was the case while drinking normal water.

When alkali water was drunk, about twice as much sulphur was ingested. The amount of sulphur eliminated through the milk is practically constant, varying in amount only as the amount of milk varies. The additional amount of sulphur was eliminated through the urine and feces, 75.6 per cent being in the urine and 24.4 per cent in the feces.

When alkali water was drunk about four times as much sodium was ingested by the cow. Of this additional sodium, 76 per cent was eliminated in the urine and 24 per cent in the feces.

The urine contained 3.15 per cent of minerals when the cows received the normal water. During the time the same cows received alkali water, the urine contained 4.05 per cent.

In this connection it should be noticed that when the cows received alkali water the amount of urine was increased. Although the cows ingested considerably less water, more urine was voided. During the 10 day preliminary period while receiving normal water the two cows voided on an average 114.6 pounds of urine. When receiving alkali water they voided 151.4 pounds of urine. They drank 806.8 pounds and 658.8 pounds of water respectively.

The cows on alkali water voided urine containing considerably more sulphur and sodium than did the urine from normal water. There was also an increase in the amount of chlorine. The following table will show the extent to which the ash constituents of the urine increased while the cows were fed alkali water.

TABLE NO. V.

Showing per cent of ash constituents, on the basis of the total consumed minerals, eliminated in urine while drinking normal and alkali water:

	Normal well water	Alkali water	Increase
Sodium	0.25	2.62	2.37
Sulphur	0.91	2.84	1.93
Chlorine	0.58	1.05	0.47
Magnesium	0.59	0.54	-0.05
Calcium	0.18	0.23	0.05
Phosphorus	0.02	0.03	0.01
Potassium	5.43	5.40	-0.03

Minerals Recovered in Feces

An average of 17.19 pounds, or 56.0 per cent of the total consumed minerals were recovered in the feces during the period the two cows, Nos. 1 and 2, received alkali water. During the time these cows received normal water, 22.77 pounds, or 77.3 per cent were recovered in the feces.

The chief ash constituent in the feces was silica. Hay was the main source of this constituent. It will be noticed that while on alkali water the cows consumed less hay than did the same cows while receiving normal water. This in a measure will explain the decrease in the per cent of the total ash in the feces while the cows received alkali water. Silica constitutes about two-thirds of the total minerals in the feces.

The per cent of each of the different ash constituents on the basis of the total consumed minerals eliminated in the feces during the first experimental period is as follows: sulphur 1.52, chlorine 0.89, phosphorus 1.59, calcium 2.72, magnesium 2.04, sodium 0.86, potassium 0.94, and silica 39.00. This is the average of cows Nos. 1 and 2.

The second experimental period will not be considered in detail. It was carried out with the same cows eight months after the close of the first experiment. The results of this second experiment corroborate the findings in the first period.

DISCUSSION OF AVERAGE RESULTS

The total average of ash constituents taken in by the cows in all of the periods is divided as follows:

In the water	8.6 per cent
In the hay	60.4 per cent
In the grain	11.3 per cent
In the silage	17.3 per cent
In the salt	2.4 per cent

About two-thirds of the minerals in the hay and about one-third in the silage, is silica. An increase or decrease in the amount of hay consumed, affects the total amount of intake of minerals considerably.

The water showed the greatest variation in mineral content, ranging from 0.2 per cent to 17.8 per cent, according to the kind of water drank. Even at its maximum the water contributes considerably less than its share of the minerals. It must be remembered in this connection that individual minerals may have more effect than a high total. Over 80 per cent of the minerals in alkali water is sodium sulphate. Since this is soluble it enters into the cow's system. The alkali water contained about six hundred times as much sodium, thirty times as much sulphur, twenty-five times as much chlorine, four times as much calcium, and fifteen times as much potassium, as did the normal well water.

The percentage intake and outgo of each of the ash constituents, on the basis of the total consumed minerals, for all cows in all periods is as follows:

	Intake	Outgo
Sulphur	3.8 per cent.	3.4 per cent.
Chlorine	3.5 per cent.	2.7 per cent.
Phosphorus	2.7 per cent.	2.6 per cent.
Calcium	4.6 per cent.	4.6 per cent.
Magnesium	3.3 per cent.	3.2 per cent.
Sodium	3.1 per cent.	2.4 per cent.
Potassium	8.6 per cent.	8.8 per cent.
Silica	49.4 per cent.	44.3 per cent.

Those ash constituents showing the largest discrepancy between the intake and outgo are silica, chlorine, sodium and sulphur. Sodium and chlorine constitute the largest part of the ash in perspiration, and therefore the determined outgo contained less of these two. The alkalies, such as sodium and potassium compounds, are soluble, while the alkali earths, such as calcium and magnsium, are mostly insoluble. It is therefore reasonable that the former should be eliminated chiefly through the urine, and the latter in the feces.

The per cent of ash constituents, on the basis of the total consumed minerals recovered in the milk, urine and feces in the different periods ranges from 81.1 to 95.0 per cent. The average per cent of minerals recovered from all cows in the different periods is 89.1 per cent. This is divided as follows:

In the milk	4.6 per cent.
In the urine	18.0 per cent.
In the feces	66.5 per cent.
	89.1 per cent.

The remaining 10.9 per cent is evidently used for building bones and body tissue, and for transudation through the skin.

As has already been mentioned, the percentage of minerals recovered in each of these outgoes from the cow will vary, first in accordance with the amount of milk the cow gives, and second with the kind of ash constituents.

The variation in per cent of minerals recovered in the milk corresponds to the amount of milk given by the cows, as the following figures show:

	Per cent of total minerals eliminated through milk	Weight of milk during 10 days
Average of cows—Preliminary period	5.3	194.4 pounds
Average of cows—Experimental period I.	4.8	177.4 pounds
Average of cows—Experimental period II.	3.5	95.1 pounds

The above figures together with the constancy of the per cent ash in the milk as shown in table III corroborate the results reported in Bul. 132 from this experiment station, in which it was shown that the total per cent ash in milk can not be changed by feeding alkali water to the cow.

EFFECT OF ALKALI WATER ON COW'S HEALTH

Physical Examination

This phase of the experiment was under the direct supervision of Dr. Moore, the station veterinarian. The examination of these cows while alive as well as the post-mortem examination at the conclusion of the ex-

periment were made by him. On account of the sudden death of Dr. Moore, some of the results of these examinations can not be given in full.

Two cows, Nos. 1 and 2, were fed on alkali water for about two years. They remained in apparent good health during all this time. No abnormal conditions arose as far as could be observed.

When the cows were first put on alkali water they refused to drink it. Previous experience had taught that it was best to start them gradually. This was done by mixing and gradually increasing the amount of alkali water and lessening the amount of normal water. In about five or six days they were drinking alkali water entirely, without having suffered from any digestive disturbances. A sudden change from normal water to alkali water usually caused diarrhea. The cows would refuse the alkali water a day or two, then they became very dry, in which condition the alkali water would physic them.

Post-mortem Examination

At the end of this time they were slaughtered in the presence of Dr. Moore and one of the authors, who carefully examined all vital organs. These investigators did not observe anything abnormal about them.

Chemical examinations were made of the kidneys and liver. They showed practically the same composition as the organs of cow No. 3, which was slaughtered at the same time. Cow No. 3 had been fed soft water. These analyses are shown in Table VI, which follows:

TABLE NO. VI.

Mineral constituents of cow's organs, on basis of original matter.

Organ	Kidneys			Liver		
Water Drank	Alkali	Alkali	Soft	Alkali	Alkali	Soft
Cow No.	I	II	III	I	II	III
Moisture	79.41	79.69	80.94	71.32	70.19	71.35
Ash	1.19	1.19	1.16	1.32	1.34	1.31
	Parts per million					
Sulphur	1931.0	1880.0	1677.0	2240.0	2303.0	2233.0
Chlorine	2448.0	2620.0	2615.0	903.0	822.0	985.0
Phosphorus	2250.0	2199.0	2126.0	3227.0	3349.0	3192.0
Calcium	151.0	87.0	94.0	56.0	47.0	65.0
Magnesium	167.0	163.0	159.0	165.0	160.0	176.0
Sodium	1968.0	2063.0	1963.0	773.0	693.0	779.0
Potassium	2338.0	2391.0	2249.0	3059.0	3090.0	2839.0
Silica	76.0	70.0	14.0	35.0	89.0	47.0

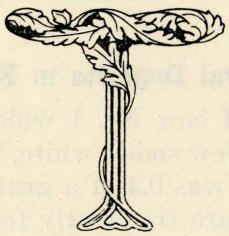
Mineral Deposits in Kidneys

The kidneys of cow No. 1 which was fed on alkali water, contained a few small, white, hard pebbles, the total weight of which was 0.4 of a gram. Dr. Moore stated that such deposits are frequently found in normal cows' kidneys, and that they probably existed before this cow had been fed any alkali water. The largest one of these weighed 0.0872 of a gram.

These silica deposits were analyzed and found to be composed as follows:

Moisture	2.8	per cent.
Organic matter	15.8	per cent.
Silica	76.9	per cent.
Calcium	00.08	per cent.
Magnesium	00.05	per cent.
Iron	00.006	per cent.

It will thus be seen that these deposits are chiefly composed of silica. Since alkali water contains practically no silica, it is reasonable to suppose that these silica deposits do not have their source in the alkali water. It is hardly probable that any of the substances in the alkali water would combine with the silica in the digestive tract and thus cause the silica to be deposited in the kidneys.



SUMMARY

I. The drinking of alkali water by the cows did not produce what is known as the "alkali disease" nor even the slightest indication of it. The feces became soft when the cows first started drinking the water, but soon resumed a normal texture. Considering that the strongest alkali well water was used, it is reasonable to conclude that the alkali disease of cows is not produced from drinking alkali water.

This conclusion does not include water which at times collects in partially dried up ponds. Such water is usually very strong and cows should not be permitted to become so thirsty as to force them to drink it.

II. The post-mortem examination and analyses of the vital organs of the cows in these experiments revealed nothing abnormal.

III. The principal mineral in the alkali water is sodium sulphate. Most of this mineral, or about three-fourths of it, is eliminated through the kidneys.

IV. Cows fed on alkali water voided more urine than did the cows receiving normal water, even though they drank less water. The urine was increased from 114.6 to 151.4 pounds during the 10 day periods by reason of drinking alkali water. This increase in urine output took place in spite of a decrease of 148 pounds in the amount of water drank during the same period.

V. The per cent of ash constituents in the urine is increased by feeding alkali water to the cows. This together with the other above mentioned facts indicates that the kidneys of cows drinking alkali water have an increased amount of work to perform.