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The Chemical Content of Oklahoma Rainfall

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CHEMICAL CONTENT OF OKLAHOMA RAINFALL

V. G. HELLER

INTRODUCTION

Considerable thought has been given to the problem of the depletion of Oklahoma farm lands during recent years. The chemical composition of the surface layers of tilled soils is constantly changing due to a number of factors. The harvesting of yearly crops of cereal or forage plants remove large quantities of both organic and inorganic constituents, and the annual loss due to washing and leaching by rainfall is suprisingly great. These losses are somewhat compensated by the addition of fertilizers from natural or artificial sources, by the growth of leguminous plants, and from another source usually overlooked, namely, rainfall. Many refer to rainfall as a pure source of water; this concept is erroneous, especially at certain seasons and locations. The question in regard to the importance of this contribution in our state has been raised, and as a result this department was requested to make an analysis of the rains from several typical sections of the state. The necessity of securing samples from a number of sources was emphasized due to the varied conditions in this state; the western section being a semi-arid area having no contaminating factory areas, but having frequent dust and electrical disturbances; the southeastern part of the state, on the contrary, receiving large rainfalls, having a more humid atmosphere, and being relatively free from contaminations of dust storms or factory wastes; the central and northeastern sections occupying an intermediate position as to depth of rainfall and dust, but undoubtedly receiving large quantities of smoke and fumes from oil fields, refineries, smelters and factories.

Previous Studies of the Problem

Miller (1) in 1905, reviewed the early reports of many investigators and showed that in many cases considerable quantities of chemical compounds had been found present in most rain water. Nitrogen in the form of ammonia, nitrous, and nitrate, as well as other organic nitrogen forms were well known. Chlorides and sulfates have been generally reported, and in certain cases in considerable quantities; especially, is

this true in the vicinities of coal burning cities, and near large factories, refineries, and mills consuming large quantities of coal, gas or oil; in other instances, considerable quantities of inorganic metallic oxides have been found near smelters. After long periods of dry weather following excessive heat periods, and after dust and electrical storms, almost unbelievable quantities of impurities have been found in the first showers which washed the laden air. These are observations which have been repeatedly noted and recorded, both in this and in other countries for several years.

Miller, working at Rothamstead, England, found that in two years, 1888-89 to 1900-01, the average amount of ammonia plus the nitrate nitrogen per acre per annum was 3.84 pounds, 70 percent of which was in the form of ammonia. There was a variation of from 3.31 pounds to 4.43 pounds. The conclusion was that the variations probably depended in part on the distribution of the rainfall and had no definite relation to the quantity; however, the lowest was coincident with the least precipitation. It was further found that the amount of nitrogen depended on the temperature, since the magnitude of precipitation was greater in the summer months. It was also found that the quantity of nitric acid washed from the air in the two seasons remained constant, while the ammonia varied widely.

From 1890 to 1900, Harrison (2) analyzed the rain water collected at Georgetown, British Guiana. His analysis showed that 34.8 percent of the nitrogen was in the form of ammonia and 65.2 percent in the form of nitrates.

In Canada, Shutt (3) determined the quantity of nitrogen in rain and snow and found that the nitrogen increased with the use of bituminous coal. A total of 4.323 pounds of nitrogen per acre was precipitated, 74 percent of which was in the form of ammonia and the remainder as nitrates. The rain contained more nitrogen than snow.

In the rain waters collected at Lincoln, New Zealand, from July 1907, to June 1909, Gray (4) found an average of 1.548 pounds of nitrogen precipitated annually with 50.9 percent of the total for 1907-1908 as ammonia and only 44.6 percent as ammonia for 1908-1909.

In Russia, Vityn (5) estimated the amount of chlorine and sulfuric acid in water collected at eight different places from April 1909, to March 1910. The analysis was made on monthly samples. The average amount of chlorine was 11.355 pounds per acre, and that for SO_3 was 29.49 pounds per acre.

Crowther and Rustan (6) concluded from their experiments at Leeds and Garforth that the ammonia content of rain water was largely determined by the locality and the amount of rain. Their analysis showed less ammonia in the summer than in the winter. Light rains were proportionately richer in ammonia than the more copious ones. There were 95.7 pounds of SO_3 per acre added to the soil annually. One station at Leeds showed 336 pounds of SO_3 per acre.

In 51 samples of rain and snow collected at Mt. Vernon, Iowa, in 1916, Artis (7) found that the ammoniacal nitrogen varied from 0.13 to 0.80 parts per million. Albuminoid nitrogen varied from 0.12 to 1.19 parts per million; the nitrate nitrogen from 0.005 to 0.80 parts per million. The chlorides ranged from 3.5 to 21.3 parts per million and sulfates ranged from 1.7 to 38 parts per million. The literature gave no data as to the quantity in pounds per acre and since there was no data relative to inches of rainfall it was impossible to calculate the annual precipitation of these substances.

Stewart (8) determined the sulfur in rain waters in Illinois. He found that 40 to 51 pounds per acre were washed down annually by the rain as shown by his analysis over a seven year period. The average was 45.1 pounds of sulfur per annum or 3.8 pounds monthly. The source of sulfur was from burning coal, sulfur dioxide and hydrogen sulfide that were liberated from industrial plants and growth of vegetation. He found that the amount of sulfur collected depended upon the quantity of rainfall. The amount added is sufficient to compensate for that lost through leaching and plant growth.

Wilson (9) found that, while the sulfur content was usually higher in industrial centers, sometimes the content was higher for agricultural districts.

Johnson (10) determined the quantity of sulfur in rain water in seven localities in Kentucky. The samples were collected at Lexington (U. S. Weather Bureau), the Van Meter farm near Lexington, Lincoln Institute, Paducah (Lone Oak), Mayfield, Russellville, and Greenville. The average rainfall was 44.77 inches, which furnished an average of 29.52 pounds of sulfur per acre per annum.

In New York, Wilson (11) analyzed samples from Ithaca, Brockport, and Alfred. An average of 7.13 pounds of ammonical nitrogen and .81 pounds of nitrate nitrogen from an average rainfall of 29.46 inches for an eleven year period was found at Ithaca. The amounts of ammonical nitrogen for

Brockport and Alfred over a three and a two year period respectively were: for an average rainfall of 31.7 inches and 32.4 inches, 2.6 pounds and 12.75 pounds. Over this same period the nitrate nitrogen for Brockport and Alfred were .23 pounds and .25 pounds respectively. The water at Ithaca furnished an average of 38.25 pounds of sulfur and those of Brockport and Alfred 77.53 pounds and 49.75 pounds respectively. The investigators verified the observation of others that the sulfur content was greater in the winter than in the summer. They observed that the amount of sulfur varies from station to station but remains constant at the same station.

Finnell and Houghton (12) furnished the only report of work done in Oklahoma. Their work was carried on at Goodwell, and the samples collected there were relatively free from industrial contamination. Their results show a greater quantity of ammonia when the rain is preceded by a dust storm.

Comparative results of these investigations will be found in Table 1.

TABLE 1.—Comparison of Chemical Content of Rainfall in Pounds per Acre as Previously Reported.

Location	Period Collected	NH_3-N	NO_3-N	Total N	Sulfur	Chlorides
Rothamstead, Eng.	1889-1901	2.690	1.150		6.86	20.040
Georgetown, Brit. G.	1890-1900	1.010	1.890			129.200
Hanoi	1902-1905			16.240		
Quebec	1909-1910	2.999	1.324	4.323		
Quebec	1911			5.271		
Lincoln, New Zealand	1884-1888				5.98	
Lincoln, New Zealand	1907-1909	0.788	0.860	1.548		
Eight places in Russia	1909-1910				11.80	11.355
Garforth	1906-1909				38.27	
Leeds	1907-1908				64.41	
Montevideo	1909-1912			6.860		46.800
Mississippi	1894			2.847		
Mississippi	1895			3.308		
Illinois, Urbana	1913-1919				45.10	
Kentucky	1924				29.520	
Kentucky	1922-1923	11.610	7.170	18.780		
Ithaca, N. Y.	1915-1926	7.130	0.810	7.940	38.250*	
Brockport	1923-1926	2.600	0.230	2.830	77.530	
Alfred	1923-1925	12.750	0.250	13.000	49.753	
Mt. Vernon, Ia.	1910			13.710		
Mt. Vernon, Ia.	1912			6.270		
Mt. Vernon, Ia.	1913-1914			3.700		
Mt. Vernon, Ia.	1922-1923			3.930		
Goodwell	1930			0.509		
Goodwell	1931	0.991	0.321	1.420		

* Eight-year period.

Fortunately, this Station has cooperating laboratories or field stations in several sections of the state. In each station were found men who were familiar with the methods and had equipment to collect and measure the rainfall. In a few cases farmers were instructed, and they faithfully cooperated during these studies. The location of these collecting stations and the persons cooperating are recorded in the following table.

Location	Station	Collector
Woodward	Southern Great Plains Field Station	E. F. Chilcott
Lawton	U. S. Dry Land Field Station	W. M. Osborn
Stillwater	Agricultural Experiment Station	Ralph Cole
Oklahoma City	Feed Control Laboratory	Charles Caskey, Jr.
Sand Springs	Chemist, Kerr's Glass Works	Raymond Gentry
Dewey	Chemist, Dewey High School	C. E. Boatman
Heavener	Experiment Station	Harry Cobb
Blackwell	Farmer	J. E. Moutrey

The water samples were collected in porcelain or earthenware vessels which were placed on stands away from trees or contaminating surfaces. The water was transferred to glass jugs and immediately expressed to this laboratory for analysis. A record of the amount of rainfall, the temperature, the direction of wind, and other interesting observations such as electrical disturbances and dust clouds were noted in each case.

The methods of analysis were, in most cases, those recommended in "Standard Methods for the Examination of Water and Sewage," American Public Health Association, New York, New York, Edition VI.

The compounds tested for and the methods used were:

Ammonia Nitrogen—by the distillation method; the only variation being the use of the ammonia color disc in the Hellige Acqua Tester.

Nitrite Nitrogen—by the sulfonilic acid a-naphthylamine acetate method, comparing the colors so produced to the nitrite nitrogen color disc.

Nitrate Nitrogen—by the phenol disulfonic acid method comparing to the Hellige nitrate nitrogen color disc.

Total Nitrogen—by the Kjeldahl (Gunning modified method) using the sample left from the ammonia determination. The total nitrogen being calculated from the ammonia and nitrate nitrogen and added to the Kjeldahl determination. In some cases the Kjeldahl was run direct upon a fresh sample by the use of the salycylic acid modification to include the nitrates.

Chloride—was determined directly by silver nitrate titration.

Sulfate—by the gravemetric barium sulfate method.

Each sample was analyzed separately and calculated. The sums of the separate determinations were added for the month's total. The latter was corrected for the month's total rainfall for this location as reported by the local weather station. This permitted the introduction of possible but unavoidable errors, due to the fact that the samples analyzed might not compare with the total rain that fell; the light first rainfall, invariably being more richly contaminated, and, also, due to the fact that the weather reporter was, in some cases, considerable distance from the collector.

The data for each station has been reported separately, and calculated in terms of pounds of material per acre, per month, and per rain. It should be stated that these figures were arrived at by the use of the following formula:

> Content of rain analyzed expressed in pounds per acre per inch×total rainfall per month=pounds per acre, per month.

This permits some error when the rain collected does not represent a true aliquot of the entire rainfall. This occurred when the inches gathered did not agree with inches reported by weather reporter.

Nitrogen, Chloride and Sulfate Content of Rain Water at Sand Springs, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
10-10-35	1.00		.1124	.0045		.1169	.0000	1.0487
10-18-35	0.50		.0408	.0004	.4532	.4944	.0000	.4311
10-25, 26-35	0.75		.0129	.0017	.0119	.0265	1.0197	.8652
Per Month		7.46	.5507	.0219	2.7757	3.3483	3.3808	7.7748
11-3, 4-35	1.00		.0707	.0032	.0159	.0898	.4532	.3730
11-25, 26-35	1.00		.0906	.0039	.0227	.1172	.4532	1.1421
Per Month		4.43	.3573	.0157	.0855	.4585	2.0077	3.3559
12-4-35	1.50		.0639	.0034	.0340	.1013	.3399	.6468
Per Month		2.05	.0873	.0046	.0464	.1383	.4645	.8839
6-6-36	3.46		.1223	.0008	.0627	.1858		
Per Month		4.44	.1569	.0010	.0805	.2384		
9-18-36	3.50		.0428	.0008	.2379	.2815	.7931	3.6483
9-27-36	1.25		.0204	.0006	.1275	.1485	.5807	.2680
Per Month		12.04	1.6020	.0035	1.1797	2.7852	3.4822	9.9267
10-7-36	3.00		.0313	.0014	.0510	.0837	1.5975	.6992
10-26-36	1.00		.0127	.0014	.1700	.1841		
Per Month		7.11	.0782	.0050	.3928	.4760	3.7861	1.6571
12-1, 4-36	1.20		.0033	.0003	.0019	.0055	.9517	.4810
12-29-36	1.25		.0552	.0011	.2832	.3395	.0708	
Per Month		3.74	.0895	.0021		.0916	1.5608	1.4991
2-19, 20-37	0.50			.0002	.0849	.0851		
Per Month		0.93						
3-12, 13-37	1.50		.0530	.0031	.5099	.5660	.5438	

Nitrogen, Chloride and Sulfate Content of Rain Water at Heavener, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS: Ammonia	Nitrite	Nitrate	Total	POUNDS PER ACRE Chlorides	Sulfates
12-5, 6-35	3.36		.3868	.0190	3.8070	4.2128	.7614	2.5453
Per Month		4.38	.5042	.0248	4.9642	5.4932	.9925	3.3178
1-8, 9-36	0.63		.0782	.0036	.2141	.2959		
Per Month		0.63	.0782	.0036	.2141	.2959		
2-26-36	1.59		.1974	.0061	.2702	.4737		
Per Month		1.59	.1974	.0061	.2702	.4737		
3-23-36	2.67		.4574	.0061	6.0502	6.5137		
Per Month		2.67	.4574	.0061	6.0502	6.5137		
5-8, 11-36	2.64		.0096	.0042	.0299	.0437	1.1964	3.4936
Per Month		2.64	.0096	.0042	.0299	.0437	1.1964	3.4936
6-6-36	0.31		.0017	.0001	.0140	.0158		
6-22-36	0.96		.0374	.0004	.0870	.1248	.6526	2.3089
Per Month		1.44	.0432	.0006	.1145	.1583	.9789	3.4634
7-2, 7-36	2.10		.0114	.0005	.1332	.1451	.9517	1.6050
Per Month		2.63	.0143	.0006	.1668	.1817	1.1918	2.0099
10-6, 7-36	0.44		.0140	.0005	.1097	.1242	.2991	.7055
10-21, 25-36	2.24		.0193	.0005	.0381	.0579	1.2943	.9814
Per Month		3.96	.0492	.0015	.2184	.2691	2.3396	2.4926
3-23-37	0.74		.0104	.0034	.5366	.5504	.5198	

Nitrogen, Chloride and Sulfate Content of Rain Water at Blackwell, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
10-20-35	1.25		.1360	.0048	.0567	.1975	.2833	.6846
10-30-35	2.25		.0610	.0014	.0170	.0794	.0567	.2272
Per Month		2.86	.3756	.0118	.1405	.5279	.6482	1.7384
11-9-35	0.50		.0308	.0019	.0227	.0554	.3399	.4661
Per Month		3.32	.2045	.0126	.1507	.3678	2.2569	3.0949
5-8-36	1.10		.0169	.0017	.0125	.0311	.2493	4.9054
Per Month		2.52	.0387	.0039	.0286	.0721	.5711	11.2378
6-5-36	1.83		.0199	.0000	.0166	.0365		
Per Month		5.48	.0596		.0497	.1093		
9-26-36	3.00		.0952	.0027	.3399	.4378	2.0734	3.9972
Per Month		6.02			1.3798	1.3798		7.2053
10-8-36	1.50		.0870	.0003	.0510	.1383	1.6995	4.3099
Per Month		2.15	.1247	.0004	.0731	.1982	2.4362	6.1782
12-1-36	0.25		.0169	.0011	.0085	.0265	.2266	
12-5-36	0.50		.0265	.0005	.0008	.0278	.4135	2.2839
Per Month		2.25	.1302	.0048	.0279	.1629	1.9203	10.2776
2-20-37	0.29		.0160	.0001	.0986	.1147		
Per Month		0.51	.0281	.0002	.1734	.2017		
3-13-37	0.50				.1812	.1812		

Nitrogen, Chloride and Sulfate Content of Rain Water at Dewey, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
11-25-35	1.00		.0616	.0016	.1700	.2332	.1133	1.5449
Per Month		1.00	.0616	.0016	.1700	.2332	.1133	1.5449
12-5, 6-35	1.21		.0877	.0019	.2056	.2952	.0000	.3383
12-26, 29-35	0.15		.0075	.0008	.0034	.0117	.0689	.1978
Per Month		1.36	.0952	.0027	.2090	.3069	.0689	.5361
1-1, 2-36	0.60		.0190	.0023	.0054	.0267	.0827	.5128
Per Month		0.60	.0190	.0023	.0054	.0267	.0827	.5128
2-1, 4-36	0.20		.0335	.0034	.0036	.0405	.0230	.1816
2-26-36	1.00		.0906	.0091	.0363	.1360	.2302	.7164
Per Month		1.20	.1241	.0125	.0399	.1765	.2532	.8980
4-9-36	0.45		.0530	.0002	.0306	.0838	.5670	.1050
4-21, 28-36	1.30		.1119	.0041	.0884	.2044	.7659	1.0567
Per Month		1.75	.1649	.0043	.1190	.2882	1.3329	1.1617
5-1-36	3.50		.1428	.0079	.0476	.1983	2.0621	4.1106
5-8-36	2.60		.0589	.0059	.0236	.0884	1.7675	2.4480
5-11-36	0.80		.0073	.0018	.0036	.0127	.2755	.6860
5-18-36	0.85		.0116	.0019	.0193	.0328	.2928	1.3997
5-22, 24-36	0.50		.0159	.0008	.0068	.0235	.2266	1.8068
Per Month		8.25	.2365	.0183	.1009	.3557	4.6245	8.6443

Continued.

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
6-5, 6, 7-36	5.10		.1063	.0046	.0693	.1802	1.7566	3.2773
6-17, 30-36	1.00		.0054	.0005	.0906	.0965	.7931	1.7246
Per Month		6.10	.1117	.0054	.1599	.2770	2.5497	5.0019
9-1-36	1.10		.0688	.0005	.2991	.3684	.8824	1.7774
9-7, 12-36	1.00		.0589	.0032	.0045	.0666	.9200	2.6542
9-16, 19-36	4.50		.0408	.0102	.1428	.1938	1.0340	5.2851
9-20-36	2.70		.1958	.0098	.0245	.2301	.9300	1.2824
9-23-36	0.90		.0408	.0004	.0734	.1146	.2068	.4023
9-26, 28-36	2.70		.0245	.0110	.0857	.1212	.3102	1.8859
Per Month		12.90	.4296	.0351	.6300	1.0947	4.2834	13.2873
10-6, 8-36	5.80		.2891	.0026	.1051	.3968	1.9977	5.4352
10-21, 22-36	1.00		.0363	.0050	.0227	.0640	.1149	3.6508
Per Month		6.80	.3254	.0076	.1278	.4608	2.1126	8.0860
11-2-36	1.90		.0344	.0060	.0000	.0404	.2183	1.0440
Per Month		1.90	.0344	.0060	.0000	.0404	.2183	1.0440
12-1, 2-36	0.70		.0063	.0011	.0476	.0550	.4029	4.3092
12-5-36	1.30		.0059	.0100	.0295	.0454	.1494	5.8236
12-31-36	1.00		.0272	.0005	.0770	.1047	.9200	7.8549
Per Month		3.00	.0394	.0116	.1541	.2051	1.4723	17.9877

Nitrogen, Chloride and Sulfate Content of Rain Water at Lawton, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
10-9-35	0.80		.0798	.0018	.0127	.0943	.1813	.1673
10-25-35	1.13		.1803	.0018	.0179	.2000	.2560	.4345
Per Month		2.94	.3962	.0055	.0466	.4483	.6661	.9167
11-24-35	0.80		.0493	.0004	.0091	.0588	.1812	.2144
11-25-35	1.31		.1472	.0021	.0297	.1790	.2968	.3969
Per Month		2.69	.2505	.0032	.0495	.3032	.6094	.7793
12-5, 6-35	1.60		.1131	.0025	.0254	.1410	.3626	.7084
Per Month		1.97	.1392	.0031	.0313	.1736	.4464	.8722
5-1-36	0.52		.0269	.0012	.0118	.0399	.3535	.3617
5-8-36	0.82		.0736	.0018	.0130	.0884	.4645	.1834
5-22, 23-36	1.12		.0792	.0003	.0010	.0805	.8883	.3121
5-28-36	1.24		.1293	.0039	.0562	.1894	.7025	3.5713
5-29-36	0.57		.0232	.0009	.0362	.0603		
Per Month		5.26	.4092	.0100	.1456	.5648	3.4244	6.2956
6-5-36	3.35		.0455	.0015	.0911	.1381		
Per Month		3.52	.0478	.0016	.0957	.1451		
9-18-36	3.35		.0440	.0030	.1518	.1988	.9489	1.8674
9-21, 23-36	3.93		.1051	.0062	.5354	.6467	1.3803	.5496
9-25-36	1.30		.0230	.0041	.2209	.2480	.6481	.1679
9-26-36	0.87		.0114	.0004	.0789	.0907	.5520	.1703
Per Month		8.71	.1691	.0126	.9086	1.0903	3.2526	2.5392
10-21, 22-36	0.51		.0308	.0027	.0347	.0682	.3177	.3423
Per Month		0.51	.0308	.0027	.0347	.0682	.3177	.3423
12-4, 5-36	0.53		.0128	.0002	.1801	.2031	.7266	.4941
Per Month		1.50	.0645	.0006	.5097	.5748	2.0564	1.3984
3-3, 6-36	1.28		.0447	.0041	.0870	.1358	.1740	

Nitrogen, Chloride and Sulfate Content of Rain Water at Woodward, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
10-16, 17-35	0.85		.0693	.0004	.0096	.0793	.1926	.1882
10-25-35	0.55		.0294	.0002	.0087	.0383	.1946	.7104
Per Month		2.57	.1812	.0011	.0336	.2159	.5823	1.6496
11-3-35	0.25		.0181	.0004	.0057	.0242	.0000	.0350
11-24-35	0.50		.0195	.0005	.0057	.0257	.1133	.1166
11-26-35	1.80		.1697	.0016	.0286	.1999	.4079	.6081
Per Month		2.53	.2081	.0023	.0377	.2481	.5733	.7972
12-1-35	0.20		.0111	.0008	.0032	.0151	.0000	
12-20-35	0.10		.0083	.0002	.0453	.0538	.0113	
Per Month		0.39	.0252	.0013	.0631	.0896	.0147	
1-1-36	0.36		.0317	.0011	.1224	.1552	.0408	
Per Month		0.89	.0784	.0027	.3026	.3837	.1009	
4-27-36	0.45		.0392	.0007	.0051	.0450		.0839
Per Month		0.65	.0566	.0010	.0074	.0650		.1212
5-7-36	0.32		.0122	.0012	.0022	.0156	.0544	.1427
Per Month		5.71	.2177	.0214	.0393	.2784	.9703	.2546
6-4-36	2.75		.0623	.0062	.0748	.1433	.6232	.3461
Per Month		2.81	.0637	.0063	.0764	.1464	.6368	.3536

Continued.

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
8-4-36	0.37		.0422	.0024	.0367	.0813	.0578	
8-28-36	0.08						.0193	
Per Month		0.45	.0422	.0024	.0367	.0813	.0771	
9-6-36	0.96		.0418	.0009	.0326	.0753	.2610	.3394
9-15-36	0.50		.0385	.0018	.0170	.0573	.0680	.0280
9-26, 27-36	0.44		.0124	.0010	.0150	.0284	.2991	.1641
Per Month		3.84	.1873	.0075	.1306	.3254	1.2694	1.0742
10-7, 8-36	1.34		.0364	.0009	.0455	.0828	.6528	1.0868
Per Month		1.76	.0478	.0012	.0598	.1088	.8574	1.4274
3-12, 13-37	1.00		.0372	.0009	.4532	.4913	.2266	

Nitrogen, Chloride and Sulfate Content of Rain Water at Oklahoma City, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
10-9, 10-35	0.75		.0000	.0031	.0085	.0116	.1699	.5855
10-17, 18-35	0.16		.0028	.0006	.0025	.0059	.0362	.0988
10-23, 24-35	0.55		.0429	.0009	.0623	.1061	.2492	.5064
10-24, 25-35	0.07		.0069	.0003	.0011	.0083	.0158	.0424
10-31-35	0.20		.0120	.0005	.0034	.0159		.0489
10-31-35	0.22		.0163	.0005	.0026	.0194	.0498	.0949
Per Month		2.84	.1178	.0086	.1171	.2435	.8453	2.0053
11-4-35	0.17		.0079	.0004	.0029	.0112	.0770	.0634
11-9-35	0.21		.0129	.0005	.0033	.0167	.0476	.0783
11-15-35	0.09		.0014	.0002	.0010	.0026	.0204	.1292
11-24-35	0.28		.0048	.0006	.0044	.0098	.0952	.1827
11-25, 26-35	1.20		.0609	.0027	.0136	.0772	.4079	.3916
Per Month		2.00	.0902	.0045	.0258	.1205	.6647	.8668
12-5, 6-35	0.81		.0316	.0004	.0092	.0412	.3670	
Per Month		1.81	.0706	.0009	.0206	.0921	.8201	
2-25-36	0.61		.0763	.0006	.0138	.0907	.1382	
Per Month		0.76	.0951	.0007	.0172	.1130	.1722	
5-1-36	0.90		.0359	.0008	.0061	.0428	.4079	.1846

Continued.

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
5-8-36	2.87		.0754	.0065	.0455	.1274	1.3006	4.4223
5-27, 28-36	1.25		.0600	.0048	.0793	.1441	.2832	2.0563
5-29-36	0.63		.0206	.0014	.0171	.0391		.1350
Per Month		5.56	.1888	.0133	.1456	.3477	3.9834	6.6984
6-4, 5-36	0.23		.0047	.0003	.0061	.0111	.1018	.3800
Per Month		0.23	.0047	.0003	.0061	.0111	.1018	.3800
9-18-36	3.60		.0979	.0008	.2447	.3434	.8973	.8729
9-19, 23-36	2.25		.0454	.0020	.1020	.1494	1.1727	.3355
9-25, 28-36	2.55		.0370	.0012	.1733	.2115		1.0459
Per Month		8.49	.1822	.0040	.5256	.7118	3.0080	2.2784
10-6, 9-36	1.45		.0746	.0003	.0986	.1735	.4107	.5543
10-21-36	0.35		.0246	.0006	.0238	.0490	.2379	.2904
Per Month		1.93	.1064	.0010	.1312	.2386	.6954	.9057
12-26-36	1.00		.0295	.0018	.4532	.4845	1.1330	.4568
Per Month		1.31	.0386	.0024	.5937	.6347	1.4842	.5984
3-6, 7-37	0.17		.0033	.0004	.0250	.0287	.0212	
3-23-37	0.50		.0002	.0008	.2266	.2276	.0113	

Nitrogen, Chloride and Sulfate Content of Rain Water at Stillwater, Oklahoma

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS: Ammonia	Nitrite	Nitrate	Total	POUNDS PER ACRE Chlorides	Sulfates
8-28-35	3.00		.2339	.0014		.2353	.0000	2.8670
Per Month		3.08	.2401	.0014		.2415	.0000	2.9434
9-25, 26-35	0.42		.0567	.0046	.0067	.0650		
Per Month		2.26	.3051	.0086	.0361	.3498		
10-18-35	0.56		.0629	.0018	.0089	.0736	.2538	
10-20-35	0.57		.0697		.0650	.1347	.1292	.1661
10-30, 31-35	0.29		.0531	.0015	.0459	.1005	.6118	
Per Month		2.18	.2892	.0087	.1865	.4844	1.5490	.6353
11-9-35	0.11		.0140	.0003	.0012	.0155	.0374	.1564
11-16-35	0.14		.0170	.0006	.0024	.0200		
11-24-35	0.23		.0206	.0005	.0026	.0237	.0521	.2064
11-26-35	1.27		.0645	.0006	.0201	.0852	.5756	
Per Month		2.16	.1432	.0024	.0325	.1781	.8923	2.3048
12-5, 6-35	1.20		.0859	.0005	.0190	.1054	.4079	.2097
12-27-35	0.03		.0018	.0001	.0136	.0155	.0000	
Per Month		1.93	.1369	.0009	.0509	.1887	.6367	.3355
4-27-36	1.03		.1167	.0016	.0233	.1416	.5835	.1728
Per Month		1.11	.1258	.0017	.0251	.1526	.6288	.1862
5-7, 8-36	2.12		.0307	.0034	.0336	.0677	1.2010	.1778
5-11-36	0.36		.0382	.0020	.1632	.2034	.2039	
5-27-36	0.81		.0316	.0031	.0073	.0420		1.5656
Per Month		4.84	.1478	.0125	.3032	.4635	2.7418	2.8797
6-5-36	1.62		.0940	.0037	.0734	.1711		2.9734
Per Month		1.91	.1108	.0044	.0865	.2017		3.5056

Continued.

Date of Rain	Rainfall Collected (Inches)	Rainfall Reported Per Mo. (Inches)	POUNDS OF NITROGEN PER ACRE AS:				POUNDS PER ACRE	
			Ammonia	Nitrite	Nitrate	Total	Chlorides	Sulfates
9-3-36	0.48		.0276	.0001	.0653	.0930	.3263	
9-16-36	1.36		.0173	.0006	.0231	.0410	.3236	.2034
9-26-36	1.30		.0253	.0029	.1326	.1608	.2062	4.2174
Per Month		5.77	.1290	.0066	.4061	.5417	1.5731	9.5892
10-7-36	0.16		.0073	.0001	.0109	.0183		1.9718
10-20-36	0.40			.0001	.0906	.0907		
10-26-36	0.29			.0001	.0197	.0198		
Per Month		2.31	.1054	.0008	.3293	.4355		28.4679
12-27-36	0.34		.0216	.0013	.4237	.4466	.0770	
12-29-36	0.17		.0070			.0293		
Per Month		1.49	.0846			.0846		
1-7, 8-37	0.22		.0071		.1496	.1567	.0748	
1-21-37	0.06		.0011	.0000	.0680	.0691	.0014	
Per Month		0.91	.0267	.0002		.0269	.2477	
3-14-37	0.35		.0309	.0023	.0238	.0570	.0793	
3-23-37	0.51		.0365	.0029	.4623	.5017	.1733	
Per Month		0.96	.0752	.0058	.5426	.6236	.2820	

CONCLUSIONS

1. From the foregoing tables one must conclude that there are appreciable amounts of chemical compounds deposited by our annual rainfalls.
2. It will be observed that the ammonical nitrogen is greater during the spring months, after which it drops until early fall when it again rises.
3. That the greater percentage of chemical content is found in the limited rainfall after prolonged dry periods, after dust storms, and near industrial centers.
4. It was observed that the nitrate nitrogen increased after electrical disturbances, especially during the month of September.
5. The nitrite nitrogen is usually small and of slight importance.
6. The chloride content seems to be greater in the spring and fall, varying with the direction of the wind and the location.
7. The sulfates are surprisingly high and vary a great deal with the location and time of year. Samples collected at industrial centers are uniformly higher, suggesting contamination from fumes of burning oil, gas or coal.

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