gypsum has a much higher solubility and it will probably disappear before the solid solutions have all disappeared.

We may therefore divide the process of leaching of superphosphate roughly into four stages: First, monocalcium phosphate disappears, and solid dicalcium phosphate and a solution of phosphoric acid containing much of the lime are formed. The weight of the resulting dicalcium phosphate is less than one-half of the original monocalcium phosphate. Very little gypsum has gone into solution at this stage. The second stage consists in the complete change of dicalcium phosphate into an amorphous solid solution, and very much more gypsum goes into solution. The third stage in the leaching process is the gradual change in the solid solution to one containing relatively less phosphoric acid and more lime. The liquid solutions are now quite dilute and consequently gypsum will dissolve freely, and it is certain that the gypsum will all be washed away before the calcium phosphate (as solid solution) has been all dissolved. The fourth stage consists in the slow solution in water of a relatively insoluble solid solution of lime in phosphoric acid, which contains relatively more lime than would be required by the formula $Ca_3(PO_4)_2$.

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THE COMPOSITION OF THE DRAINAGE WATERS OF SOME ALKALI TRACTS.[1]

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IN the reclamation of an alkali tract the analysis of the drainage water is the most ready method of following the changes taking place within the soil. That the nature of the drainage water and the changes which it may undergo are problems of great practical importance is obvious when it is considered that agricultural plants display such marked difference in their tolerance of different salts and salt mixtures in their nutrient media. It is also important to note that a study of drainage water not only furnishes a clue to the nature of the soil solution in the land from which it flows, but that it may have an important bearing on the management of neighboring lands upon which it may be desirable

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to use the water again for irrigation or where the land may be affected through seepage.

It has popularly been supposed that the composition of a drainage water from an alkaline soil could be easily predicted from a knowledge of the respective solubilities of the salts composing the alkali, and even the recent literature contains discussions of this subject based upon the erroneous notion that the several components of a mixture will necessarily be removed in the order of the individual solubilities. That such is not the case, but that the relation of the vapor-pressures of the solution and of the solid components, the formation of new molecular species (such as so-called double salts), as well as some other possible factors in each individual case, must be considered, has been known, though generally ignored, by chemists and soil investigators. That the composition of the resulting solution with respect to the dissolved constituents remains constant so long as no one of the solid components disappears is well illustrated in a simple case, a mixture of sodium nitrate and potassium nitrate. If such a mixture be treated by successive portions of water, assuming, of course, that the temperature be kept constant, the composition of the several resulting solutions will be exactly the same so long as both solid salts remain in the mixture. Precisely the same sort of thing will happen with any mixture of solids, no matter how complex the course of the washing out of a mixture of salts by water, the composition of the solution which results will depend only on the solid phases which are present and not on their relative amounts. When any one of the solid phases becomes completely washed out, the composition of the solution will change.

The accumulation of alkali at the surface of soils is due mainly to the evaporation of seepage waters from lower levels. These seepage waters will in all probability have a constant composition as the water has become saturated with respect to all the constituents of the salts in the lower depths. In the converse process of washing out, the solution should have a constant composition until some one or more of the salts completely disappears. This has actually been observed in the investigations of this Bureau.

A tract of land near Salt Lake City, Utah, has been under process of reclamation, tile drains having been installed and the land leveled and frequently flooded. When reclamation was undertaken, the surface soil of this tract contained, on the average, upward of 2.7 per cent. soluble salts, while it now contains less than 0.3 per cent. soluble salts. At frequent intervals since the installation of the drains, samples of the water from the outlet weir of the drainage system have been forwarded to the laboratory for analysis. The composition of the principal dissolved mineral constituents, at several different dates, is given in the following table, the analyses up to September, 1904, having been made by Mr. Bailey E. Brown, and the subsequent analyses by Mr. W. C. Taber.

TABLE I.—COMPOSITION OF SOLUBLE SALTS CONTAINED IN THE DRAINAGE WATER OF THE TRACT NEAR SALT LAKE CITY, UTAH.

Date.		Ca. Per cent.	Mg. Per cent.	Na. Per cent.	K. Per cent.	SO_4. Per cent.	Cl. Per cent.	HCO_3. Per cent.	CO_3. Per cent.	Parts per million in solution.
1902	Sep.	0.38	0.50	33.74	2.04	18.62	37.76	6.49	0.48	18035
	Oct.	0.23	0.78	34.73	1.49	19.14	39.52	5.06	0.29	17915
	Nov.	0.19	0.74	34.42	1.40	18.61	40.46	3.95	0.23	19905
1903	May	0.38	0.61	34.48	0.84	29.90	38.19	4.30	0.25	18752
	June	0.45	0.85	34.18	1.09	17.52	41.00	4.23	0.42	21099
	July	0.50	0.80	34.06	1.25	18.24	40.24	4.67	0.30	19089
	Aug.	0.35	0.90	34.40	1.12	17.15	42.37	3.48	0.16	26060
	Sep.	0.49	0.72	34.54	1.24	17.31	42.02	3.36	0.33	22240
	Oct.	0.47	1.02	33.43	1.52	16.08	43.28	3.33	0.30	19020
	Dec.	1.25	0.70	32.62	1.69	19.89	37.44	6.18	0.22	12966
1904	Jan.	0.15	0.75	33.93	1.26	20.08	36.64	6.94	0.25	11334
	Feb.	0.34	0.78	34.59	0.70	18.95	40.15	4.49	...	.....
	Mar.	0.29	0.77	34.57	1.28	16.31	42.28	3.81	0.19	21006
	Apr.	0.29	0.70	34.28	1.37	20.93	38.04	3.33	1.06	16372
	May	0.71	0.74	26.92	4.01	21.26	40.93	4.05	1.38	12677
	June	0.37	0.70	32.60	3.55	19.94	37.42	4.05	1.37	12695
	Aug.	0.37	0.86	33.85	2.13	17.12	41.31	3.20	1.16	15073
	Sep.	0.42	0.79	34.10	1.35	19.01	39.85	4.11	0.37	15717
	Oct.	1.04	0.60	33.01	1.86	21.42	36.63	4.68	0.76	11623
1905	Feb.	0.32	0.67	33.59	0.99	22.30	33.32	8.45	0.36	8235
	Mar.	0.31	0.66	33.46	1.30	21.60	33.86	8.46	0.35	8455
	Apr.	0.35	0.65	34.20	1.01	20.03	36.99	6.22	0.55	10701
	May	0.45	0.86	33.43	1.20	20.59	36.04	6.96	0.47	9569
	June	0.40	0.94	34.05	1.32	20.89	35.85	5.71	0.84	10612
	July	0.32	0.69	33.67	1.30	21.17	34.94	7.23	0.68	8763
	Aug.	0.35	1.04	33.12	1.58	21.58	35.92	5.72	0.99	9000
	Sep.	0.42	0.82	33.39	1.26	21.18	34.85	7.41	0.67	8992
1906	Jan.	0.55	0.84	33.12	1.11	21.10	34.35	8.57	0.36	8401
	Apr.	0.32	0.77	34.03	1.09	19.84	37.40	6.03	0.52	11531

It will be observed that the variations of the several constituents, within an interval of nearly four years, are very small, such differences as do appear being readily attributable to the relatively small changes in the actual concentrations of the drainage water at different times, produced by the addition of large quantities of water in flooding, some of which reached the tiles before coming into equilibrium with the soil components.

In Tables II, III and IV are given the data obtained with drainage waters from a tract near Fresno, California, a tract near North Yakima, Washington, and a tract near Billings, Montana. In these cases it has not been considered necessary to have such complete analyses, over the entire time which the reclamation has been progressing, so that the data given apply to much shorter intervals than in the case of the Swan tract. They furnish, nevertheless, interesting examples of the same character.

TABLE II.—COMPOSITION OF SOLUBLE SALTS CONTAINED IN THE DRAINAGE WATER OF THE TRACT NEAR FRESNO, CALIFORNIA.

Date, 1903.	Ca. Per cent.	Mg. Per cent.	Na. Per cent.	K. Per cent.	SO_4. Per cent.	Cl. Per cent.	HCO_3. Per cent.	CO_3. Per cent.	Parts per million in solution.
March 28	8.90	3.77	11.78	2.66	12.23	6.66	54 00	.....	450
April 25	6.91	6.06	7.88	2.18	4.85	8.85	63.27	.....	824
May 2	3.59	4.15	16.35	1.75	2.39	8.95	60.99	1.83	1251
May 9	3.57	3.64	20.49	1.58	2.06	9.62	51.82	7.22	1454
May 16	3.58	3.76	19.72	1.44	1.88	9.69	54.79	5.14	1592
May 23	5.36	4.28	15.47	1.76	3.06	10.73	59.34	.....	1306
May 30	2.07	3.47	23.55	2.00	7.01	10.55	40.63	10.57	1639
June 6	3.01	3.15	22.84	2.35	6.45	11.79	40.50	9.79	1495
June 13	3.24	2.96	22.70	2.19	3.91	13.35	43.32	8.29	1048
June 20	3.81	3.21	21.82	1.87	2.79	11.78	54.19	.....	1494
June 21	3.20	3.38	21.09	2.82	2.63	9.88	56.96	.....	1062
July 4	3.06	2.27	20.82	2.63	4.98	6.12	57.21	2.97	1143
July 11	3.60	1.69	23.04	3.77	6.38	18.09	39.32	3.90	768

TABLE III.—COMPOSITION OF SOLUBLE SALTS CONTAINED IN THE DRAINAGE WATER OF THE TRACT NEAR NORTH YAKIMA, WASHINGTON.

Date, 1903.	Ca. Per cent.	Mg. Per cent.	Na. Per cent.	K. Per cent.	SO_4. Per cent.	Cl. Per cent.	HCO_3. Per cent.	CO_3. Per cent.	Parts per million in solution.
Aug. 1	4.93	5.26	12.91	4.09	20.06	4.85	47.91	.....	1440
Aug. 9	8.43	6.46	7.06	4.27	17.57	7.30	48.87	.....	1684
Aug. 15	7.58	3.23	14.19	4.68	24.51	6.47	36.95	2.40	2162
Aug. 22	7.57	5.03	12.09	3.37	23.68	6.45	39.10	2.66	2166
Aug. 29	5.27	5.06	14.52	3.56	21.36	4.79	41.43	3.96	1460
Sep. 5	7.36	5.21	12.38	1.86	23.33	5 01	43.40	1.38	2092
Sep. 12	9.32	5.59	10.29	1.32	25.55	6.79	41.12	trace	2575
Sep. 19	4.80	10.91	0.33	0.56	26.06	5.94	46.21	2.43	1768
Sep. 26	5.05	4.98	14.44	3.49	15.18	5.21	47.31	4.32	1343
Oct. 3	5.09	0.41	15.36	2.20	14.12	0.47	54.23	.....	1451

TABLE IV.—COMPOSITION OF SOLUBLE SALTS CONTAINED IN THE DRAINAGE WATER OF THE TRACT NEAR BILLINGS, MONTANA.

Date.	Ca. Per cent.	Mg. Per cent.	Na. Per cent.	K. Per cent.	SO_4. Per cent.	Cl. Per cent.	HCO_3. Per cent.	CO_3. Per cent.	Parts per million in solution.
1905 June	2.0	5.84	20.44	0.45	65.98	1.57	3.65	0.07	22376
July	2.33	5.71	20.29	0.53	65.27	1.60	4.27	.....	15490
Aug.	3.25	5.36	19.45	0.82	63.53	1.79	5.80	.....	7841
1906 May	3.63	5.95	18.72	0.46	69.07	1.47	0.45	0.25	11950

The data just presented are believed to be of more than ordinary importance, because they so well illustrate the character of the results which may be anticipated in a large number of cases in actual field work. How long the practically constant percentage composition of the dissolved salts would continue in the drainage water under continued flooding it is, of course, difficult, if not impossible, to predict. It is reasonably certain that sooner or later some one or more of the solid components in the soil would be completely removed, barring absorption or some other special phenomena, and the nature of the solution might then be very materially altered. As a practical matter, however, it should be remembered that the persistence of the several solid phases of the alkali mixture does not necessarily mean that they are evenly distributed in the soil, and that while they may be determining the composition of the solution as it passes into the drain tiles, some of these solid phases may have been removed from the surface soil, which would then hold a solution of different character, in which latter crops could very well grow. This seems to be true, as there is evidence that crops can now be grown on some of these tracts, if proper cultural methods be maintained to prevent the subsequent capillary rise of the water added in flooding. It appears certain, however, that in such cases the land can not be truly regarded as finally reclaimed until the change in the composition of the drainage water shows that there has been a complete removal of some of the solid salts from that portion of the soil which feeds the drains.

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