SAR and Adjusted SAR Calculation

1. Scope, Applications and Summary of Method

The sodium adsorption ratio (SAR) uses sodium, calcium, and magnesium concentrations to determine if irrigation water is likely to cause soil permeability problems. The adjusted SAR takes into account calcium carbonate solubility. As SAR or adjusted SAR increases, soil quality tends to decrease. SAR requires sample results for sodium, calcium, and magnesium. Adjusted SAR requires sample results for sodium, calcium, magnesium, conductivity, and bicarbonate.

2. Detection and Reporting Limits

There are no reporting limit or units associated with SAR.

3. Sample Collection, Preservation and Holding Times

Since SAR and adjusted SAR require sodium, calcium, magnesium (all covered in ISOP1.03 ICP), conductivity (WCSOP2.05 Cond), and bicarbonate (WCSOP2.01 Alk&Bicarb) in order to be determined, see these SOPs for sample collection, preservation, and holding times. The shortest hold time is 14 days for bicarbonate.

4. Data Analysis and Reporting

1. SAR is calculated using the following equation:

$$\text{SAR} = \frac{[\text{Na}]}{\sqrt{\frac{[\text{Ca}] + [\text{Mg}]}{2}}},$$

where [Na], [Ca], and [Mg] are the concentrations of sodium, calcium, and magnesium respectively, given in milliequivalents per liter (meq/L). Milliequivalents per liter are calculated by multiplying the analyte concentration (in mg/L) by its valence, then dividing by atomic weight. The conversion factor for sodium is 22.99, calcium 20.04, and magnesium 12.16.

2. The adjusted SAR is calculated using the following equation:

$$\text{adjusted SAR} = \frac{[\text{Na}]}{\sqrt{\frac{[\text{Ca}_x] + [\text{Mg}]}{2}}},$$

where [Na] and [Mg] are the concentrations of sodium and magnesium respectively, given in meq/L (see above). To determine $[Ca_x]$, first calculate the ratio of bicarbonate and calcium, $[HCO_3]/[Ca]$ in meq/L. The formula weight of HCO_3 is 61.0. Along the left side of the Ca_x Table, find the ratio nearest the calculated ratio. Along the top of the table, find the conductivity value, in millimohs (or decisiemens/meter), nearest the measured value. The number at the intersection of this column and row is $[Ca_x]$.

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Ratio of HCO_3/Ca	Conductivity (millimohs)											
	0.1	0.2	0.3	0.5	0.7	1.0	1.5	2.0	3.0	4.0	6.0	8.0
0.05	13.20	13.60	13.92	14.40	14.79	15.26	15.91	16.43	17.28	17.97	19.07	19.94
0.10	8.31	8.57	8.77	9.07	9.31	9.62	10.02	10.35	10.89	11.32	12.01	12.56
0.15	6.34	6.54	6.69	6.92	7.11	7.34	7.65	7.90	8.31	8.64	9.17	9.58
0.20	5.24	5.40	5.52	5.71	5.87	6.06	6.31	6.52	6.86	7.13	7.57	7.91
0.25	4.51	4.65	4.76	4.92	5.06	5.22	5.44	5.62	5.91	6.15	6.52	6.82
0.30	4.00	4.12	4.21	4.36	4.48	4.62	4.82	4.98	5.24	5.44	5.77	6.04
0.35	3.61	3.72	3.80	3.94	4.04	4.17	4.35	4.49	4.72	4.91	5.21	5.45
0.40	3.30	3.40	3.48	3.60	3.70	3.82	3.98	4.11	4.32	4.49	4.77	4.98
0.45	3.05	3.14	3.22	3.33	3.42	3.53	3.68	3.80	4.00	4.15	4.41	4.61
0.50	2.84	2.93	3.00	3.10	3.19	3.29	3.43	3.54	3.72	3.87	4.11	4.30
0.75	2.17	2.24	2.29	2.37	2.43	2.51	2.62	2.70	2.84	2.95	3.14	3.28
1.00	1.79	1.85	1.89	1.96	2.01	2.09	2.16	2.23	2.35	2.44	2.59	2.71
1.25	1.54	1.59	1.63	1.68	1.73	1.78	1.86	1.92	2.02	2.10	2.23	2.33
1.50	1.37	1.41	1.44	1.49	1.53	1.58	1.65	1.70	1.79	1.86	1.97	2.07
1.75	1.23	1.27	1.30	1.35	1.38	1.43	1.49	1.54	1.62	1.68	1.78	1.86
2.00	1.13	1.16	1.19	1.23	1.26	1.31	1.36	1.40	1.48	1.54	1.63	1.70
2.25	1.04	1.08	1.10	1.14	1.17	1.21	1.26	1.30	1.37	1.42	1.51	1.58
2.50	0.97	1.00	1.02	1.06	1.09	1.12	1.17	1.21	1.27	1.32	1.40	1.47
3.00	0.85	0.89	0.91	0.94	0.96	1.00	1.04	1.07	1.13	1.17	1.24	1.30
3.50	0.78	0.80	0.82	0.85	0.87	0.90	0.94	0.97	1.02	1.06	1.12	1.17
4.00	0.71	0.73	0.75	0.78	0.80	0.82	0.86	0.88	0.93	0.97	1.03	1.07
4.50	0.66	0.68	0.69	0.72	0.74	0.76	0.79	0.82	0.86	0.90	0.95	0.99
5.00	0.61	0.63	0.65	0.67	0.69	0.71	0.74	0.76	0.80	0.83	0.88	0.93
7.00	0.49	0.50	0.52	0.53	0.55	0.57	0.59	0.61	0.64	0.67	0.71	0.74
10.0	0.39	0.40	0.41	0.42	0.43	0.45	0.47	0.48	0.51	0.53	0.56	0.58
20.0	0.24	0.25	0.26	0.26	0.27	0.28	0.29	0.30	0.32	0.33	0.35	0.37
30.0	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.24	0.25	0.27	0.28

Ca_x Table

This calculation is set up in the spreadsheet located at W:\Spreadsheets\IONS_SAR Rev.2.00.xls. An alternative procedure which does not require a lookup table, is included on the same spreadsheet. The background and justification for this calculation is described in Reference (5).

3. Results are entered into the LIMS as follows:

a. Create a LIMS batch. At DataEntry/Review, create a Data Entry Table for the batch and save it as a user file.

b. Enter the date of analysis, result, instrument (CALC), and qualifiers for each sample, save the user file, then post the data.

c. At Data Entry/Review, query the batch. Check results. Add appropriate qualifiers. After the batch has been checked over, lock the data and update status to Analyzed.

5. References/Method Source

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1. Hanson, Blaine R., "Estimating the Sodium Adsorption Ratio". *Agricultural Salinity and Drainage*. Received via FAX transmittal from the Department of Land, Air, and Water Resources, University of California, Davis 6/4/01

2. Hanson, Blaine R.; Bowers, Wilbur; Grattan, Stephen R.; Grimes, Donald W.; and Tanji, Kenneth K.. "Trace elements limit potential for blending San Joaquin drainwater with canal water". *California Agriculture,* March-April 1991

3. "Interpretation of Irrigation Water Analyses", A & L Agricultural Laboratories, 1977

4. "Water Quality for Agriculture", Food and Agriculture Organization of the United Nations. Received from Stephen Grattan, University of California, Davis, 12/8/89.

5. Lesch SM, Suarez DL. Technical Note: A Short Note on Calculating the Adjusted SAR Calculation. *American Society of Agricultural and Biological Engineers*. 2009; 52(2):493-496

6. Ayers RS, Westcot DW. *Water Quality for Agriculture, 29,* Rev. 1. Rome, Italy: Food and Agricultural Organization of the UN; 1985: Chapter 3. Infiltration. http://www.fao.org/docrep/003/t0234e/T0234E04.htm#ch3. Accessed November 12, 2012.