

**Use of  $^{22}\text{Na}$  in the Determination  
of the Gypsum  
Required for Ameliorating Soil Alkalinity**

A. M. BALBA, H. BASSIUNY and H. HAMDY

*Middle Eastern Regional Radioisotope Centre for the Arab  
Countries, Cairo, UAR*

Soils rich in sodium carbonate are encountered at certain locations in the U. A. R. Wady Al Natroun, Farhash and Tal Al Kabir are places famous for their alkali soils and their high content of  $\text{Na}_2\text{CO}_3$ . Alkali soils are also encountered as scattered spots in the Nile valley area. Several theories have been suggested to explain the formation of  $\text{Na}_2\text{CO}_3$  in soils. These theories have been reviewed by KELLEY [4] and others [5].

Saline-sodic soils which cover a vast area in the northern part of the Nile Delta may change to sodic soils that contain sodium carbonate during their leaching process. When these soils do not contain a source of calcium ions, as gypsum or calcium carbonate, the removal of salts causes the undesirable properties of sodic soils to appear [1].

To ameliorate sodic soils or to prevent the change of saline sodic soils to sodic soils, farmers are advised to add gypsum. The added calcium ions precipitate the  $\text{CO}_3$  and replace  $\text{Na}^+$  on the clay surface. The determination of the amount of gypsum required to effect these reactions is usually carried out in the U. A. R. laboratories by a method described by SCHOONOVER [6]. The method can be summarized as follows: Five-gram soil samples are shaken with 100 ml. of saturated gypsum solution for 10 min. and filtered. The Ca + Mg are determined in (a) the gypsum solution and (b) the filtrate. The difference represents the Ca + Mg consumed in replacing the adsorbed sodium and precipitating soluble carbonate.

This method gives satisfactory results for the gypsum requirement "GR" of sodic soils. Its application to saline-sodic soils gave unsatisfactory results. The present study was carried out to evaluate this method as compared with one based on the calculation of "GR" from exchangeable sodium values found by a radioactive technique.

#### Experiments and methods

1. Soil samples containing different amounts of soluble salts were collected from different locations. Their soluble cations and  $\text{CO}_3$  and  $\text{HCO}_3$ , in 1 : 20 soil-water extracts and their exchangeable sodium contents were determined and are shown in Table 1.

2. The soil samples 1-6 inclusive, were used to show changes in soil composition that took place during reaction with gypsum solutions. The

Table 1  
Soluble cations and anions in 1:20 soil-water ratio and exchangeable Na determined by  $^{22}\text{Na}$  in 1:5 and 1:20 soil water extracts

Soil No.	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Exch. 1:20	Na 1:5
	me./100 g soil							
1. M0	4.43	0.34	0.82	0.46	—	4.43	2.72	4.18
2. M1	299.14	0.75	4.49	3.64	—	4.43	15.05	19.34
3. M2	65.48	0.44	0.61	0.46	—	7.75	16.56	20.10
4. M3	18.61	0.51	0.61	0.46	—	9.97	16.44	21.04
5. M4	12.70	0.86	0.82	0.25	0.88	9.97	15.44	20.13
6. M5	11.65	1.54	1.01	1.12	0.88	11.07	13.76	20.92
7. Mb	8.65	0.87	1.78	0.90	—			25.52
8. H1	47.74	1.62	4.26	7.79				5.49
9. Sh	18.41	0.35	0.46	0.05				18.75
10. M7	5.87	0.46	0.28	2.50				12.05
11. M8	5.69	0.99	0.74	0.89				12.22

cations, carbonate and bicarbonate were determined after equilibration with the gypsum solution. The results are shown in Table 2.

3. The methods of determining soluble Ca<sup>2+</sup>, Mg<sup>2+</sup>, K<sup>+</sup>, Na<sup>+</sup>, HCO<sub>3</sub><sup>-</sup> and CO<sub>3</sub><sup>2-</sup> were those described by the U. S. Sal. Lab. [5]. Exchangeable sodium was determined by an isotopic dilution method using radioactive  $^{22}\text{Na}$  as follows:

Table 2  
Soluble cations, anions and exchangeable Na after equilibration with a saturated gypsum solution using a soil-water ratio of 1:20

Soil No.	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Exch. Na
	me./100 g soil						
1. M0	6.96	0.62	43.04	14.74	—	2.33	1.27
2. M1	308.54	1.07	46.10	12.10	—	2.44	5.18
3. M2	79.54	0.83	35.90	6.68	—	3.99	2.80
4. M3	34.26	0.62	33.46	6.35	—	3.54	2.10
5. M4	26.09	0.62	32.03	6.71	—	3.32	1.42
6. M5	22.35	0.62	33.86	7.44	—	2.66	1.81
Sat. gyp. solution	0.61	0.03	55.28	5.92		1.22	

One gram of the soil sample was weighed and transferred to a centrifuge tube. Distilled water was added and 0.05–0.1  $\mu\text{c}$  of carrier-free  $^{22}\text{Na}$  in 1 ml. of water was added, then water was added to give the final soil-water ratio. The mixture was shaken 4–6 hr. (lengthening the period of shaking gave better results in the cases of higher salt contents), then centrifuged. One ml. of the supernatant solution was pipetted into a well-scintillation tube and the activity was counted using an automatic EKCO scaler type N 530 E. The inactive sodium was determined in the same sample with a flamephotometer. The original activity was also determined by adding the same amount of activity in 1 ml. of the carrier-free  $^{22}\text{Na}$  to a total volume equal to the

water used with the soil and measuring the activity of 1 ml. in the well scintillation tube. The amount of exchangeable sodium in the soil was calculated by applying the formula:

$$\frac{\text{exch. } ^{22}\text{Na}}{\text{sol. } ^{22}\text{Na}} = \frac{\text{exch. } ^{23}\text{Na}}{\text{sol. } ^{23}\text{Na}}$$

### Results and discussion

A comparison of the values of cations and anions for the samples in Table 1 shows the variation in the values of the cations and anions which took place after equilibration with a gypsum solution. It will be seen that  $\text{Na}^+$ ,  $\text{K}^+$  and  $\text{Mg}^{2+}$  increased in the solution phase, while soluble  $\text{Ca}^{2+}$  and exchangeable  $\text{Na}^+$  decreased. The decrease in the latter in 1 : 20 soil-water extracts was almost equal to the increase in soluble Na, while the decrease in soluble  $\text{Ca}^{2+}$  was greater than the increase in the sum of soluble  $\text{Na}^+ + \text{K}^+ + \text{Mg}^{2+}$ . The difference was nearly equal to the decrease in  $\text{CO}_3^{2-} + \text{HCO}^-$ . From this analysis, it is clear that the soluble Ca + Mg originally present in the soil should be taken into consideration in calculating the amount of Ca + Mg consumed from the gypsum solution. Their amounts should be added to the Ca + Mg of the gypsum solution before subtracting the Ca + Mg remaining in solution after equilibration with gypsum.

Saline-sodic soils, contrary to the nonsaline sodic soils, contain appreciable amounts of soluble calcium and magnesium which affect the results of the gypsum requirement determination with the SCHOONOVER method. A correction was made and the corrected values for gypsum requirements are shown in Table 3.

Table 3

**Exchangeable Na determined by  $^{22}\text{Na}$  in 1 : 5 soil water extracts and the gypsum requirement values determined and calculated from equation 1**

Soil No.	Exchangeable Na meq./100 g	SCHOON.	Corrected	Calculated
		Gypsum requirement, me./100 g		
1. M0	4.18	3.42	4.71	4.38
2. M1	19.34	3.00	11.13	20.25
3. M2	20.10	18.62	19.69	22.05
4. M3	21.04	21.40	22.47	22.03
5. M4	20.13	22.57	23.46	21.08
6. M5	20.92	23.33	25.47	21.91
7. Mb	25.52	28.32	29.91	26.72
8. H1	5.49	8.01	6.52	5.75
9. Sh	18.75	15.80	18.01	19.63
10. M7	12.05	6.70	11.34	12.62
11. M8	12.22	9.59	13.71	12.79

"G.R." = 1.047 exch. Na + 0.0 where 1.047 and 0.0 are constant.

Table 1 shows the values of exchangeable sodium determined by the  $^{22}\text{Na}$  method. In this technique the soil-water ratio in which the equilibrium between  $^{22}\text{Na}$  and  $^{23}\text{Na}$  takes place is of special importance. It is known that widening this ratio favours the displacement of the adsorbed monovalent

cations by the divalent cations [3]. Hence, exchangeable sodium is expected to be lower in the case of a soil-water ratio 1 : 20 than in the case of 1 : 5 as seen in Table 1.

Table 3 shows that the "GR" values were close to the values of the exchangeable sodium determined in 1 : 5 soil-water ratio. A mathematical relationship was tentatively established between these values (of 1 : 5 ratio) and the "GR" values by using the least squares method.

The "calculated" gypsum requirement "GR" values are given in Table 3. Thus after the determination of exchangeable sodium, the soil gypsum requirement can be calculated. The determination of exchangeable sodium is not an easy task in saline-sodic soils when the classic methods [2] are used. The use of radioactive techniques made it simple, easy and relatively accurate.

The calculated values of gypsum requirement were greater than the values of exchangeable sodium. Table 2 shows that calcium had replaced most of the adsorbed sodium after equilibration with gypsum. One may consider that these gypsum requirement values are higher than necessary to lower the exchangeable sodium to less than 15 per cent. However, field conditions are different from those prevailing in the laboratory.

### Summary

A study of the determination of the amount of gypsum required to ameliorate soil alkalinity was carried out. The results showed that  $\text{Ca}^{2+} + \text{Mg}^{2+}$  originally present in the soil should be taken into consideration in the calculation of the gypsum requirements (GR) by the SCHOONOVER method.  $^{22}\text{Na}$  was used to determine exchangeable sodium at soil water ratios of 1 : 5 and 1 : 20. It was found that values of exchangeable sodium at the former ratio were close to the values of "GR". A tentative mathematical relationship was established to calculate "GR" from exchangeable Na values.

### References

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