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# A Comparison of Sequential Extraction Methods for Used to Determine Exchangeable Cations (Ca,MgNa,K) of Erzurum Plain Agricultural Soils

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## ABSTRACT

The purpose of this study was to studiedsuitablity of sequential extraction method for determining exchangeable cations (Ca,Mg,K and Na) in Erzurum plain agriculture soils.
The purpose of also thiswas aimed investigation to exchangeable cation status of Erzurum plain soils was as well as to determine find out suitability of different extraction methods (NH40Ac extraction method and sequential extraction method) for the availability exchangeable cations (Ca,Mg,K,Na)in Erzurum region soils. Representative 19 of soils samples were collected from different soil locations of Erzurum. In order to select the most suitable chemical method as related to exchangeable cations content of the test plant (potato) was taken as the standart (biological) index.
The results of this study showed that plant available Ca,Mg,K,Na obtained with sequentaly extraction step 2 exchangeable K and step.6 exchangeable Na residual chemical exraction methods were interrelated ($p<0.05$) with K and Na content of potato leaf (biological index) for Erzurum Plain soils.

**Keywords:** Availability,Soil-exchangeable cationstests , NH40Ac and SequentialyExtraction Methods,Correlation, Biological indexes

## 1. INTRODUCTION

Soil test is a chemical or physical measurement of soil its properties based on the sample of soil (Melsted and Peck.1973). Commonly, however, the soil test is considered as a rapid chemical analysis or quick test to assess the readily extractable chemical elements of a soil. Interpretations of soil tests provide assessments of the amount of available nutrients, which plants may absorb from the soil. Recommendations for fertilization may be based on the results of soil tests. Chemical soil tests may also measure salinity, pH, and presence of elements that may have inhibitory effects on plant growth. A basic principle of soil testing is that an area can be sampled so that chemical analysis of the samples will assess the nutrient status of the entire sampled area(Peckand Melsted.1973)
Results of soil tests must be calibrated with crop responses in the soil. Crop responses, such as growth and yields, are obtained through experimentation. In the calibrations, the results of soil tests are treatedas independent variables affecting crop growth and yields; otherwise, all other variables such as weather, season, diseases, soil types, weeds, and other environmental factors must be known and interpreted. The consideration of results of soil test as independent variables may impart difficulties in interpreting the results, especially if the environmental factors have marked effects on crop yields.Results of soil analysis, sometimes called total analysis, in which soil mineral and organic matter are destroyed with strong mineral acids, heat, or other agents do not correlate well with crop responses (Morgan,1941). Generally, soil tests involve determination of a form of a plant nutrient with which a variation in amount is correlated with crop growth and yield. These forms of nutrients are commonly called available plant nutrients. The different forms of nutrients are extracted from the soil with some solvent. Many different methods of extraction of soil samples are being used for measurement of available nutrients in soils. Extractants are various combinations of water, acids, bases, salts, and chelating agents at different strengths. The extractants are designed to extract specific nutrients or are universal extractants (Morgan 1941;Watanabe and Olsen.1962).
A plant nutrient is a chemical element that is essential for plant growth and reproduction. Essential element is a term often used to identify a plant nutrient. The term nutrient implies essentiality, so it is redundant to call these elements essential nutrients. Seventeen elements are considered to have met the criteria for designation as plant nutrients. Carbon, hydrogen, and oxygen are derived from air or water. The other 14 are obtained from soil or nutrient solutions. For all the nutrients, their roles in agriculture were the subjects of careful investigations long before the elements were accepted as nutrients. One of them are Ca,Mg, K and as a beneficial element Na(Barker and Pilbeam,2007).Calcium was one of the 20 essential elements that Sprengel identified.Within the fraction of soils where particles are as small as clay particles, calcium occurs in gypsum,calcite, hornblende, and plagioclase.Any calcium present in these more mature soils will be present attached to cation-exchange sites, where it usually constitutes a high proportion of total exchangeable cations, so the amounts present depend on the CEC of the soil.The main test for soil calcium is to calculate the amount of the limestone required for a particular crop on a particular soil.The amount of lime required is determined from soil analysis, either by a pH base saturation method or a buffer solution method.The most important potassium-bearing minerals in soils are alkali feldspars (30 to 20 g K/kg) , muscovite (K mica, 60 to 90 g K/kg), biotite (Mg mica, 36 to 80 g K/kg), and illite (32 to 56 g K/kg). These are the main natural potassium sources from which K is released by weathering and which feed plants.Fractions of potassium in soil are (a) total potassium, (b) nonexchangeable (but plant-available) potassium, (c) exchangeable potassium, and (d)

 

water-soluble potassium. The total potassium comprises the mineral potassium and potassium in the soil solution and in organic matter. Soil solution potassium plus organic matter potassium represent only a small portion of the total in mineral soils. The total potassium depends much on the proportion of clay minerals and on the type of clay minerals.Several decades ago it was assumed that the 'activity ratio' between the K activity and the $Ca^2$plus $Mg^2$ activities in the soil solution would describe the K availability in soils according to the equation (Beckett,1964) AR=K/(Ca2 Mg2).
The most common test for available K is the exchangeable K obtained by extraction with 1M $NH_4Cl$ or $NH_4$ acetate. In surface soils, magnesium concentrations usually range from 0.03 to 0.84%, with sandy soils typically having the lowest magnesiumconcentrations (0.05%), and clay soils containing the highest magnesium concentrations (0.50%) . Like other metallic elements, the soil magnesium pool consists of three fractions: nonexchangeable, exchangeable, and water-soluble fractions. The nonexchangeable fraction consists of the magnesium present in the primary minerals and many of the secondary clay minerals. In most soils, magnesium can be extracted with a solution containing ammonium acetate $CaCl_2$ or with water .Sodium and potassium, being adjacent elements in Group 1 of the Periodic Table, have similar chemical properties.Much of the sodium is in seawater, to the extent of 30.6% by weight compared with only 1.1% for potassium and 1.2% for calcium. Chloride, although present at only 0.05% in the Earth's crust, makes up 55% of the mass of seawater salts.Some sodium occurs in most soils, but in temperate climates, the concentrations are often similar to, or lower than, those of potassium. Excessive amounts of sodium may be present in the soil in arid and semi-arid areas, and where evapotranspiration is similar to or greater than precipitation (Barker and Pilbeam,2007).
With correlation to plant growth, development, and yield, soil testing indicates the capacity of soils to supplyplant nutrients and suggests appropriate corrective measures. Plant analysis, used in conjunction with plant symptoms and soil testing, is another common tool for assessment of the nutritional status of plants. The development of a soil test requires selection of an extractant, development of studies that correlate the amount of nutrient extracted with element accumulation by crops, and calibration studies that determine a relationship between soil test results and amount of fertilizer required foroptimal production (Barker and Pilbeam,2007).
A chemical method for estimating the nutrient suppling capacity of a soil ; measures a portion of a nutrient from a 'pool' that is used by plants; an index of nutrient availability ; does not measure the total amount of nutrient in the soil ; needs to be calibrated in field /greenhouse rate studiesto then use in nutrient (fertilizer) recommendations. Can determine soil nutrient status before a crop ( field, vegetable, ornamental) is planted ( Carrie, 2008; Heckendron, 2007)
Research on the selection of chemical extraction method has been done for different climate and will be continued fort he future of all different soil and plant nutrient in Erzurum region ( Yildiz and et al.1999; Yildiz and et al.2003; Yıldız and et.al 2008); Yildiz and Güler 2010a; Yildiz and Güler.2010b; Yildiz and at al. 2010; Dizikisa and Yildiz 2016a; Dizikisa and Yildiz 2016b; Yıldız and Dizikısa.2017).

## 2. MATERIAL AND METHOD

Soils from 19 representative were sampled from potato grown fields in early April. 2010 with the aim of defining the nutrient potential in potato plants cultivated in central Erzurum. Soil samples from 0-40 cm depth in selected particular stations were taken and sieved with a 2mm mesh screen to analyse the different chemical properties and soil nutrient status. Leaf tissue was oven dried at 68 °C for 48 hours and ground to pass through a 1 mm mesh screen. The potato plant leaf sampled in start flowering from the 4th leaf plant leaf sample was taken June 2010 (Yildiz and Dizikisa, 2016b).
Sequential Extraction Procedure for the Speciation ofParticulate Trace Metals (Tessier et all.1979 ; Cheng, 2005 )In defining the desired partitioning of trace metals, care was taken to choose fractions likely to be affected by various environmental conditions; the following six fractions were selected.

**Fraction 1. Water soluble forms** . 05 g soil and 10ml pure water, vortex 3 hour. And filtrated. After centrifuged.

**Fraction 2. Exchangeable**. Numerous studies (Possek et all 1968; Weijden et all 1977) performed on sediments or on their major constituents (clays, hydrated oxides of iron and manganese, humic acids)

**Fraction 3. Bound to Carbonates**. Several workers (Gupta and Chen 1974; Stover et all 1976 ;Chester.et all 1967; Perkc.1974) have shown that significant trace metal concentrations can be associated with sediment carbonates; this fraction would be susceptible to changes of pH.

**Fraction 4. Bound to Iron and Manganese Oxides (Metal oxides)**. It is well established (Jenne,1968) that iron and manganese oxides exist as nodules, concretions, cement between particles, or simply as a coating on particles

**Fraction 5. Bound to Organic Matter**. living organisms, detritus, coatings on mineral particles, etc. The complexation and peptization properties of natural organic matter (notably humic and fulvic acids) are well recognized.

**Fraction 6. Residual.** These metals are not expectedto be released in solution over a reasonable time span underthe conditions normally encountered in nature.

## 3. RESULTS AND DISCUSSION

Determining of exchangeable Na,K,Mg,Na contents of Erzurum plain soils 2 different chemical methods ( NH4-acetat and sequential extraction methods ) were used results shown in table 1and table1 2(see appendix).
Plant Ca,Mg,Na, and K content of potato leaf were determined (Table 2) as a results of Biological indexes(Yildiz and Dizikisa,2016b).
Results showed that the step 2 exchangeable and step.6 residual chemical exraction methods might be used for plant available (exchangeable and residual fraction form) at least in this conditions growing potato in this location.
The results of this study showed that plant available Ca,Mg,K,Na obtained with sequentaly extraction step 2 exchangeable K and step.6 exchangeable Na residual chemical exraction methods were interrelated ($p<0.05$) with were interelated with K and Na content of potato leaf (biological index) in Erzurum Plain soils (Table 3)
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# APPENDIX

**Table 1: Results of Sequentialextraction analyses of soil samples**

| SE | Step1 | | | | Step2 | | | | Step3 | | | | Step4 | | | | Step5 | | | | Step6 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ÖRN .NO. | Na | Mg(ppm) | Ca(ppm) | K(ppm) | Na (ppm) | Mg (ppm) | Ca (ppm) | K (ppm) | Na | Mg (ppm) | Ca(ppb) | K(ppb) | Na | Mg (ppm) | Ca (ppm) | K (ppm) | Na (ppm) | Mg(ppm) | Ca (ppm) | K(ppm) | Na (ppm) | Mg (ppm) | Ca (ppm) | K (ppm) |
| 1 | 5,9 | 346,35 | 202,09 | 1160,23 | <0.00 | 59580,21 | 1392,81 | 1696,77 | 0 | 1,27 | <0.00 | <0.00 | 0 | 743,37 | <0.00 | 212,13 | 2994,48 | 8916,23 | 1751,79 | 2620,19 | 1359,42 | 14,46 | 261,07 | 771,48 |
| 2 | 28,3 | 200,69 | 54,09 | 158 | <0.00 | 40807,93 | 451,25 | 275,05 | 0 | 1,27 | <0.00 | <0.00 | 0 | 942,48 | 262,64 | 232,63 | 2734,52 | 4655,68 | 1651,17 | 1599,83 | 3666,62 | 25,52 | 286,27 | 853,89 |
| 3 | 4,51 | 103,4 | 51,16 | 34,53 | <0.00 | 55896,23 | 562,25 | 3193,42 | 0 | 0,15 | <0.00 | <0.00 | 0 | 602,51 | <0.00 | 256,55 | 1318,98 | 3498,5 | 757,82 | 1127,02 | 1599,79 | 28,47 | 338,42 | 889,61 |
| 4 | 24,04 | 58,83 | 25,93 | 20,42 | <0.00 | 64603,15 | 1331,45 | 823,86 | 0 | 0,65 | <0.00 | <0.00 | 0 | 604,68 | <0.00 | 138,7 | 2854,88 | 6824,03 | 1658,13 | 3082,79 | 699,96 | 123,1 | 515,12 | 751,27 |
| 5 | 44,79 | 261,76 | 59,45 | 75,26 | <0.00 | 36008,59 | 560,42 | 268,4 | 0 | 1,16 | <0.00 | <0.00 | 0 | 865,84 | 620,99 | 149,41 | 1365,79 | 6559,36 | 825,08 | 2254,59 | 3458,63 | 311,96 | 877,09 | 1586,77 |
| 6 | 21,12 | 38,43 | 22,34 | 64,69 | <0.00 | 47483,44 | 699,28 | 377,82 | 0 | 0,8 | <0.00 | <0.00 | 0 | 576,9 | 40,98 | 199,89 | 2649,59 | 4218,3 | 1559,08 | 2669,04 | 573,76 | 38,06 | 247,36 | 732,27 |
| 7 | 5,56 | 125,47 | 77,33 | 123,12 | <0.00 | 41659,04 | 838,42 | 359,05 | 0 | <0.00 | <0.00 | <0.00 | 0 | 538,72 | <0.00 | 83,15 | 3009,73 | 9826,99 | 1754,88 | 3557,2 | 1340,65 | 63,61 | 461,84 | 1265,77 |
| 8 | 15,19 | 39,7 | 52,97 | 59,54 | <0.00 | 45416,75 | 911,99 | 1078,16 | 0 | 2,49 | <0.00 | <0.00 | 0 | 260,52 | <0.00 | 214,86 | 11608,9 | 8795,37 | 6336,9 | 12531,03 | 2331,21 | 15,76 | 338,43 | 742,49 |
| 9 | <0.00 | <0.00 | <0.000 | <0.00 | <0.000 | <0.00 | <0.00 | <0.00 | 0 | <0.00 | <0.00 | <0.00 0 | 0 | <0.00 | <0.00 | <0.00 | <0.00 | <0.00 | <0.00 | <0.00 | 1997,16 | 15,74 | 367,8 | 1159,87 |
| 10 | <0.00 | <0.00 | <0.00 | <0.00 0 | <0.00 | <0.00 | 0<0.00 | <0.00 | 0 | <0.00 | <0.00 | <0.00 | 0 | <0.00 | <0.00 | <0.00 | <0.00 | <0.00 | <0.00 | <0.00 | 1266,27 | 35,74 | 245,43 | 610,25 |
| 11 | 7,24 | 143,61 | 55,26 | 59,68 | <0.00 | 80293,98 | 2102,91 | 1192,03 | 0 | 0,71 | <0.00 | <0.00 | 0 | 837,34 | 7,56 | 298,1 | 2064,54 | 5926,29 | 1206,44 | 2779,58 | 1197,12 | 893,99 | 600,49 | 1233,9 |
| 12 | 97,22 | 136,31 | 41,32 | 25,09 | <0.00 | 42639,3 | 845,36 | 100,63 | 0 | 0,41 | <0.00 | <0.00 | 0 | 799,47 | <0.00 | 238,68 | 2174,89 | 6639,86 | 1267,85 | 2578,21 | 731,39 | 9,66 | 175,76 | 727,42 |
| 13 | 7,67 | 112,3 | 35,9 | 24,24 | <0.00 | 46802,71 | 552,55 | 185,39 | 0 | 6,84 | <0.00 | <0.00 | 0 | 5081,6 | 1896,52 | 1423,36 | 2581,36 | 11021,99 | 1521,76 | 2627,89 | 1178,73 | 67,47 | 458,23 | 556,22 |
| 14 | 4,67 | 200,31 | 34,32 | 47,75 | <0.00 | <0.00 | <0.00 | <0.00 | 0 | 0,35 | <0.00 | <0.00 | 0 | 920,72 | <0.00 | 44,44 | 3441,24 | 15403,71 | 1981,74 | 1523,03 | 658,43 | 53,33 | 179,79 | 679,53 |
| 15 | 9,96 | 111,97 | 48,51 | 43,1 | <0.00 | 6322,19 | 89,94 | 2,7426 | 0 | 0,03 | <0.00 | <0.00 | 0 | 701,07 | 166,7 | 130,38 | 5803,74 | 12113,22 | 3109,96 | 4754,26 | 451,88 | 16,07 | 225,73 | 456,86 |
| 16 | 6,82 | 110 | 73,98 | 42,07 | <0.00 | 9689,85 | 121,23 | 37,91 | 0 | 1 | <0.00 | <0.00 | 0 | 468,69 | <0.00 | 71,61 | 4689,25 | 13621,84 | 2499,83 | 4802,82 | 426,06 | 1,84 | 148,43 | 184,33 |
| 17 | 9,24 | 154,23 | 188,79 | 99,85 | <0.00 | 9660,73 | 205,54 | 77,86 | 0 | 0,6 | <0.00 | <0.00 | 0 | 668,19 | <0.00 | 140,98 | 2302,57 | 6244,6 | 1347,99 | 1854,63 | 196,79 | 7,81 | 136,8 | 342,77 |
| 18 | 15,09 | 145,09 | 111,9 | 50,64 | <0.00 | 11279,37 | 192,8 | 74,88 | 0 | 0,35 | <0.00 | <0.00 | 0 | 579,17 | <0.00 | 73,98 | 2219,61 | 9704,59 | 1282,38 | 2538,97 | 543,87 | 47,63 | 286,26 | 740,82 |
| 19 | 12,87 | 202,12 | 77,31 | 70,55 | <0.00 | 3346,04 | 6,46 | <0.00 | 0 | 0,47 | <0.00 | <0.00 | 0 | 519,71 | <0.00 | 155,07 | 2104,83 | 9947,47 | 1209,37 | 4078,33 | 1994,33 | 91,62 | 309,42 | 724,59 |

 

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**Table 2: The results of NH40Ac extraction method and Biological Index (potato plant leaf)**

| Na (ppm) | Mg (ppm) | Ca (ppm) | K (ppm) | Na % | Mg (ppm) | Ca (ppm) | K (ppm) |
|---|---|---|---|---|---|---|---|
| 5,75 | 23,5 | 135,7 | 58,6 | 0,02 | 0,47 | 0,91 | 2,77 |
| 4,48 | 18,4 | 106,2 | 46 | 0,05 | 0,57 | 0,95 | 2,4 |
| 4,71 | 19,4 | 111,9 | 48,3 | 0,09 | 0,48 | 0,89 | 3,27 |
| 5,4 | 22 | 127,3 | 54,9 | 0,05 | 0,55 | 1,07 | 4,21 |
| 5,17 | 21,3 | 122,9 | 53 | 0,06 | 0,46 | 0,66 | 3,62 |
| 5,06 | 20,7 | 119,1 | 51,4 | 0,02 | 0,57 | 1,08 | 4,42 |
| 5,17 | 21,3 | 122,6 | 53 | 0,03 | 0,35 | 0,6 | 4,48 |
| 5,63 | 23,1 | 132,9 | 57,5 | 0,08 | 0,37 | 0,61 | 5 |
| 7,47 | 30,3 | 174,6 | 75,4 | 0,03 | 0,36 | 0,79 | 5,69 |
| 13,11 | 53,7 | 309 | 133,7 | 0,03 | 0,34 | 0,7 | 5,55 |
| 5,86 | 23,9 | 137,7 | 59,4 | 0,03 | 0,47 | 0,65 | 3,6 |
| 6,32 | 25,9 | 149,4 | 64,7 | 0,04 | 0,47 | 0,67 | 3,84 |
| 4,94 | 20,2 | 116,4 | 50,3 | 0,04 | 0,47 | 0,88 | 4,12 |
| 5,06 | 20,8 | 120,1 | 51,8 | 0,03 | 0,43 | 0,8 | 2,96 |
| 5,29 | 21,4 | 123,2 | 53,2 | 0,02 | 0,62 | 1,26 | 4,75 |
| 10,3 | 38,7 | 221,3 | 105,8 | 0,02 | 0,67 | 1,3 | 4,87 |
| 4,94 | 20,2 | 116,3 | 50,3 | 0,03 | 0,48 | 1,17 | 5,29 |
| 8,97 | 24,7 | 211,3 | 91,2 | 0,03 | 0,77 | 1,33 | 5,56 |
| 5,63 | 22,9 | 138,2 | 57,1 | 0,03 | 0,63 | 1,24 | 4,15 |

 

**Table 3: The results ofthe concentrations between, Biological indexeswith of Ca,Mg, K , NaObtained $NH_4$0Ac method and Sequential extraction methods**

| (SEM) Step1-step6 | | Step 1 | | | | Step 2 | | | Step 3 | Step 4 | | | Step 5 | | | | Step 6 | | | | AA | | | | Bl | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | Mg | Ca | K | Mg | Ca | K | Mg | Mg | Ca | K | Na | Mg | Ca | K | Na | Mg | Ca | K | Na | Mg | Ca | K | Na | Mg | Ca | K |
| Step 1 | Na | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Mg | 0.161 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Ca | -0.103 | .664** | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| | K | -0.112 | .659** | .680** | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| Step 2 | Mg | 0.218 | 0.15 | 0.06 | 0.286 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| | Ca | 0.17 | 0.182 | 0.15 | 0.357 | .921** | 1 | | | | | | | | | | | | | | | | | | | | | |
| | K | -0.159 | 0.118 | 0.17 | 0.341 | .641** | .507* | 1 | | | | | | | | | | | | | | | | | | | | |
| Step3 | Mg | -0.037 | 0.04 | -0.025 | 0.037 | 0.282 | 0.132 | -0.019 | 1 | | | | | | | | | | | | | | | | | | | |
| Step 4 | Mg | 0.001 | 0.13 | -0.041 | -0.028 | 0.234 | 0.074 | -0.068 | .903** | 1 | | | | | | | | | | | | | | | | | | |
| | Ca | 0.011 | 0.081 | -0.145 | -0.095 | 0.149 | -0.03 | -0.141 | .894** | .943** | 1 | | | | | | | | | | | | | | | | | |
| | K | 0.01 | 0.038 | -0.063 | -0.016 | 0.357 | 0.183 | 0.07 | .932** | .968** | .913** | 1 | | | | | | | | | | | | | | | | |
| Step 5 | Na | -0.029 | -0.077 | 0.084 | 0.029 | 0.106 | 0.129 | 0.065 | 0.238 | -0.034 | -0.063 | 0.029 | 1 | | | | | | | | | | | | | | | |
| | Mg | -0.06 | 0.415 | 0.274 | 0.101 | -0.141 | -0.087 | -0.211 | 0.244 | 0.306 | 0.173 | 0.176 | .490* | 1 | | | | | | | | | | | | | | |
| | Ca | -0.019 | -0.057 | 0.096 | 0.043 | 0.128 | 0.147 | 0.07 | 0.251 | -0.019 | -0.053 | 0.042 | .999** | .494* | 1 | | | | | | | | | | | | | |
| | K | 0.031 | -0.1 | 0.075 | -0.0 | 0.163 | 0.199 | 0.072 | 0.247 | -0.0 | -0.0 | 0.042 | .947** | 0.411 | .945** | 1 | | | | | | | | | | | | |

 

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 14 | | | | | 57 | 59 | | | | | | | | | | | | | | | | | |
| Step 6 | Na | 0.122 | 0.248 | -0.162 | 0.063 | 0.157 | 0.032 | 0.124 | 0.125 | -0.029 | 0.178 | 0.02 | -0.004 | -0.321 | 0.006 | 0.066 | 1 | | | | | | | | | | | |
| | Mg | -0.022 | 0.138 | -0.08 | -0.089 | **.483*** | **.641**** | 0.164 | -0.011 | 0.04 | 0.028 | 0.077 | -0.155 | -0.09 | -0.151 | -0.051 | 0.121 | 1 | | | | | | | | | | |
| | Ca | 0.076 | 0.145 | -0.202 | -0.094 | **.464*** | 0.441 | 0.163 | 0.2 | 0.19 | 0.358 | 0.201 | -0.163 | -0.167 | -0.155 | -0.013 | **.526*** | **.612**** | 1 | | | | | | | | | |
| | K | 0.144 | 0.176 | -0.193 | 0.017 | 0.374 | 0.382 | 0.206 | -0.159 | -0.135 | 0.005 | -0.118 | -0.287 | -0.355 | -0.275 | -0.165 | **.610**** | .512* | **.804**** | 1 | | | | | | | | |
| AA | Na | -0.168 | -0.377 | -0.178 | -0.13 | -.459* | -0.328 | -0.291 | -0.22 | -0.297 | -0.218 | -0.302 | -0.203 | -0.211 | -0.23 | -0.156 | -0.218 | -0.109 | -0.252 | -0.274 | 1 | | | | | | | |
| | Mg | -0.164 | -0.415 | -0.268 | -0.115 | -0.414 | -0.285 | -0.257 | -0.207 | -0.297 | -0.201 | -0.281 | -0.214 | -0.304 | -0.241 | -0.171 | -0.147 | -0.089 | -0.225 | -0.242 | **.951**** | 1 | | | | | | |
| | Ca | -0.162 | -0.377 | -0.187 | -0.128 | -.461* | -0.327 | -0.29 | -0.231 | -0.303 | -0.22 | -0.305 | -0.231 | -0.25 | -0.257 | -0.176 | -0.197 | -0.103 | -0.236 | -0.24 | **.996**** | **.949**** | 1 | | | | | |
| | K | -0.164 | -0.372 | -0.176 | -0.129 | -.456* | -0.327 | -0.288 | -0.218 | -0.296 | -0.217 | -0.302 | -0.201 | -0.207 | -0.227 | -0.154 | -0.215 | -0.111 | -0.253 | -0.275 | 1.000** | .952** | .995** | 1 | | | | |
| Bl | Na | 0.168 | -0.107 | -0.199 | -0.218 | 0.376 | 0.153 | **.607**** | 0.167 | 0.02 | 0.097 | 0.132 | 0.256 | -0.236 | 0.26 | 0.295 | **.511*** | -0.011 | 0.351 | 0.296 | -0.301 | -0.267 | -0.288 | -0.296 | 1 | | | |
| | Mg | 0.076 | 0.206 | 0.227 | -0.047 | -0.14 | -0.18 | -0.158 | -0.065 | 0.016 | -0.049 | -0.038 | 0.034 | 0.383 | 0.031 | 0.041 | -0.253 | -0.073 | -0.221 | -0.397 | 0.043 | -0.175 | 0.015 | 0.042 | -0.258 | 1 | | |
| | Ca | -0.203 | 0.063 | 0.313 | -0.01 | -0.379 | -0.404 | -0.211 | -0.098 | -0.023 | -0.09 | -0.084 | 0.001 | 0.319 | -0.008 | -0.034 | -0.422 | -0.32 | -0.441 | -.631** | 0.091 | -0.071 | 0.062 | 0.088 | -0.379 | .867** | 1 | |
| | K | -0.228 | -.671** | -0.117 | -0.42 | -.511* | -0.393 | -0.417 | -0.119 | -0.22 | -0.128 | -0.193 | 0.059 | -0.189 | 0.033 | 0.146 | -0.378 | -0.214 | -0.178 | -0.253 | .569* | .492* | .570* | .562* | -0.23 | 0.02 | 0.229 | 1 |
| | N.N.O. | -0.078 | -0.1 | 0.091 | -0.409 | -.638** | -.489* | -.579** | 0.002 | 0.1 | 0.026 | 0.021 | 0.052 | 0.448 | 0.035 | 0.089 | -.503* | -0.026 | -0.371 | -.488* | 0.291 | 0.174 | 0.283 | 0.287 | -0.439 | 0.399 | **.476*** | **.508*** |

**: Correlation is significant at the 0.01 level (2-tailed). *; Correlation is significant at the 0.05 level (2-tailed).**

**SEM; Sequential Extraction Methods ( Step1-Step 6)**

 