# THE RELATIONSHIP BETWEEN THE MINERAL STATUS OF THE YAK, MINERAL CONTENT OF THE SOIL AND MINERAL CONTENT OF THE HERBAGE DURING SUMMER

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## Abstract

There are over 12 million domestic yaks in de republic of China. They are kept for al lot of different purposes and that is why they are very important for the people that live outside the cities high up in de mountains. Before it is possible to improve the health status and the production of the yak, it is required to know more about the yak. This research described in this paper was done to determine the mineral status of the yak. Furthermore, the mineral status of the soil and fodder was determined. The samples are taken during the summer of 2017 from six different places in the Tibetan highlands (Qinghai province). The soil and feed samples are analyzed by using an Atomic Absorption Spectrometry (AAS). The blood serum sample are analyzed by the local hospital using a "Beckham coulter chemistry analyzer AU5800". The mineral concentration in the serum was between the 2.50 and 2.61 mmol/L calcium, 21.61 and 29.73 μmol/L iron, 4.88 and 5.15 mmol/L potassium, 0.85 and 1.13 mmol/L magnesium and 137.8 and 142.9 mmol/L sodium. For iron, magnesium and sodium, there was a significant difference between the sample places. The minerals in the soil and feed samples have also been determined, but they were much higher than expected, so the calibration of de AAS was probably not right. This means these results are considered not reliable and further research is required. Compared to previous research the calcium and magnesium concentration in the serum were in the same range. The iron concentration was much lower, but compared to the iron concentration in ruminants serum, there was no deficiency. Lastly the sodium serum concentration was much higher compared to other research. In the end this research has led to a better understanding of the mineral status of the yak, but for the mineral status of the soil and fodder more research is needed.

# Introduction

The republic of China is a very special country. With over a billion inhabitants, which means that one seventh of all the people in the world lives in China. It has many cities with more than a million inhabitants, but also a lot of people live outside the city in the mountains or on the grasslands. The mountains and grasslands are difficult to reach and a high altitude. This means the people have to adapt to their environment, they need to be self-foreseeing.

China has the biggest population of yaks (Bos grunniens) of the world. Approximately 85% of all the domesticated yaks live in China. This means there are at least 12 million yaks in China (Patil et al., 2013). These animals are well adapted to the difficult environment. They are able to live at very high altitudes (around 4500 meter above sea level) and survive extremely cold temperatures (averages of -4°C and minima of -40°C) and snow during the winter. These animals are held for a lot of different purposes. They are kept for milk and meat, and they are also used for transportation. Furthermore, the manure can be used as fuel and the skin and hairs are used for making clothes (Qinghai Sheng et al.,2007). In short, the yak is very important livestock in China.

In Europe much research has been done on cattle. Also, specific mineral research has been done for the cattle population (Commissie onderzoek Minerale Voeding, 2005; Kincaid et al., 2000). However, little is known about the mineral status of the free ranging yaks. The mineral status of the yak is important to keep the animals healthy and to make sure the people can rely on the yaks for food. Before being able to do more research for the most efficient way to keep these animals, it is necessary to obtain reference values. Therefore it is important to do an inventory study about the mineral status of the free ranging yaks. The following minerals are examined in this research: calcium (Ca), iron (Fe), potassium (K), magnesium (Mg) and sodium (Na).

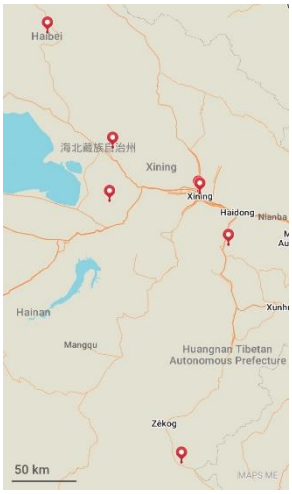
In addition, it would be useful to do research on the mineral content of the soil and the feed samples. Later on it will be examined if there is a relationship between the mineral-level in the soil, the feed samples and the yak itself. Furthermore, the mineral status of the yak may be compared to that of a bovine in Holland. Finally, it is anticipated that on the basis of the obtained results further research on specific minerals is warranted.

## Materials and Methods

The samples are collected during the summer of 2017. Six different locations are used for this experiment. All the locations where in de Qinghai province in the middle of China. There was at least 50km distance between the different sample sites. The yaks where free ranging on the grasslands where the samples have been taken.

A lot of free razing yaks are kept in the afore mentioned area. That is why these locations have been chosen to do an inventory study about the mineral status of the soil, grass and the free ranging yak. Also, the herdsmen were expected to be willing to help. As the yaks are a very important part of their business. Therefore, it turned out to be difficult to convince the herdsmen to participate in the research.

### The sample locations




The samples have been taken on six different locations. 1. Haibei Research station, 2. Datong Yak Farm, 3. Haiyan County Farmer Grassland, 4. Riyue Maintain, 5. Laji Mountain and 6. Henan county. These places are at least 50 kilometers apart from each other and have a very different environment. Unfortunately, it was not possible to collect blood samples at Datong Yak Farm, so this sample place is left out of the research. This should have been sample place 2.

### Soil samples

At each sample site a minimum of six soil samples are taken. There was at least 25 meters distance between the soil samples. The places where chosen completely random. The samples were taking by digging a hole, 10cm by 10cm, and 5cm deep. At least 50 grams of soil was stored in a plastic bag and brought back to the research laboratory in Xining. During this trip, the samples where kept as dry as possible and away from direct sun light.

Up on arrival at the laboratory in Xining the soil samples where weighed and dried for 48 hours at 65°C. After two days, the soil was weighed again to determine the dry matter content. Subsequently, the soil was grind in a mortal. After grinding, 20.0 ml of the extracting solution (0.05N HCL + 0.025N $H_2SO_4$) was used to solute 4.00 grams of dry soil. The solution was places in a mechanical shaker for 15 minutes. Afterwards the solution was filtered and diluted to 50ml.

### Feed samples

The protocol for the feed samples is similar to the one for the soil samples. Also, a minimum of six samples have been taken at least 25 meters from each other. At the same places as the soil samples. The grass was cut two centimeters above ground level to avoid soil contamination. The samples were stored in a plastic bag and brought back to the research laboratory in Xining. The grass was also kept as dry as possible and away from direct sun light.

Immediately after arriving in Xining, also, the feed samples where dried for 48 hours at 65°C. Both the dry weight and the starting weight were measured. A FOSS Cyclotec 1093 was used to grind the fodder. The weight of the grind feed sample was determined before and after the incineration process. The feed sample was incinerated at 550°C for 6 hours.

After the incineration process, 0.200 grams of ash was solved in 5.0ml of 20% HCl. To dissolve the residue, the solution was slowly heated up to 50°C. After dissolving the solution was filtered and diluted to 100ml with deionized water. To determine calcium and magnesium the final sample dilution should contain 1% lanthanum.

## Blood samples

At each location ten adult female yaks where randomly chosen. After the yaks where caught, 20 ml blood was collected from each yak. The blood was collected from the vena jugularis. After collecting the blood it was stored in a blood tube with anticoagulant and kept at 4°C. As soon as possible the serum was separated by centrifuging at 3000 rpm for 10 minutes. The serum was stored at -20°C. At sample place six, Henan County, it was even possible to collect 14 blood samples. In total this research contains 54 blood samples of adult female yaks.

## Sample analysis

The atomic absorption spectrometry (TAS -990 super AFG atomic absorption spectrophotometer was used to analyze the different kind of minerals in de soil and feed samples. Two different kind of standard solution have been used to determine the minerals. For the determination of Ca, Mg and Fe; the following standard solution was used: 0.2μg/ml, 0.4μg/ml, 0.6μg/ml, 0.8μg/ml and 1.0μg/ml. K and Na was determined by a different standard solution. 0.1μg/ml, 0.2μg/ml, 0.3μg/ml, 0.4μg/ml and 0.5μg/ml.

After centrifuging the blood, a part of the serum was sent to the human hospital. They determined the following minerals: K, Na, Ca, P, Mg, and Fe in the serum. It was done by using the “Beckham coulter chemistry analyzer AU5800”.

## Statistical analysis

For the statistical analysis “SPSS Statistics” 25 is been used. First to determine the average mineral concentration of all the samples from the different sample places and the standard deviations. After that a “general linear univariate model” is been used to analyze the data. To determine a significant different between the different sample places a “tukey’s-b” test has been performed. The results are showed in table 1, 2 and 3.

# Results

The mean of each sample place is determined. Also, the standard deviation is calculated. Table 1 contains the serum concentrations of Ca, Fe, K, Mg and Na of the five different locations. Respectively between, 2.50 and 2.61 mmol/L, 21.61 and 29.73 μmol/L, 4.88 and 5.15 mmol/L, 0.85 and 1.13 mmol/L and 137.8 and 142.9 mmol/L.

Table 1 also contains the P-values to determine if there is a significant difference between the serum mineral levels on the different location sites.

Table 1: Mean mineral concentration (n = 10) in serum samples at five different sample places.

| | **Sample place 1** | **Sample place 2** | **Sample place 3** | **Sample place 4** | **Sample place 5** | **SEM** | **P-value** |
|---|---|---|---|---|---|---|---|
| **Serum Na (mmol/L)** | 142.9$^{a}$ | 137.8$^{b}$ | 139.3$^{b}$ | 140.3$^{ab}$ | 138.9$^{b}$ | 0.78 | 0.002 |
| **Serum K (mmol/L)** | 5.12 | 5.15 | 4.88 | 4.88 | 4.98 | 0.14 | 0.652 |
| **Serum Ca (mmol/L)** | 2.50 | 2.55 | 2.61 | 2.58 | 2.54 | 0.04 | 0.627 |
| **Serum P (mmol/L)** | 2.10$^{a}$ | 1.06$^{c}$ | 2.21$^{a}$ | 2.36$^{a}$ | 1.41$^{b}$ | 0.08 | <0.001 |
| **Serum Mg (mmol/L)** | 0.91$^{bc}$ | 1.13$^{a}$ | 0.96$^{b}$ | 0.85$^{c}$ | 1.06$^{a}$ | 0.02 | <0.001 |
| **Serum Fe (umol/L)** | 24.35$^{ab}$ | 29.73$^{a}$ | 21.61$^{b}$ | 24.42$^{ab}$ | 28.51$^{a}$ | 1.34 | 0.002 |

$^{a,b,c,}$ Values in the same row with different superscripts differ ( P < 0.05; Tukey's-b test).

Based on these results there is no proof of a significant difference between the calcium and potassium concentrations at the different sample sites. The calcium concentration is between the 2.50 mmol/L and 2.61 mmol/L. And the potassium serum concentration ranging from 4.88 mmol/L and 5.15 mmol/L.

In contrast to the calcium and the potassium serum concentration, there is a significant difference (P<0.05) between the serum concentration of iron, magnesium and sodium in comparison to the other sample places. The serum iron concentration is significantly different between sample place 1-2, 3-5, 2-3 and 2-4. The serum magnesium concentration is significantly different between all the sample places, except between sample places 1-3 and 1-4. At last the sodium serum concentration shows a significant difference between 1-3, 1-5 and 1-2.

Also the minerals in the soil have been determined. Table 2 shows the results of the soil analysis. The same six minerals are determined at the same five locations: Ca, Fe, K, Mg and Na. The concentration was respectively between 0.76 and 1.57 g/kg dry soil, 5.73 and 7.38 g/kg dry soil (with one exception at sample place 1 the Fe concentration was higher, 76.32 mg/kg dry soil), 63.00 and 178.16 mg/kg dry soil, 38.65 and 43.49 mg/kg dry soil and 41.49 and 72.96 mg/kg dry soil.

Table 2: Mean mineral concentration (n = 6) in dry soil samples at five different sample places.

| | Sample place 1 | Sample place 2 | Sample place 3 | Sample place 4 | Sample place 5 | SEM | P-value |
|---|---|---|---|---|---|---|---|
| **Dry soil Na (g/kg)** | 51.38$^{c}$ | 41.49$^{b}$ | 49.20$^{bc}$ | 72.96$^{a}$ | 46.90$^{bc}$ | 2.24 | <0.001 |
| **Dry soil K (g/kg)** | 63.00$^{c}$ | 131.53$^{b}$ | 131.49$^{b}$ | 99.25$^{b}$ | 178.16$^{a}$ | 9.98 | <0.001 |
| **Dry soil Ca (g/kg)** | 1.57$^{a}$ | 0.84$^{b}$ | 0.76$^{c}$ | 0.85$^{b}$ | 0.89$^{b}$ | 0.22 | <0.001 |
| **Dry soil Mg (mg/kg)** | 43$^{a}$ | 38$^{b}$ | 39$^{bc}$ | 40$^{c}$ | 43$^{a}$ | 0.56 | <0.001 |
| **Dry soil Fe (mg/kg)** | 76$^{a}$ | 6$^{b}$ | 7$^{b}$ | 5$^{b}$ | 6$^{b}$ | 9.56 | <0.001 |

$^{a,b,c,}$ Values in the same row with different superscripts differ ( P < 0.05; Tukey's-b test).

For all the six minerals there is a significant difference between at least two sample places. The results are depicted in table 2. The iron concentration in the soil at location 1 is significantly different (P<0.05) from all the other sample places. For the potassium concentration there is a significant difference between all the locations except for sample place 2, 3 and 4.

The results of the mineral concentration in de feed sample can be found in table 3. Only the calcium concentration at sample place 5 is significantly different (P<0.05) compared to sample places 1, 2 and 3. The calcium concentration at the rest of the sample places is somewhere between 1.41 and 1.78 g/kg dry feed sample.

Table 3: Mean mineral concentration (n = 6) in dry feed samples at five different sample places.

| | Sample place 1 | Sample place 2 | Sample place 3 | Sample place 4 | Sample place 5 | SEM | P-value |
|---|---|---|---|---|---|---|---|
| **Dry feed Na (g/kg)** | 0.21$^{a}$ | 0.16a$^{b}$ | 0.12$^{b}$ | 0.19$^{a}$ | 0.17a$^{b}$ | 0.01 | 0.004 |
| **Dry feed K (g/kg)** | 0.55$^{b}$ | 0.83$^{a}$ | 0.46$^{b}$ | 0.79$^{a}$ | 1.02$^{a}$ | 0.06 | <0.001 |
| **Dry feed Ca (g/kg)** | 1.51$^{b}$ | 1.41$^{b}$ | 1.61$^{b}$ | 1.78$^{ab}$ | 2.36$^{a}$ | 0.19 | 0.016 |
| **Dry feed Mg (mg/kg)** | 132$^{b}$ | 146$^{a}$ | 96$^{ab}$ | 155$^{a}$ | 172$^{a}$ | 11.28 | 0.001 |
| **Dry feed Fe (mg/kg)** | 322$^{b}$ | 410$^{b}$ | 317$^{b}$ | 669$^{a}$ | 393$^{b}$ | 56.01 | 0.001 |

$^{a,b,}$ Values in the same row with different superscripts differ ( P < 0.05; Tukey's-b test).

The iron concentration in the feed sample is between the 317.06 and 410.97 mg/kg dry feed sample. Again there is one exception. Sample place 4 has a significantly higher iron concentration in the feed sample (669.14 mg/kg dry feed sample).

All the sample places have no significant different (P<0.05) concentration of sodium in the feed sample. Apart from sample place 3. The sodium concentration in the feed sample at sample place 3 is much lower compared to the other sample places.

## Discussion

Compared to other research about the mineral status of yaks on the Tibetan plateau, the calcium levels are normal. The serum concentration of calcium should be at least 2.0mmol/L (Nyima Tashi et al., 2005). Research from 2007 in the Arunachala Pradesh region show that the serum calcium concentration of the yak is 2.57 mmol/L (P Konwar et al., 2007). Also in India there has been another experiment with yaks. It shows an average of 1.693 mmol/L for female adult (tree years and older) yaks (Chatterjee et al., 2004).

Nyima Tashi et al. also show that the serum iron concentration of yaks is between the 40 and 110 μmol/L. This research discussed in this paper shows a serum iron concentration that is much lower. Between the 21.61 and 29.73 μmol/L at all five different sample places. For ruminants, there is a different scale. If the serum iron concentration is lower than 21.49 μmol/L, then there is a deficiency If it is among 23.28 and 44.77 μmol/L it is adequate. Above 71.63 μmol/L means there is an intoxication of iron in the serum (Kincaid et al., 2000).

The potassium serum concentration is according to this experiment the same at all five sample places, as there appears to be no significant difference. It is all around 5 mmol/L. Again, in India an experiment shows a different range for the potassium serum concentration (5.83 mmol/L) (Chatterjee et al., 2004).

In addition, more research has been done on the serum magnesium concentration of the yak. This research was done in Damxiong, Jiali, Linzhou and Naqu. The results show that the serum magnesium concentration of the yak are expected to be between 0.70 mmol/L and 1.03 mmol/L (Nyima Tashi et al., 2005). Konwar even says the magnesium concentration should be around 0.51 mmol/L. The blood serum samples from sample place 6 are much higher than those two other experiments. Chatterjee et al. conclude that there is a linear relationship between magnesium serum concentration and the magnesium intake through fodder. The magnesium serum concentration should be between 0.053 and 1.813 mmol/L.

At last the sodium serum concentration was determined. There is a significant difference between some of the sample places. But compared to the research of Chatterjee, the serum sodium concentration is much higher. Chatterjee measured an average of 130.7 mmol/L. The current research shows results between 137.8 and 142.9 mmol/L.

This research does not explain the different of mineral concentrations between the different sample places, but it is possible that the difference can be explained by the different kind of pasture. Because of the different heights of sample places, the pasture and vegetation was different.

One of the remarkable things about the soil and fodder results is the iron concentration at sample place 4. The iron concentration in the soil at sample place 4 is low compared to the other sample places, but the iron in the dry feed samples at sample place 4 is significant high compared to the other sample places. One of the possible explanations for this, is the high availability of iron at sample place 4. All the iron is consumed from the soil.

One other noteworthy result is the correlation between potassium and magnesium in the soil samples at sample place 1. When the concentration of magnesium in the soil is high, the potassium is low. Some Dutch research describes this same correlation (Bokhorst et al., 2016).

Although the results of the soil and fodder minerals concentrations shows significant difference and correlation, the results are considered unreliable. This is because the standard solutions (explained in materials and methods) are way too different from the results in the samples. The calibration of the AAS was set for much smaller concentrations. For example, the calibration for calcium was between the 0.0 and 1.0μg/ml. The feed samples concentration after preprocessing was around the 40μg/ml. This means the results of the soil and feed samples are way too far off the calibration to give meaningful value to the results.

# Conclusion

The first goal of the research was to determine the mineral  status of the yak. This data was necessary to do any further research. The serum concentration was compared to other research in comparable environments. The calcium concentration is between 2.50 and 2.61 mmol/L. This research found a much lower iron concentration, but compared to the ruminant iron concentration there was no way of any kind of deficiencies. The potassium serum concentration corresponded to comparable research. For the magnesium concertation there is a big variation possible. At last the sodium concentration was much higher than when compared to other research.

For the feed and soil samples it is not possible to conclude anything, because of lack of reliability of the data. It is possible to use the results as a guideline to determine the correct range for the standard solutions.

As a last comment it is important to mention that all the yaks that were examined for this research where in good conditions. There were no clinical signs for any kind of deficiency.

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# Attachment

| **Blood serum results - Sample place 1** | | | | | | |
|---|---|---|---|---|---|---|
| Sample | K (mmol/L) | Na (mmol/L) | Ca (mmol/L) | P (mmol/L) | Mg (mmol/L) | Fe (umol/L) |
| 1 | 4.22 | 145 | 2.63 | 2.40 | 0.97 | 30.52 |
| 2 | 5.04 | 145 | 2.38 | 1.99 | 1.08 | 29.85 |
| 3 | 6.09 | 143 | 2.43 | 1.86 | 0.81 | 19.45 |
| 4 | 5.40 | 142 | 2.56 | 1.83 | 0.86 | 23.87 |
| 5 | 4.37 | 142 | 2.44 | 2.52 | 0.93 | 16.90 |
| 6 | 4.41 | 142 | 2.65 | 1.63 | 0.78 | 24.68 |
| 7 | 4.78 | 142 | 2.46 | 2.41 | 1.01 | 25.34 |
| 8 | 5.12 | 144 | 2.56 | 1.77 | 0.97 | 24.77 |
| 9 | 6.86 | 143 | 2.47 | 1.87 | 0.79 | 29.15 |
| 10 | 4.88 | 141 | 2.45 | 2.76 | 0.91 | 18.93 |
| **Blood serum results - Sample place 3** | | | | | | |
| Sample | K (mmol/L) | Na (mmol/L) | Ca (mmol/L) | P (mmol/L) | Mg (mmol/L) | Fe (umol/L) |
| 1 | 4.76 | 139 | 2.60 | 2.42 | 1.01 | 20.41 |
| 2 | 4.73 | 138 | 2.75 | 2.39 | 0.98 | 24.38 |
| 3 | 5.09 | 137 | 2.63 | 1.79 | 0.94 | 24.33 |
| 4 | 4.74 | 140 | 2.60 | 2.38 | 0.92 | 25.58 |
| 5 | 4.68 | 140 | 2.56 | 2.26 | 1.09 | 23.84 |
| 6 | 4.94 | 141 | 2.46 | 2.47 | 0.87 | 15.52 |
| 7 | 4.18 | 139 | 2.64 | 2.20 | 0.95 | 22.27 |
| 8 | 4.83 | 138 | 2.42 | 1.69 | 0.88 | 22.84 |
| 9 | 5.59 | 143 | 2.89 | 2.07 | 0.96 | 20.06 |
| 10 | 5.25 | 138 | 2.51 | 2.43 | 0.97 | 16.88 |
| **Blood serum results - Sample place 4** | | | | | | |
| Sample | K (mmol/L) | Na (mmol/L) | Ca (mmol/L) | P (mmol/L) | Mg (mmol/L) | Fe (umol/L) |
| 1 | 4.19 | 141 | 2.72 | 2.24 | 0.95 | 31.30 |
| 2 | 4.72 | 139 | 2.77 | 2.03 | 0.92 | 17.92 |
| 3 | 5.04 | 140 | 2.71 | 2.23 | 0.82 | 18.58 |
| 4 | 4.72 | 139 | 2.60 | 2.67 | 0.84 | 28.84 |
| 5 | 5.29 | 139 | 2.66 | 2.57 | 0.88 | 21.77 |
| 6 | 4.81 | 147 | 2.60 | 2.48 | 0.87 | 24.16 |
| 7 | 4.63 | 129 | 1.85 | 1.95 | 0.77 | 24.04 |
| 8 | 4.60 | 142 | 2.62 | 2.07 | 0.80 | 27.31 |
| 9 | 5.34 | 141 | 2.71 | 2.41 | 0.85 | 27.01 |
| 10 | 5.45 | 146 | 2.57 | 2.91 | 0.79 | 23.27 |
| **Blood serum results - Sample place 5** | | | | | | |
| Sample | K (mmol/L) | Na (mmol/L) | Ca (mmol/L) | P (mmol/L) | Mg (mmol/L) | Fe (umol/L) |
| 1 | 5.29 | 139 | 2.65 | 1.23 | 1.08 | 33.86 |
| 2 | 4.91 | 136 | 2.58 | 1.79 | 0.97 | 24.92 |
| 3 | 5.22 | 136 | 2.62 | 1.1 | 1.06 | 37.38 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 4.52 | 137 | 2.63 | 1.43 | 0.94 | 37.08 |
| 5 | 5.15 | 138 | 2.47 | 1.04 | 1.12 | 23.15 |
| 6 | 4.43 | 143 | 2.41 | 1.45 | 1.15 | 27.25 |
| 7 | 5.39 | 141 | 2.42 | 1.95 | 1.1 | 21.22 |
| 8 | 4.02 | 135 | 2.39 | 1.11 | 0.94 | 18.2 |
| 9 | 5.6 | 143 | 2.69 | 0.88 | 1.08 | 33.34 |
| 10 | 5.24 | 141 | 2.58 | 2.11 | 1.11 | 28.65 |

**Blood serum results - Sample place 2**

| Sample | K (mmol/L) | Na (mmol/L) | Ca (mmol/L) | P (mmol/L) | Mg (mmol/L) | Fe (umol/L) |
|---|---|---|---|---|---|---|
| 1 | 4.83 | 138 | 2.38 | 1.13 | 1.1 | 35.54 |
| 2 | 6.13 | 138 | 2.56 | 1.36 | 1.06 | 34.07 |
| 3 | 4.9 | 139 | 2.61 | 0.99 | 1.11 | 32.21 |
| 4 | 6.04 | 144 | 2.69 | 0.89 | 1.12 | 31.93 |
| 5 | 5.03 | 137 | 2.51 | 1.1 | 1.24 | 24.36 |
| 6 | 5.39 | 135 | 2.62 | 1.11 | 1.26 | 24.64 |
| 7 | 5.25 | 137 | 2.7 | 0.85 | 1.13 | 23.05 |
| 8 | 5.3 | 140 | 2.52 | 0.96 | 1.14 | 27.75 |
| 11 | 4.84 | 135 | 2.46 | 1.18 | 1.17 | 26.3 |
| 12 | 4.77 | 137 | 2.6 | 0.73 | 1.01 | 39.44 |
| 13 | 4.97 | 135 | 2.56 | 1.4 | 1.14 | 25.98 |
| 14 | 4.68 | 135 | 2.64 | 0.86 | 1.08 | 36.67 |
| 15 | 4.66 | 140 | 2.31 | 1.07 | 1.18 | 26.32 |
| 16 | 5.28 | 139 | 2.55 | 1.18 | 1.09 | 27.91 |

| **Soil results -Sample place 1** | | | | | |
|---|---|---|---|---|---|
| Concentration in 4.00gr soil in 50ml solution | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 7.060 | 4.249 | 8.109 | 3.433 | 126.228 |
| 2 | 5.243 | 4.027 | 0.077 | 3.387 | 118.742 |
| 3 | 5.530 | 4.038 | 3.224 | 3.489 | 127.974 |
| 4 | 5.564 | 4.303 | 6.995 | 3.415 | 124.873 |
| 5 | 5.729 | 3.994 | 6.068 | 3.625 | 129.338 |
| 6 | 1.115 | 4.053 | 12.161 | 3.527 | 124.912 |
| **Soil results -Sample place 3** | | | | | |
| Concentration in 4.00gr soil in 50ml solution | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 11.555 | 3.075 | 0.627 | 30.640 | 55.015 |
| 2 | 11.040 | 3.623 | 0.660 | 31.220 | 59.965 |
| 3 | 9.117 | 3.846 | 0.145 | 30.690 | 67.952 |
| 4 | 11.094 | 4.528 | 0.718 | 31.710 | 61.140 |
| 5 | 10.832 | 3.496 | 0.804 | 31.310 | 58.410 |
| 6 | 9.476 | 5.046 | 0.587 | 32.020 | 60.300 |
| **Soil results -Sample place 4** | | | | | |
| Concentration in 4.00gr soil in 50ml solution | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 9.252 | 5.368 | 0.285 | 3.355 | 65.776 |
| 2 | 7.934 | 6.006 | 0.530 | 3.296 | 67.630 |
| 3 | 7.093 | 5.851 | 0.244 | 3.263 | 69.451 |
| 4 | 7.117 | 6.561 | 0.662 | 3.277 | 68.459 |
| 5 | 7.924 | 6.072 | 0.436 | 3.279 | 68.565 |
| 6 | 8.322 | 5.164 | 0.593 | 3.195 | 66.768 |
| **Soil results -Sample place 5** | | | | | |
| Concentration in 4.00gr soil in 50ml solution | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 9.252 | 5.368 | 0.285 | 3.355 | 65.776 |
| 2 | 7.934 | 6.006 | 0.530 | 3.296 | 67.630 |
| 3 | 7.093 | 5.851 | 0.244 | 3.263 | 69.451 |
| 4 | 7.117 | 6.561 | 0.662 | 3.277 | 68.459 |
| 5 | 7.924 | 6.072 | 0.436 | 3.279 | 68.565 |
| 6 | 8.322 | 5.164 | 0.593 | 3.195 | 66.768 |
| **Soil results -Sample place 2** | | | | | |
| Concentration in 4.00gr soil in 50ml solution | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 12.223 | 3.655 | 0.623 | 3.035 | 58.997 |
| 2 | 12.689 | 2.903 | 0.431 | 3.102 | 67.941 |
| 3 | 14.240 | 3.273 | 0.516 | 3.085 | 58.269 |
| 4 | 11.087 | 3.082 | 0.035 | 3.055 | 74.069 |
| 5 | 7.728 | 3.444 | 1.335 | 3.181 | 67.793 |
| 6 | 5.167 | 3.558 | 0.016 | 3.093 | 74.857 |

| **Feed sample results -Sample place 1** | | | | | | |
|---|---|---|---|---|---|---|
| Concentration in 0.2gr ass in 100ml solution | Inorganic substance | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 0.087 | 13.836 | 5.186 | 10.754 | 3.340 | 46.390 |
| 2 | 0.084 | 13.972 | 5.794 | 6.702 | 3.391 | 28.100 |
| 3 | 0.095 | 13.873 | 5.958 | 9.311 | 3.378 | 45.452 |
| 4 | 0.072 | 13.965 | 4.288 | 6.452 | 3.275 | 43.455 |
| 5 | 0.066 | 13.718 | 5.743 | 8.057 | 3.255 | 31.384 |
| 6 | 0.072 | 13.417 | 5.050 | 6.762 | 3.331 | 30.365 |
| **Feed sample results -Sample place 3** | | | | | | |
| Concentration in 0.2gr ass in 100ml solution | Inorganic substance | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 0.063 | 13.571 | 3.851 | 7.178 | 2.829 | 54.655 |
| 2 | 0.073 | 13.436 | 3.602 | 8.807 | 2.757 | 52.406 |
| 3 | 0.104 | 11.930 | 3.278 | 11.946 | 2.567 | 28.169 |
| 4 | 0.075 | 13.383 | 3.510 | 8.513 | 2.682 | 49.254 |
| 5 | 0.060 | 13.339 | 2.841 | 6.955 | 2.744 | 51.932 |
| 6 | 0.052 | 13.013 | 3.255 | 8.042 | 2.745 | 46.162 |
| **Feed sample results -Sample place 4** | | | | | | |
| Concentration in 0.2gr ass in 100ml solution | Inorganic substance | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 0.112 | 13.745 | 3.909 | 12.350 | 2.807 | 30.917 |
| 2 | 0.097 | 14.690 | 3.446 | 11.230 | 2.840 | 33.788 |
| 3 | 0.090 | 14.056 | 3.409 | 11.653 | 2.858 | 38.065 |
| 4 | 0.085 | 14.142 | 3.534 | 11.251 | 2.843 | 38.605 |
| 5 | 0.164 | 14.781 | 3.171 | 12.468 | 2.701 | 29.115 |
| 6 | 0.120 | 13.370 | 3.593 | 12.512 | 2.785 | 25.977 |
| **Feed sample results -Sample place 5** | | | | | | |
| Concentration in 0.2gr ass in 100ml solution | Inorganic substance | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 0.089 | 20.019 | 3.965 | 9.672 | 3.361 | 58.555 |
| 2 | 0.124 | 19.787 | 3.502 | 8.772 | 3.390 | 45.082 |
| 3 | 0.098 | 20.610 | 3.591 | 7.999 | 3.352 | 32.170 |
| 4 | 0.095 | 19.661 | 3.140 | 9.024 | 3.272 | 43.603 |
| 5 | 0.100 | 20.235 | 2.780 | 5.915 | 3.558 | 57.063 |
| 6 | 0.100 | 20.554 | 3.246 | 5.412 | 3.575 | 45.760 |
| **Feed sample results -Sample place 2** | | | | | | |
| Concentration in 0.2gr ass in 100ml solution | Inorganic substance | K-[ug/ml] | Na-[ug/ml] | Fe-[ug/ml] | Mg-[ug/ml] | Ca-[ug/ml] |
| 1 | 0.108 | 19.444 | 3.989 | 9.184 | 3.544 | 34.405 |
| 2 | 0.094 | 19.216 | 3.627 | 10.843 | 3.341 | 24.149 |
| 3 | 0.079 | 19.861 | 3.176 | 7.796 | 3.364 | 26.353 |
| 4 | 0.097 | 19.421 | 3.775 | 9.245 | 3.598 | 54.580 |
| 5 | 0.073 | 19.808 | 4.477 | 9.933 | 3.374 | 27.029 |
| 6 | 0.059 | 19.319 | 4.363 | 11.573 | 3.460 | 27.660 |