Ecological stoichiometry of C, N and P on different time enclosed in desertification steppe soil

W.Z. Yang¹, Y. Jiao², Y. Q. Jia³
¹Water-saving Agricultural Engineering Research Center, Inner Mongolia Normal University, Hohhot, China
²College of Chemistry and Environmental Sciences, Inner Mongolia Normal University, Hohhot, China
³Water Conservancy and Civil Engineering College, Inner Mongolia Agricultural University, Hohhot, China

Abstract: It is the research object for the ecological stoichiometry of C, N and P on the different time of desertification grasslands enclosed and grazing grassland in Taibusi country of the Inner Mongolia, China. Through the measurement and analysis on ecological stoichiometric ratio of C, N and P in soil, the time of desertification grassland enclosed is determined. There are 13 soil of desertification grassland with different en-closure time, and 1 soil of grazing grassland. They are analyzed for the soil organic carbon, total nitro-gen, total phosphorus content and their density. The C/N of soil were increased with the extension of the time of desertification grassland enclosed. To 22 years enclosed, the C/N of grassland desertification soil enclosed is greater than the soil of grazing grassland that is 17. After the desertification grassland is en-closed, the C/N of soil is 13, and it is accumulated to maximum for C and N, and The grazing period is the best.

1 General Instructions
Hunshandake sandy land is located in the northern part of China, which is an important ecological barrier of central Asia. It is rarely reported for optimal nutrition of ecological system of degraded grassland at home and abroad. The international scientists adopted ecological stoichiometry method to determine the chemical elements C, N and P balance within the ecosystem and determine the time used, which become the classic method of modern ecology re-search [6]. It is lacking for the research of ecological stoichiometry of C and N and P on desertification steppe ecosystem. We will find the element composition ratio of C, N and P in soil, and determine the time enclosed in the degraded grassland ecosystem, reveal the indicating function of the ecological stoichiometry of C, N and P in desertification steppe [4].

2 Material and Methods

2.1 Experimental sites
The study area is in the typical steppe of Taipusi County south of Xilinguole City in Inner Mongolia, China. The geographical position is latitude 41°35′~42°10′, east longitude 114°51′~115°49′, the type of climate is temperate semi-arid con-tinental climate, winter cold and dry, warm and hu-mid summer. The annual average temperature 1.6°C, frost free period 138 days, the average annual rainfall 407mm,
mainly concentrated in the june, ju-ly. Leymus chinensis and Stipa krylovii are the do-minant species in the region, which is upper in the grass cluster, lower vegetation is Cleistogenes squa-rosa, Koeleria cristata, Artemisia frigida, Potentilla acaulis, companion has Agropyron michnoi, Carex duriuscula, Melilotoidesruthenica, Serratula centau-roides, A. capillaris, P. bifurca,Heteropappus altai-cus, Allium anisopodium, Salsola, collina, Iris di-chotoma [9].

2.2 Soil property measurements
Using GPS positioning, soil samples were collected by the method of S shape arranged. There were 3 repeat in 3 plots set up on each time enclosed, each kind of S sampling had 10 sampling points, each sample point was stratified sampling using the soil drilling for 100cm long, acquisition of 0~10cm, 10~20cm, 20~30cm of soil samples, respectively, at the same time, undisturbed soil samples were collected using a ring knife, used for determination of soil bulk density. Soil samples were air dried, back to the lab, 1mm screen, used for determination of soil chemical properties. Determination of soil bulk density by cutting ring method, determination of organic carbon content in plant and soil components by the application of potassium dichromate oxidation-heating method, the determination of soil total nitrogen content using semi micro Kjeldahl method, the application of acid soluble molybdenum antimony anti-Determination of total phosphorus content in the soil of colorimetric method [1].

2.3 Data analysis
According to the determination numbers of soil SOC, TN, TP content, C/N, N/P, C/P, statistics and analysis of ecological stoichiometry of different enclosing years soil. Under application of SPSS13.0, data were analyzed by one-way ANOVA (p<0.05).

3 Results
3.1 Ecological stoichiometry change characteristics of C/N on different ages of grassland enclosed and grassland grazed freely
The experimental results (see Table 1), C/N of soil on different time of grassland enclosed has significant difference (F=13.714, p=0.000). The desertification steppe enclosed before 14 years, the C/N decreased with the prolongation of time enclosed. to 14 years enclosed, C/N increased with the prolongation of time enclosed. After 22 years enclosed, the C/N of soil enclosed increased year by year, is larger than that of free grazing grass-land, which is 17.

Table 1. Ecological stoichiometry of C/N different time enclosed in desertification steppe

| Time enclosed /Years | 0~10cm   | 10~20cm  | 20~30cm |
|----------------------|----------|----------|---------|
| 0                    | 16.15±0.8| 14.78±1.5| 14.62±2.5|
| 5                    | 15.85±1.0| 15.22±0.4| 19.65±2.3|
| 7                    | 13.16±0.9| 17.20±0.8| 18.10±0.5|
| 8                    | 12.92±2.6| 13.79±1.9| 17.42±1.7|
| 10                   | 13.36±0.5| 12.70±0.5| 15.19±2.1|
| 11                   | 12.01±4.2| 14.17±7.1| 15.58±7.3|
| 13                   | 12.14±0.4| 12.10±0.5| 14.32±0.5|
| 14                   | 12.47±1.6| 11.61±0.9| 14.28±1.2|
| 18                   | 11.25±0.2| 13.77±0.6| 19.29±0.4|
| 20                   | 14.75±0.1| 13.00±0.8| 12.47±0.6|
| 21                   | 14.01±0.3| 16.63±2.4| 15.55±1.5|
| 22                   | 12.51±0.4| 24.42±2.4| 33.38±4.5|
| 24                   | 14.11±0.9| 22.70±0.9| 33.91±2.0|
| 25                   | 16.92±11.4| 24.90±0.4| 62.86±4.3|
3.2 Ecological stoichiometry change characteristics of N/P on different time of grassland enclosed and grassland grazed freely

The N/P of soils of different time enclosed has significant difference in desertification steppe (F=9.721, p=0.000), compared with grassland grazed freely (see Table 2). Soil N/P free grazed steppe were greater than the grassland enclosed, and decreased with the prolongation of time enclosed.

| Time enclosed /Years | N/P | 0~10cm       | 10~20cm      | 20~30cm      |
|----------------------|-----|--------------|--------------|--------------|
| 0                    | 8.72±1.2 | 8.34±1.9 | 6.75±1.5  |
| 5                    | 7.78±0.2 | 7.06±0.9 | 6.20±0.7  |
| 7                    | 6.29±0.2 | 4.71±0.3 | 3.44±0.6  |
| 8                    | 6.25±2.2 | 5.79±2.3 | 4.33±1.9  |
| 10                   | 6.02±1.8 | 5.92±1.1 | 5.66±1.3  |
| 11                   | 7.03±3.0 | 4.80±0.5 | 3.91±0.6  |
| 13                   | 6.29±0.7 | 5.80±0.9 | 4.88±0.1  |
| 14                   | 5.28±1.1 | 5.39±2.8 | 4.55±0.2  |
| 18                   | 5.40±0.1 | 5.42±0.2 | 3.73±1.3  |
| 20                   | 4.37±0.2 | 6.38±0.9 | 4.71±0.2  |
| 21                   | 4.30±0.9 | 5.24±1.7 | 4.27±1.0  |
| 22                   | 4.32±0.7 | 3.49±0.3 | 2.98±1.2  |
| 24                   | 4.33±0.5 | 3.21±0.6 | 2.93±0.7  |
| 25                   | 4.28±2.2 | 2.96±0.6 | 1.37±0.5  |

3.3 Ecological stoichiometry change characteristics of C/P on different time of grassland enclosed and grassland grazed freely

The C/P of grassland soils has significant difference on different time enclosed (F=7.055, p=0.000), compared with grassland grazed freely (see Table 3). The C/P of soil of steppe grazed freely were greater than the grassland enclosed, and decreased with the prolongation of time enclosed.

| Time /Year | C/P | 0~10cm       | 10~20cm   | 20~30cm     |
|------------|-----|--------------|-----------|-------------|
| 0          | 140.74±20.6 | 123.28±24.9 | 98.63±30.2 |
| 5          | 123.23±5.3  | 107.45±3.3  | 121.90±3.0 |
| 7          | 82.76±10.8  | 80.98±1.4   | 62.19±1.2  |
| 8          | 80.69±41.1  | 79.82±29.5  | 75.43±25.2 |
| 10         | 80.36±21.3  | 75.19±11.7  | 85.94±10.6 |
| 11         | 84.46±48.7  | 68.04±27.8  | 60.84±30.9 |
| 13         | 76.34±13.5  | 70.25±5.8   | 69.88±4.6  |
| 14         | 65.90±20.7  | 62.58±30.8  | 64.98±15.5 |
| 18         | 60.80±1.1   | 74.63±0.7   | 71.91±4.6  |
| 20         | 64.45±7.6   | 82.96±4.4   | 58.76±7.6  |
| 21         | 60.25±10.2  | 87.18±7.2   | 66.33±7.7  |
| 22         | 54.00±6.5   | 85.27±1.0   | 99.57±31.7 |
| 24         | 61.06±7.4   | 72.85±5.2   | 99.20±51.6 |
| 25         | 72.42±3.9   | 73.67±1.1   | 86.38±5.3  |
4 Discussion

4.1 Different ages of enclosing grassland and free grazing grassland soils C/N

Soil C/N ratio can show soil biological decomposition process, which contains a close conversion relationship between C and N. Soil C/N is an auxiliary index that can reflect the fertility of soil. The small C/N ratio of soil is more favorable for the decomposition of organic matter. The C/N is required, when microbes decompose soil organic matter. C/N ratio is high relatively, microorganisms need N to meet their growth, and the soil will be in low N condition relatively, and the decomposition rate of organic matter is slow too. Therefore, the soil will accumulate more organic matter, when the C/N ratio is low. Those N more than this part of microbial growth will be released into the soil and litter, nitrogen accumulation is favorable, it will not affect the decomposition of organic matter [5] [3]. The results showed that the C/N ratio of soil of grassland decreased from 17 to 13 before 14 years enclosed with extension of time en-closed, which is lower than that of grassland grazed freely (Table 1). It can be found to exist significant correlation between C/N of soil of grassland-en closed and total nitrogen content from the table 1, those correlation coefficient is greater than one between C/N and organic carbon, to clear C/N of soil grassland enclosed is mainly restricted by total nitro-gen content.

The organic matter is decomposed to supply to the most nutrients of soil, it was further revealed the relative lack of soil total nitrogen, mainly because microbial decomposition ability of organic matter is weak, not because soil organic matter can’t provide sufficient nitrogen. Free grazing grass-land situation is just the opposite, the results of this study showed that (Table 1), free grazing grassland soil C/N value is about 17, this is same with De Camargo [5] research results. The correlation coefficient between soil organic matter and C/N is larger, however, the correlation coefficient between soil organic matter and total nitrogen in soil is very small, mainly because soil organic carbon in the grassland enclosed was significantly greater than that of free grazing grassland, grazing grassland N is lack of source because organic carbon can’t provides enough N, to confirm free grazed steppe is relatively deficient in nitrogen. The results are consistent with Yin [11] that soil C/N of communities seriously degraded is higher than recovery community in different restoration succession stage on desertification steppe of Inner Mongolia. Enclosure is advantageous for accumulation of soil C and N, it reached the maximum value to 14 years for the grassland enclosed. However, after 14 years in the area enclosed, soil C/N will enter the increase trend, to 22 years for the grassland enclosed, soil C/N of steppe soil free grazed is less than fenced enclosure’s, it confirmed that the grassland will enter the retrogressive succession stage, and it is detrimental for the grassland soils C and N accumulation if the time is too long. The global mean C/N is 13.33 [8]. The grassland soil C/N value for enclosing years, grassland soil fenced for 14 years had the lowest C/N value, about 13, soil C/N value for 25 years was the highest in grassland fenced, about 27, it were higher than the average value 10:1~12:1 of soil C/N value in china. This may be owing to differences of soil nutrient content, geographical position and climate condition on the desertification steppe in the northern China.

4.2 Different ages of enclosing grassland and free grazing grassland soils N/P

Based on the data of N/P of soil, the elements to limit soil nutrients are able to be identified. During growth season enclosed on the grassland degraded severely, the soil N/P of grassland grazed freely was higher than that of plots enclosed, and decreased with the prolongation of time enclosed, soil N/P between grassland enclosed and grassland grazed freely are decreased with expansion of depth of soil. Liu’s [7] results show that the N/P of soil on different succession stages of south subtropical forest decreased with expansion of depth of soil, N/P of the surface of soil is the maximum value, the research results are same with the paper’s. Wu’s [10] study shows that fixation of biological nitrogen in soil decreases with the increase of N/P in terrestrial ecosystem. The results of this experiment obtain that fixation of biological nitrogen in the soil of grassland grazed freely decreased, because N/P value of grassland grazed freely is relatively large, N content in the soil is relatively low, therefore, relative to the grassland enclosed, grassland grazed show that nitrogen is the limiting elements, however, the re-
sult of quantity of nitrogen fixation in soil increase due to N/P decreased on the growth season enclosed, the N content of grassland enclosed is improved, the trend that the N content of soil enlarge with the extension of years enclosed is consistent with this research. Phosphorus is the limiting elements on grassland enclosed relative to grassland grazed freely. This is consistent with Yin’s [11] result. In theory, the N and P of soil should work together to limit soil N/P, however, the results of this study show that the correlation coefficient between N, P content and N/P is quite different between grassland enclosed and grassland grazed freely. In the grassland grazed freely, correlation coefficient between P and N/P is less than one between N and N/P, therefore, to limit the extent of content of P on N/P is less than N in soil, content of N and P were relatively low on grassland grazed freely, so the N of grassland grazed freely is the restrictive elements. Correlation coefficient between P and N/P is larger in grassland enclosed than one between N and N/P, it confirmed P is the restrictive elements in the areas enclosed, the results obtained are consistent with this research.

4.3 Different ages of enclosing grassland and free grazing grassland soils C/P
The Low C/P ratio is an indicator of high effectiveness of phosphorus, the validity of P is determined by the decomposition rate of soil organic matter(Wang & Yu 2008). the effectiveness of P is low owning to high C/P of grassland grazed freely, low C/P in grassland enclosed leads the high effectiveness of P. results that measures enclosed improve the content of total phosphorus in soil is consistent with that of N/P on desertification steppe. The research that C/P of Chinese average is 105 are broadly consistent with our results [2]. Before 14 years in different ages on grassland enclosed, the trend that C/P grassland enclosed was significantly lower than that of grassland grazed freely were decreased with the prolongation of enclosing. After 14 years on plots enclosed, C/P is increased. The time enclosed is too long, so the soil C, N and P decreased. The growth of microorganisms cannot be satisfied and its biomass is decreased. Therefore, soil properties will enter the regressive succession. The correlation coefficient between C/P and soil organic carbon was less than the correlation coefficient between C/P and total P between grassland enclosed and grassland grazed freely, and the results that P of grassland enclosed is the restrictive elements clarified further. the results of research are agreement with that of N/P.

5 Conclusions
The time of grassland enclosed for 14 years is when the soil and vegetation achieve the best life on eco-logical stoichiometry ratio of C and N and P on the grassland soil. After 14 years, the C/N of soil will be increased to 22 years. The C/N of soil of steppe grazed freely is less than that enclosed. The grassland will be in retrograde succession stage, if the time enclosed is too long. The C and N accumulation of soils of grassland is unfavorable. N is restriction element on grassland grazed free, P is restrictive element on grassland enclosed. We should take corresponding ecological utilization and protective measures, if the time enclosed is more than 14 years. The grassland should be mowed and grazed on basis of the growth, climate and environment, the demand of social economic development.

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