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Original Research Paper

# Soil Chemical Properties and Biological Characteristics of Discontinued Farmland in the Downstream of Shiyang River

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## ABSTRACT

Soil inorganic nitrogen (nitrate nitrogen, ammonium nitrogen), enzyme activities (catalase, urease, phosphatase and invertase) and microbial biomass of secondary grassland in an abandoned farmland with different restoration years of Shiyang River are measured and analyzed. The results indicated that the soil ammonium nitrogen decreased and nitrate nitrogen increased in each layer (0-10cm, 10-20cm, 20-30cm, 30-40cm) as the restoration age increased. In addition to the 30-40cm soil layer, soil microbial biomass carbon in each layer had a downward trend in shorter abandoned ages (from 1a to 5a ) and an upward trend in longer ages (from 8a to 31a); soil microbial biomass nitrogen reduced initially (from 1a to 4a), afterward increased (from 4a to 8a) and reached a steady level finally (from 8a to 31a); soil microbial biomass phosphorus increased firstly (from 1a to 5a) and then declined (from 5a to 31a). The activity of catalase altered insignificantly while those of other three soil enzymes varied significantly in the same layer within different restoration years. Soil enzyme activity declined with the increase in soil depth during the same restoration year.

## INTRODUCTION

As a component of the ecosystem and an environmental factor, soil provides necessary environmental conditions for growth, development and reproduction of creatures in the ecosystem. Soil nitrogen is an essential nutrient element for plants. However, organic nitrogen cannot be directly absorbed by plants. It must be mineralized to form inorganic nitrate nitrogen and ammonium nitrogen, thus absorbed by plants. Therefore, the contents of nitrate nitrogen and ammonium nitrogen in the soil, affect the growth of grassland in the abandoned farmland. Soil enzyme is an important part of the soil, which is closely correlated with the soil physicochemical properties (Gao et al. 2007), and can reflect the status of biological metabolism and substance transformation in soil (Zhu et al. 2002), and better reflect the apparent soil fertility (Zhou et al. 1973). Soil microbial biomass is a living organic matter in soil, which is an important source of soil nutrients. By studying microbial biomass, we can reveal soil nutrients, thus representing the soil fertility and matter and energy flow in soil ecosystem, which is of important theoretical reference value for restoration of soil ecological environment. In recent years, with acknowledgement of the important role of microorganisms in the whole ecosystem, more and more researches have focused on the use of soil microbial parameters to evaluate soil fertility and quality (Wang et al. 2013, Wendu et al. 2010). Currently, the research on restoration of grassland in the abandoned farmland has become a hot topic in the field of ecology.

The midstream and downstream areas of the Shiyang River basin are the oases with dense plants and rich water resources at the beginning of agricultural production (Feng 1963). However, as the scale of agricultural production in the upstream is expanding, the demand for water increases every year, and the volume of water flowing into the oasis region at the midstream and downstream drastically reduces (Su et al. 2006, Wang et al. 2008). In order to maintain the basic needs of the existing agricultural production, within a period of time, the irrigation need is met by the excessive exploitation of underground water (Li et al. 2004, Wang et al. 2003). It is reported that (Wang et al. 2014), at present, the underground water level in this area sharply falls from 2m to 10m, and tens of meters in some areas. The severe water shortage leads to natural vegetation death, dry-up and salinity of Weiu Lake as well as desert invasion (Liu et al.

Table 1: Inorganic nitrogen content of different years abandoned cultivated lands.

| Indicator | depth (cm) | Returning (year) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1a | 2a | 3a | 4a | 5a | 8a | 15a | 24a | 31a |
| Ammonium-N | 0-10 | 4.02f | 4.78f | 16.41c | 18.51c | 19.26d | 29.53e | 18.13b | 12.33a | 23.49c |
| (mg/kg) | 10-20 | 3.73g | 3.9g | 16.28e | 11.71c | 17.88d | 30.72f | 18.2b | 9.33a | 19.89c |
| | 20-30 | 3.52f | 2.86f | 12.85d | 9.89bc | 13.58bc | 26.79e | 14.29c | 7.91a | 11.94b |
| | 30-40 | 2.97f | 2.41f | 11.23e | 7.13c | 13.36d | 25.99e | 15.45cd | 6.47a | 11.46b |
| Nitrate-N | 0-10 | 9.25g | 21.46f | 26.95d | 9.86e | 31.79g | 35.7a | 33.39d | 37.27b | 31.96c |
| (mg/kg) | 10-20 | 1.26h | 4.13g | 5.94f | 9.59e | 29.94b | 25.62c | 29.91b | 33.05a | 22.75d |
| | 20-30 | 0.3h | 0.24h | 4.84f | 3.57g | 24.89a | 11.57d | 9.38e | 12.88c | 14.93b |
| | 30-40 | 0.27e | 0.23e | 0.47e | 1.14d | 10.33a | 8.75b | 1.57d | 5.41c | 8.99b |

2001), thus leaving a large area of land uncultivated, which becomes a secondary grassland. In recent years, the government has adopted the policy of "well shutdown and cultivated land reduction" and the policy of farmland returning to woodland, so the area of secondary grassland in the abandoned farmland increases again. Without timely treatment, a large area of secondary grassland will gradually become a desert through desertification. Therefore, in this study, we take the secondary grassland in the abandoned farmland at the midstream and downstream of Shiyang River Basin as the object, and study the changes in soil inorganic nitrogen, soil microbial biomass and soil enzyme activity at different soil depths in different years of farmland returning to woodland, aiming at providing a basis for exploration of microbial mechanism of grassland desertification in the abandoned farmland, vegetation restoration, soil improvement and scientific management.

## MATERIALS AND METHODS

**Overview of research area**: The research area is the abandoned farmland of Huanghui Village and Ziyun Village, Xiqu Town at the north of Minqin County in Gansu Province. The altitude is 1300-1311m and the geographical coordinates are 39°01'30"-39°03'28" N and 103°35'57"-103°37'56" E. At the eastern, northern and western are the surfaces of Qingtu Lake. The average annual temperature is 7.4°C, the extreme maximum temperature is 38.1°C, the extreme minimum temperature is -28.8°C; the average annual rainfall is 110mm, mainly concentrated in July to September, accounting for 73% of annual rainfall; the average annual evaporation is 2644mm, the annual sunshine time is 2832.1h; and the annual average wind speed is $2.3 m \cdot s^{-1}$. There are shrubs such as *Kalidium foliatum*, *Lycium ruthenicum*, *Nitraria sibirica*, *Reamuria soongoria*; herbaceous plants such as *Convolvulus arvensis*, *Chenopodium album*, *Halogeton arachnoideus*, *Acroptilon repens* (L.), *Suaeda glauca*, *Peganum harmala*, *Peganum nigellastrum* and *Salsola ikonnikovii*.

**Sample land selection and soil sampling:** In June 2012, we visited the villages and towns at the midstream and downstream of Shiyang River and looked into the records on land use. We selected the land sections where the landform does not changed due to natural factors, or the soil substances are re-allocated due to human factors as the test area. On the premise of ensuring the same parent material of sandy soil, we selected No. 1, 2, 3, 4, 5, 8, 15, 24 and 31a abandoned lands as the sample lands. The area of each sample land is $1hm^2$. According to the S shape, we selected 5 representative sections as the fixed sampling points and marked each sampling point. We set up 5m × 5m quadrat to measure the community characteristics of herbaceous plants as well as the soil characteristics; 5-10m × 5-10m quadrat to investigate the characteristics of shrubs and semi-shrubs (the specific size of quadrat is determined by the plant species and through the preliminary pre-test). We dug soil profile in each fixed sampling point, set up three profiles, and sampled soil by a ring knife at four layers of 0-10cm, 10-20 cm, 20-30 cm and 30-40cm in the profiles. We uniformly mixed 5 sample soils at the same land according to the same layer, and took 2 pieces back to the laboratory for analysis with the quartering method. One piece was used to measure the soil inorganic nitrogen and soil microbial biomass; after air-dried, another piece was used to measure the soil enzyme.

**Measurement of $NH_4^+$ N and $NO_3^-$ N in Soil:** Ammonium N was meased by the indophenol blue colorimetric method as described by Gao & Xiang (2006), and nitrate nitrogen by the dual-wavelength ultraviolet spectrophotometry (Yu et al. 1995).

**Measurement of soil enzyme:** Measure the catalase activity with the volumetric method (Guan 1986). It is expressed by the mL of 0.1N (i.e. $0.02 mol.L^{-1}$) potassium permanganate in 1g of soil after 30min. The urease activity was measured with the indophenol blue colorimetric method (Guan 1986). It is expressed by the mg of $NH_3$-N in 1.0g of soil after 24h. The phosphatase activity was measured with the disodium phenyl phosphate colorimetric method. It is ex-

Table 2: Characteristics of soil enzyme activity under the different years abandoned cultivated lands.

| Indicator | Depth (cm) | Returning (year) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1a | 2a | 3a | 4a | 5a | 8a | 15a | 24a | 31a |
| Catalase | 0-10 | 3.91ab | 3.94ab | 3.76ab | 3.15c | 4.03a | 3.89ab | 3.73b | 3.35c | 3.93ab |
| mL/(g·20min) | 10-20 | 3.8a | 3.4b | 3.34bc | 2.89d | 3.86a | 3.36bc | 2.76d | 3.21c | 3.47b |
| | 20-30 | 3.43a | 3.33ab | 3.50a | 2.73c | 3.44a | 2.87c | 2.68c | 3.11b | 3.26ab |
| | 30-40 | 2.96a | 2.93a | 2.85a | 2.00c | 2.92a | 2.43b | 1.92c | 1.40d | 1.84c |
| phosphatase | 0-10 | 2.55b | 2.88b | 2.01c | 3.60a | 2.17c | 3.36a | 1.58d | 0.85e | 1.24d |
| mg/(g·d) | 10-20 | 1.74c | 2.10b | 1.80c | 2.68a | 1.33de | 2.33b | 1.40d | 0.68f | 1.09e |
| | 20-30 | 1.24cd | 1.47c | 1.36c | 2.26a | 1.18cd | 1.86b | 1.18cd | 0.49e | 1.06d |
| | 30-40 | 0.93ef | 1.22bc | 1.08cde | 1.70a | 0.97de | 1.29b | 1.09cd | 0.41g | 0.79f |
| Urease | 0-10 | 0.60ab | 0.63a | 0.54cd | 0.57bc | 0.53cd | 0.52d | 0.45e | 0.48e | 0.23f |
| mg/(g·d) | 10-20 | 0.61a | 0.61a | 0.43c | 0.56ab | 0.42cd | 0.51b | 0.36d | 0.27e | 0.13f |
| | 20-30 | 0.55a | 0.56a | 0.26c | 0.53a | 0.41b | 0.43b | 0.16de | 0.18d | 0.12e |
| | 30-40 | 0.43b | 0.51a | 0.20de | 0.53a | 0.34c | 0.41b | 0.13e | 0.13e | 0.24d |
| Sucrase | 0-10 | 8.23f | 14.33c | 12.88d | 21.79a | 12.22d | 15.02c | 9.70e | 12.67d | 17.38b |
| mg/(g·d) | 10-20 | 6.65e | 12.11b | 9.93c | 20.83a | 9.99c | 12.74d | 6.57e | 7.00de | 7.63d |
| | 20-30 | 4.77d | 5.96cd | 9.39b | 17.37a | 6.42c | 8.76b | 5.77cd | 4.79d | 2.06e |
| | 30-40 | 2.95f | 4.95d | 6.86b | 10.06a | 3.96e | 5.64c | 4.64d | 2.71f | 1.68g |

pressed by the mg of phenol released from 1.0g of soil after 24h. The sucrase activity was measured with the colorimetric method. It is expressed by the mg of glucose in 1.0g of soil after 24h.

**Measurement of soil microbial biomass:** It was measured with chloroform fumigation method (Xu et al. 1986). Weigh 3 pieces of soil samples (10.0g) through screening and 7d of pre-cultivation, and respectively put them in a 50mL beaker, and place them together into the same desiccator. At the bottom of the desiccators, place several pieces of water-moistened filter paper, and respectively put them in a small beaker with 50mL of NaOH solution (1mol·$L^{-1}$) and in a small beaker of 50mL without ethanol chloroform (add a small amount of substance resistant to uprising boiling, such as anhydrous $CaCl_2$). Seal the desiccators with a small amount of petroleum jelly. Use the vacuum pump to exhaust until the chloroform is boiling at least for 2min. Close the desiccator valve and place for 24h at 25°C darkness. Open the valve. If there is no sound of air flow, it indicates the air leakage of the desiccator. Re-weigh samples for fumigation. When there is no air leakage in the desiccators, take out the glass bottle with NaOH solution and chloroform. Wipe the bottom of the desiccator, remove the filter paper and use the vacuum pump to repeatedly exhaust until there is no smell of chloroform. In fumigation, set up 3 pieces of soil samples without fumigation for comparison.

**Measurement of soil microbial biomass carbon (SMBC):** After chloroform fumigation, extract the soil with 0.5mol·$L^{-1}$ $K_2SO_4$ solution. The carbon measurement is based on the potassium dichromate sulfuric external heating method.

SMBC = Ec-Eco/0.38

**Measurement of soil microbial biomass nitrogen (SMBN)(Yang 2007):** After chloroform fumigation, extract the soil with 0.5mol·$L^{-1}$ $K_2SO_4$ solution. The nitrogen measurement is based on the Kjeldah method.

SMBN = Ec-Eco/0.54

**Measurement of soil microbial biomass phosphorus (SMBP)(Yang 2007):** After chloroform fumigation, extract the soil with 0.5mol·$L^{-1}$ $NaHCO_3$ solution. The phosphorus measurement is based on the molybdenum blue colorimetric method.

SMBP = Ec-Eco/0.40

Where, Ec is the content of organic carbon (nitrogen and phosphorus) in the fumigated soil extract liquid; Eco is the content of organic carbon (nitrogen and phosphorus) in the non-fumigated soil extract liquid.

**Data processing:** Excel software was used for statistical processing of test data, and then SPSS 18.0 software was used for analysis.

## RESULTS

**Spatial distribution characteristics of soil inorganic nitrogen in abandoned farmland in different years**: The measurement and analysis of soil inorganic nitrogen in abandoned farmland in different years at the midstream and downstream of Shiyang River indicates that at the same soil layer of abandoned land in different years, the soil nitrate nitrogen shows a rising trend with the extension of returning year. The nitrate nitrogen concentrations at each soil layer are 37.27mg·$kg^{-1}$, 33.05mg·$kg^{-1}$, 14.93mg·$kg^{-1}$ and 10.33mg·$kg^{-1}$, at most, in the No. 24a, 24a, 31a and 5a abandoned lands

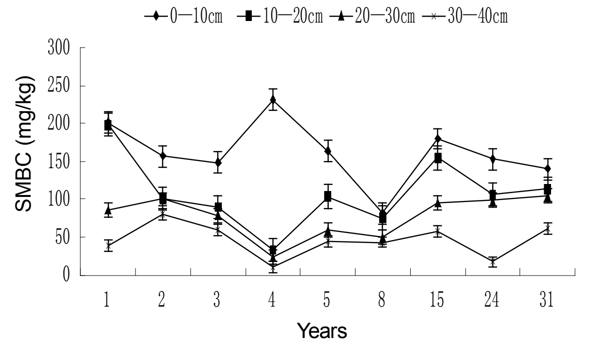


Fig. 1: The change law of SMBC of abandoned land in different years.

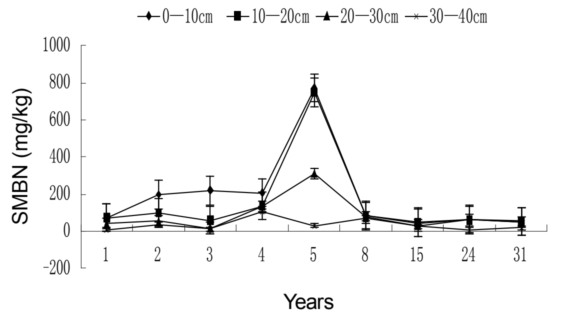


Fig. 2: The change law of SMBN in different returning years.

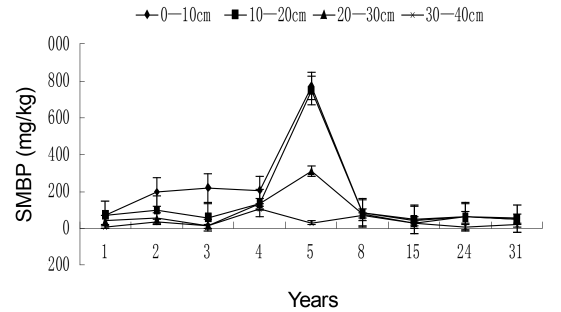


Fig. 3: The change law of SMBP at the same soil layer in different returning years.

respectively. The soil ammonium nitrogen increases first and then decreases with the extension of returning years. The soil ammonium nitrogen concentrations at each soil layer are 29.53mg·kg$^{-1}$, 30.72mg·kg$^{-1}$, 26.79mg·kg$^{-1}$and 25.99mg·kg$^{-1}$ respectively, reaching to the maximum at No. 8a abandoned land. In the same returning year, the difference of soil nitrate nitrogen and soil ammonium nitrogen is larger with the change of soil layer. Namely, the difference is narrowed with the deepening of soil layer, showing an obvious surface gathering effect.

**Spatial distribution characteristics of soil enzyme in abandoned farmland in different years**: The measurement results of activity of soil sucrase (glucose), urease ($NH_3$-N), phosphatase (phenol) and catalase show that in different returning years, the difference in catalase activity at the same soil layer is not significant, and the difference in activity of other 3 soil enzymes are significant. In the same returning year, the soil enzyme activity weakens with the deepening of soil layer.

**Spatial distribution characteristics of soil microbial biomass in abandoned farmland in different years**: The change law of SMBC of abandoned land in different years is shown in Fig. 1. At the same soil layer in different returning years, SMBC is expressed as follows: At 0-30cm soil layer, with the extension of returning year, in the shorter years (from 1 to 5a), SMBC shows a general falling trend; in the longer years (from 8a to 13a), SMBC shows a general rising trend. The maximums of SMBC at soil layers are 231.66mg·kg$^{-1}$, 198.42mg·kg$^{-1}$ and 104.06mg·kg$^{-1}$ in No. 4a, 1a and 31a abandoned lands respectively. At 30-40cm soil layer, with the increase of returning year, SMBC shows a general falling trend, maximum in No. 2a abandoned farmland, namely 79.46mg·kg$^{-1}$. At the same returning year, SMBC reduces with deepening of soil layer.

The change law of SMBN in different returning years is shown in Fig. 2. With the increase of returning year, SMBN shows a falling (from 1a to 4a), then a rising (from 4a to 8a), finally a stable (from 8a to 31a) trend. At the 0-20cm soil layer, the maximum content of SMBN is in No. 5a, 113.60mg·kg$^{-1}$ and 96.26mg·kg$^{-1}$ respectively. At 20-40 cm soil layer, the maximum content of SMBN is in No. 1a, 49.13mg·kg$^{-1}$ and 32.56mg·kg$^{-1}$ respectively. At the same returning year, the difference in SMBN is larger with the change of soil layer. Namely, SMBN in surface layer is more than that in deep layer. The surface gathering effect is significant.

The change law of SMBP at the same soil layer in different returning years is shown in Fig. 3. At 0-30cm soil layer, with the increase of returning year, SMBP shows a rising (from 1a to 5a) and falling (from 5a to 31a) trend. Its content is highest in No. 5a, namely 774.77mg·kg$^{-1}$. At 30-40cm soil layer, with the increase of returning year, SMBP shows a rising (from 1a to 4a) and falling (from 4a to 31a) trend. Its content is highest in No.4a, namely107.79mg·kg$^{-1}$. At the same returning year, the change trend of SMBP is similar to that of SMBC and SMBN.

## DISCUSSION

**Spatial variability characteristics of soil inorganic nitrogen in abandoned farmland in different years:** Ammonium nitrogen is generally adsorbed on the surface of soil colloid, while the nitrate nitrogen is not, with a strong mobility. The content of nitrate nitrogen in soil is easily affected by the supply of ammonium nitrogen, number of nitrifying bacteria, leaching of precipitation and gas release, so its content is more instable than ammonium nitrogen and its spatial variability is larger. Meanwhile, the plant's absorption of ammonium and nitrate nitrogen has the obvious bias, namely the change in contents of soil ammonium and nitrate nitrogen is also affected by the vegetation types. In this study, at different returning years, the change trends of soil nitrate nitrogen and ammonium nitrogen are different. After 5a and 24a of returning, the content of nitrate nitrogen at 20-40cm and 0-20cm soil layers can be increased; after 8a, the content of ammonium nitrogen at 30-40cm soil layer can be increased, and obviously higher than other returning years. This result is consistent with the research result concluded by Lin Changhu et al. (2007), that nitrogen level in abandoned land increases with extension of returning year. Therefore, in the vegetation restoration in this area, we can select appropriate plant species according to the returning years and root depth. Meanwhile, this study indicates that the difference between nitrate nitrogen and ammonium nitrogen is larger with the change of soil layer, namely the difference is narrowed with the deepening of soil layer. This result is consistent with the result concluded by Shi Zuomin et al. (2004) and Sun Jingling et al. (2010). This study also shows a significant surface aggregation effect, which is mainly because the soil nitrogen is from fallen matters, and the soil nitrogen first gathers on surface layer of soil, and then moves and spreads to the lower layer with water and other media, thus forming the distribution pattern that the soil nitrogen content is smaller from surface to depth. This result is consistent with the research result concluded by Niu Yun et al. (2014) and Wei Qiang et al. (20012).

**Spatial distribution characteristics of soil enzyme in abandoned farmland in different years**: With the increase in the years of secondary grassland in abandoned farmland evolved and replaced, the overall trend of soil enzyme activity gradually weakens. This result is consistent with the research result concluded by Tai Jicheng et al. (2008) and Wendu Rile et al. (2010), about the vertical change of soil enzyme activity, while they have differences. In this study, we found that the catalase activity showed a gradually decreasing, then increasing and finally stable trend, thus reaching the relatively balanced state. The sucrase activity showed a fluctuant increasing, decreasing and relatively stable trend, reaching the relatively balanced state. In 4a, the sucrase activity reached the maximum at the same layer. In 5a, it returned to the state in 3a and tend to be stable. Especially, the sucrase activity in 15a, 24a, 31a at the 10-20cm soil layer is very close. Urease activity showed a fluctuant decreasing trend with the increase of returning year, and finally tend to be stable. The volatility was relatively stable. In 3a, it significantly reduced. The average urease activity was reduced from 0.547mg/(g.d) in 1a to 0.357mg/(g.d) in 3a. In 4a, it returned to be stable. With the restoration of plants, it finally tend to be relatively stable. Phosphatase activity showed a fluctuant increasing and decreasing trend. Its change trend was similar to sucrase activity. From 1a to 3a, the change was relatively stable. In 4a, phosphatase activity significantly increased, reaching the maximum, and then tend to be stable.

**Spatial distribution characteristics of soil microbial biomass in abandoned farmland in different years**: Soil microbes are the "sources" and "libraries" of nutrient fixing and releasing. Its turnover is very fast. Soil microbial biomass is the driving force of conversion of soil organic matter and soil nutrient and the main biological characteristic index of soil quality, which can quickly indicate the change of soil quality. This study shows that SMBC at 0-10cm, 10-20cm and 20-40cm soil layers can be respectively increased in 4a, 1a and 2a. SMBN at 0-40cm soil layer can be increased in 5a. SMBP at 0-30cm and 30-40cm soil layers can be increased in 5a and 4a, and SMBC, SMBN and SMBP are significantly higher than other returning years. Therefore, with the increase of returning year as well as continuous growth of plants, the roots will gradually increase. Thus, the soil nutrients will constantly accumulate and the available substrates of soil microbe gradually increase. However, the returning year can be shortened according to actual situation. Meanwhile, SMBC, SMBN and SMBP reduce with the deepening of soil layer. This is mainly because a lot of dry branches and fallen leaves gather on the surface, the surface nutrients are abundant, which is conducive to microbial activities, and the hydrothermal condition of topsoil and the ventilation conditions are good. Additionally, due to fast turnover of thin roots and fallen maters, the growth of microbes is more vigorous and the metabolism is more active, which has a positive impact on the bio-availability of various nutrients, thus showing a significant surface gathering effect. This is consistent with the change law of soil nutrient as the soil layer changes.

## CONCLUSION

Soil ecosystem is a complex process of substance metabolism and cycle. In this paper, we used the method of mutual replacement of time and space to study the physicochemical and biological properties of soil in abandoned lands at the downstream of Shiyang River Basin. With the increase in years of secondary grassland in the abandoned farmland evolved and replaced, as well as continuous growth of plants, roots will gradually increase, soil nutrients will constantly accumulate. With the increase of fallen matters, the available substrates of soil microbes also gradually increase. Thus, SMBN, SMBC and SMBP reduce with the deepening of soil layer. However, the soil nitrogen is from fallen matters, and the soil nitrogen first gathers on surface layer of soil, and then moves and spreads to lower layer with water and other media, thus forming the distribution pattern that the soil nitrogen content is smaller from surface to depth. Meanwhile, the soil enzyme activity shows an overall gradually decreasing trend. Therefore, to obtain the continuous change law, it is necessary to conduct a long positioning inspection.

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## REFERENCES

Feng, Shengwu 1963. Water system evolution of Minqin oasis. Geographical Journal, 29(3): 241-249.

Gao Dusen and Xiang 2006. Soil Analysis Standards. China Agriculture Press, Beijing, 44-46.

Gao, Xuefeng, Han, Guodong, Zhang and Gong et al. 2007. Dynamic research on soil enzyme activity and nutrient content in desert steppe under different grazing intensities. Grassland Science, 24(2): 10-13.

Guan, Songyin 1986. Soil Enzyme and its Research Method. Beijing Agricultural Press, Beijing.

Li, Ding, Ma, Jinzhu and Nan, Zhongren 2004. Groundwater recession characteristics in Minqin basin and sustainable utilization evaluation. Chinese Deserts, 21(6): 734-739.

Li, Guicai, Han, Xingguo, Huang, Jianhui and Tang, Jianwei 2001. Progress of research on factors affecting soil mineralization in forest ecosystem. Journal of Applied Ecology, 7: 1187-1195.

Lin, Changhu, Zhang, Qinghai and Duan, Pei 2007. Soil nitrogen variation characteristics in different ecological patterns in eastern desertification region of Guizhou. Soil and Water Conservation Journal, 21(1): 128-130.

Liu, Heng, Zhong, Huaping and Gu, Ying 2001. Research on water resource utilization in northwest dry inland river basin and oasis evolution law. Advances in Water Science, 12(3): 378-384.

Niu, Yun, Liu, Xiande and Zhao, Weijun 2014. Soil carbon and nitrogen content characteristics in superficial layer of *Picea crassifolia* forest in Qilian mountains. Chinese Deserts, 34(2): 371- 377.

Shi, Zuomin, Liu, Shirong and Cheng, Ruimei 2004. Soil carbon and nitrogen characteristics of four community types of plants in Ordos, inner Mongolia. Forestry Science, 40(2): 21-27.

Su, Zhizhu, Lu, Qi and Wu, Bo 2006. Possible impacts of climate change and human activities on desertification in China. Chinese Deserts, 26(3): 229-334.

Sun, Jingling, Wang, Ping and Wang, Dequan 2010. Time-space dynamic change analysis of soil nitrate nitrogen content in wheat soil at Hexi area. Soil Science, 41(4): 882-885.

Tai, Jicheng, Yang, Hengshan, and Zhang, Qingguao 2008. Soil enzyme activity and distribution of artificial grassland of *Medicago sativa* in different growth years. Grassland Science, 25(4): 76-78.

Wang, Lide, Yao, Tuo, He, Fanglan and Han, Fugui 2014. Natural recovery process of secondary grassland in abandoned farmland at downstream of Shiyang river as well as change of soil enzyme activity. Grassland Journal, 23(4): 253-261 .

Wang, Shijin, He, Yuanqing and Zhao, Chengzhang 2008. Water resources optimized arrangement and sustainable utilization in northwest inland river basin. Soil and Water Conservation Research, 15(5): 22-29.

Wang, Shaokun, Zhao, Xueyong and Zhang, Tonghui 2013. Impact of afforestation on number of soil microbes, SMBC and enzyme activity in sandy soil. Chinese Deserts, 33(2): 529-535.

Wang, Qi, Shi, Ji'an and Zhang, Zhongning 2003. Analysis of environment state and evolution trend of Shiyang river basin. Chinese Deserts, 23(1): 46-52.

Wang, Yanjie, Zou, Guoyuan, Fu, Hua and Liu, Hongbin 2005. Progress of research on soil nitrogen mineralization. Chinese Agricultural Science Bulletin, 10.

Wei, Qiang, Ling, Lei and Chai, Chunshan 2012. Physical and chemical properties of soil in evolution of Xinglongshan forest in Gansu. Journal of Ecology, 32(15): 4700-4713.

Wendu, Rile, Li, Gang and Zhang, Jingni, et al. 2010. Research on soil microbial biomass and soil enzyme activity on different types of grassland on Hulunbeier. Grassland Journal, 19(5): 94-102.

Xu, Guanghui and Zheng, Hongyuan 1986. Soil Microbial Analysis Manual. Agricultural Press, Beijing.

Yang, Chengde 2007. Research on microbial biomass and physical and chemical properties of soil of different types of grassland on Qilian mountains. Gansu Agricultural University, Lanzhou.

Yu, Mengde, Mo, Jiangming and Kong, Guohui 1995. Preliminary research on measurement of soil available nitrogen in monsoon evergreen broadleaf forest of Dinghu mountain with the ion exchange resin method. Tropical and Subtropical Plant Journal, 34: 44-48.

Zhu, Li, Guo, Jixun and Lu, Ping 2002. Comparative study of soil enzyme activity of *Leymus chinensis* and Alkaligrass community. Grassland Journal, 11(4): 28-34.

Zhou, Likai, Zhang, Zhiming and Cao, Chengmian 1983. Role of soil enzyme activity in evaluation of soil fertility. Soil Journal, 20(4): 413-417.