Analysis on Vegetation Growth Characteristics of Manas River Basin in Sinkiang

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Abstract

Based on the field research on the characteristis of vegetation growth, soil and shallow groundwater in the Manas River Basin in Sinkiang area and the summary of the results of relavant laboratory tests, vegetation of the Manas River Basin can be sorted into four regions by coverage rate, namely, region with high vegetation coverage, region with medium vegetation coverage, region with medium vegetation coverage and desert region. Additionally, the relation between vegetation growth characteristics, the buried depth of shallow groundwater, soil composition, moisture content and soluble salt is also analyzed comprehensively. Through the analysis, we find that the buried depth of the groundwater is a decisive factor that influences vegetation growth characteristics of this climatic region. In the area where the buried depth of shallow groundwater is lower than 2.5 m, vegetation coverage may be high, especially where near rivers and lakes, but the area where the buried depth of groundwater is higher than 5.0 m is usually desert region. The soil characteristic is another factor that decides vegetation growth characteristics. That's to say, the soil composition, moisture content and the content of soluble salt are also important factors that may influence the development of vegetation. It is further pointed out that the developed clayey soil is more favorable to the development of vegetation than the sandy soil is where the buried depth is lower than 50 cm. In the area where the buried depth is lower than 30 cm, whether the moisture content is higher than 10% or not is a criteria to determine whether the area belong to high coverage area or low coverage area. In the area with buried depth lower than 50 cm, the content of soluble salt has the largest influence on the vegetation coverage.

Key Words: Manas river basin in China, the vegetation coverage, Gound water level, Property of soil, Content of soluble salt

1. Introduction

The Manas River Basin of Sinkiang in China is located in the north slope of Tianshan Mountain and also the southern Junggar Basin. It stretches from the watershed in the north slope of Yilianhabierga Mountain in the south to the Gurbantunggut Desert in the north and from Taxi River in the east to the Bayingou River in the west. Administratively, the basin covers Manas County, Shawan County, Shihezi City, 19 regiments, villages of the No. 8 agricultural production division and the Xinhu regiment of the No. 6 agricultural production division. The Manas River Basin of Sinkiang is located in the typical arid region, where a variety of landforms exist including the accumulative denudation landform, piedmont alluvial-proluvial fan, floodplain terrace, marshland in edge-spring overflow area, alluvial-proluvial plain and desert. The microrelief like floodplain terrace, depression and marshland only exists in the two sides of the Manas River. Influenced by the weather system of the temperature zone and the weather system of the Arctic Ocean, this area is dry and rainless, where the evaporation capacity is much higher than the precipitation. As a result, the development of local vegetation mainly relies on groundwater recharge. Due to the combined actions of over exploitation of shallow groundwater and the artificial interception of surface water, the water yield of the Manas River Basin have decreased dramatically and the regional groundwater level have kept decreasing as well. In addition, the hot dry climate leads to intense evaporation, with evaporation capacity (1500mm-2500mm) much higher than the precipitation (100mm-200mm) and the annual evaporation being 10-20 times of the precipitation. The annual temperature is 6.5 ℃, warm in the summer and autumn, and cold in the spring and winter. These climatic conditions intensify the salination and desertization of the soil, deteriorate the

basic habitat of plants, forcing vegetation of the Manas River Basin evolves from the one that is tall, straight and dense to the one that is thin, small and sparse.

Survival of the fittest(Serafini Y V, Sud Y C. 1987; DelworthT L. 1988; Delworth T. L. and Manabe S. 1988; Tsvetsinskaya E.A., et al. 2001; Wu W, et al. 2002), it is the same way for plants. The wild vegetation can live in the climate that is suitable for it to survive. The development of vegetation is directly related to the buried depth of groundwater, the property of soil, climate factors, etc. Although, there are already some researches conducted on the vegetation ecology and climatic problems in this research area, comprehensive analysis on vegetation, the soluble salt in soil and the groundwater is not much.

On the basis of previous study achievements, by conducting field survey on the development of vegetation of the Manas River Basin and the shallow groundwater and combining the laboratory test results on the soluble salt in soil and soil composition, this research is conducted, revealing the influence of factors like the soil property in the shallow groundwater, content of soluble salt, climatic condition and environmental condition on vegetation in terms of variety and development. It is believed that the region with medium vegetation coverage has certain adjustment ability, thus it is easy for it to transform into region with high vegetation coverage. The research result can provide scientific basis for protection of the eco-environment of vegetation and for the effective governance of the desert.

2. Environment Characteristics of Vegetation

2.1 Relation between the Distribution of Vegetation and the Depth of Groundwater

According to the survey result, this basin can be divided into four regions, namely, region with high vegetation coverage, region with medium vegetation coverage, region with low vegetation coverage and desert region, of which the detailed characteristics are described as below:

(1) Region with high vegetation coverage

For the wild vegetation region, the region with high vegetation coverage means the region where the vegetation coverage is higher than 60%. This region is usually located about 200 m far from the rivers, groundwater seepage area, marshland and lakes. The vegetation in this region features wide variety, dense and strong appearance and vigorous growth trend. The plants live here include reed, cattail, rose willow, ulmus parvifolia, populus euphratica forest, etc. In several regions, there also grows tall and dense populus euphratica. On the earth's surface, salinization can be found occasionally. The wild landscape is shown in Photo. 1.

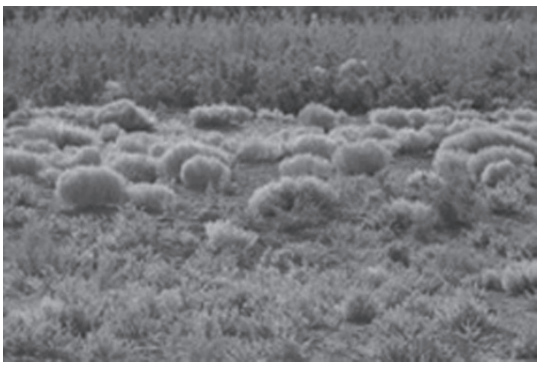

Photo. 1. Region with high vegetation coverage

The shallow groundwater in this region is buried shallowly, with buried depth lower than 2.5 m.

(2) Region with medium vegetation coverage

For the wild vegetation region, the region with medium vegetation coverage means the region where the vegetation coverage is at 30%～60%. This region is usually located about 200m-500m far from the rivers, lakes and artificial irrigation ditches. The vegetation characteristics of this region: major plants growing here include rose willow, Karelinia caspica, Achnatherum splendens, Acid smartweed, Sophora alopecuroide, etc. These plants show medium growth trend, with height mainly at 30cm～40cm, looking slim and fragile and some even dying up. See Photo 2.

Photo. 2 Region with medium vegetation coverage

for vegetation characteristics. The salinization of this region belongs to moderate degree and is severer than that of the high coverage region. The depth of the groundwater here is 2.5m-4.0 m. The perennial plants with long root can draw water from groundwater and aeration zone.

(3) Region with low vegetation coverage

The coverage rate of region with low coverage vegetation coverage is at 15%～30%. This region is located about 500 m-1000 m far from the rivers, lakes and artificial irrigation ditches. Plants adapted to salt and alkali condition are growing here, including rose willow, sacsaoul, Karelinia caspica, Alhagi camelorum, Achnatherum splendens, Sophora alopecuroide, suaeda salsa, etc. These plants show poor growth trend, looking slim and weak, with height less than 10 cm. The salinization belongs to severe degree. The landscape is shown in Photo 3. The buried depth of groundwater here is usually

Photo. 3 Region with low vegetation coverage

4.0m～5.5 m. The root system of most of the plants can hardly reach to the shallow groundwater. For example, in the research spot 04-15#, the water level in the junction of Mahe River and Gurbantunggut Desert, the depth of underground water level is deeper than 4.3m and the wetting line is 2.0 m from the ground and 2.3 m from the water surface. The water here is very salty.

(4) Desert region

The vegetation coverage of this region is lower than 10% due to its location that it is located over 1000 m away from the rivers, lakes and artificial ditches, most of the region are in desert and Gobi zone with little vegetation. This region suffers from severe salinization and desertization, as shown in Photo 4. The buried depth of the groundwater level of this region is lower than 5.5 m.

Photo. 4 Desert region

2.2 Relation between Vegetation Distribution and Soil Property

The soil is the basic term for plant growth and water is the necessary condition for creatures to survive. Only by absorbing water, nutrient and sunshine from the environment continuously, can the creatures maintain their normal life activities. Additionally, water is a necessary for plants in cell swelling, transpiration, photosynthesis as well as absorbing and transporting nutrient. The moisture in the soil mainly comes from climate recharge and surrounding recharge. The content of water in the soil is not only related to the regional climate and the soil property, but also to the buried depth of groundwater. The content of water in soil has decisive influence on the development of vegetation. According to a research, the soil that contains more water has better water bearing capacity, where the vegetation is more diverse and the vegetation coverage is higher, as described below:

(1) Region with high vegetation coverage

This region has buried depth of less than 2.5 m, where the soil is silty clay, clayey silt and a little bit sandy soil, appearing yellowish brown to light grayish brown. The water content of the soil is medium to high, at 15%-38%, in a saturation condition, i.e. saturability ≥ 85%.

(2) Regions with medium vegetation coverage

This region has buried depth of less than 2.5 m, where the soil contains a certain amount of clayey soil, mainly appearing yellowish brown to light grayish brown. The water content of the soil is medium to high, at 10%-15%, in a saturation condition, i.e. 50% ≤ saturability ≤ 85%.

(3) Regions with low vegetation coverage

This region has buried depth of lower than 2.5 m, where the soil is mainly silty soil (i.e., silt or silty

sand) with good water permeability thus easy to make water evaporable. The ground surface is of high degree of salinization. In the sandy soil with depth higher than 1.50 m, the water content is 10%-15% and thus the soil is in slightly wet condition.

(4) Desert region

The surface soil is in severe salinization and desertization. The buried depth of this region is higher than 1.5 m where the soil is mainly sandy soil or Gobi gravels, with water content less than 6% and thus sees very dry. The detailed changes on relation between vegetation distribution and water content are shown in Fig. 1.

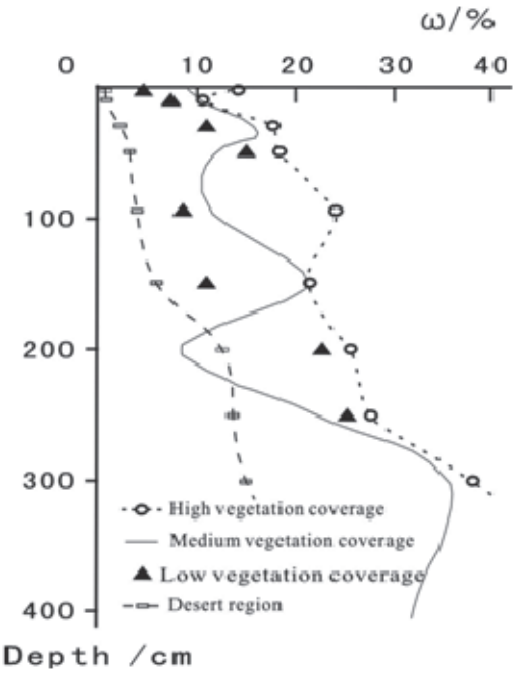

Fig. 1 Curves between vegetation with water content and depth of soil

2.3 Relation between Vegetation Distribution and Content of Soluble Salt

The research finds that the degree of mineralization of ground water is higher than 5.0g/L, thus the water belongs to SO_4^{2-}- Cl^- - Na type with high degree of mineralization. As for the distribution condition of water quality, the water shows increasing mineralization from the upstream area to the downstream area accompanied with increasing content of $\mathbf{SO_4^{2-}}$ and Cl^-. The mineral substance in the shallow groundwater mainly comes from the upper soil mass. In natural condition, the degree of vegetation coverage is determined by the content of K^+,Na^+, $Cl^-$and some other ions. The distribution characteristics are as below:

(1) K^+

The less the $\mathbf{K^+}$ in the soil, the better the vegetation grows. The region with high vegetation coverage and the region with medium vegetation coverage have similar content of $\mathbf{K^+}$, i.e., in the area with buried depth at 30cm-250cm, the content of K^+ is lower than 0.9mmol($1/2B^+$)/kg soil both in the region with high and medium vegetation coverage. And the content of K^+ is a little bit higher in the medium vegetation coverage region than in the high one. The area with the buried depth is higher than 250cm and the content of K^+ higher than 3.2 mmol($1/2B^+$)/kg soil belongs to desert region.

(2) Na^+

The high the Na^+ content in the soil, the lower the vegetation coverage is. The region with high vegetation coverage and the region with medium vegetation coverage have similar content of Na^+, i.e., in the area with buried depth at 30cm-250cm, the content of Na^+ is lower than 57 mol($1/2B^+$)/kg soil. And the content of Na^+ is a little bit higher in the medium vegetation coverage region than in the high one. The content of Na^+ in the desert is much higher than 177 mol($1/2B^+$)/kg soil.

(3) Ca^{2+}

In the area with buried depth within 10cm, the content of Ca^{2+} is similar in no matter the high, medium or low vegetation coverage area. In the region with high vegetation coverage, the content of Ca^{2+} is lower than 19 mol($1/2B^{2\pm}$)/kg soil, but in the desert region, the content of Ca^{2+} is higher than 35 mol($1/2B^{2\pm}$)/kg soil.

(4) Mg^{2+}

In the area with buried depth within 2.5m, the content of Mg^{2+} is similar in no matter the high, medium or low vegetation coverage area. But in the desert region, the content of Mg^{2+} is higher than 12.7/mmol ($1/2B^{2\pm}$)/kg soil.

(5) CI^-

The high the CI^- content in the soil, the lower the vegetation coverage is. In the area with buried depth within 30 cm where the vegetation coverage is high, the content of CI^- is lower than 38 mol($1/2B^{2\pm}$)/kg soil. But in the desert area, the content of CI^- is higher than 83mo($1/2B^{2\pm}$)/kg soil.

(6) CO_3^{2-} and HCO_3^-

The high the content of $\mathbf{CO_3^{2-}}$ in the soil, the better the vegetation grows. In the regions with medium or low vegetation coverage, the content of $\mathbf{CO_3^{2-}}$; but the distribution shows little regularity. In the desert region with buried depth within 50 cm， the content of CO_3^{2-} approaches to 0.

The lower the content of HCO_3^- in the soil, the better the vegetation grows. In the area with buried depth within 30 cm, the content of HCO_3^- is lower than 1.3mol$\mathbf{(1/2B^{2-})}$/kg soil in the high vegetation coverage area but higher than value in the desert area.

(7)SO_4^{2-}

The less the SO_4^{2-}, the high vegetation coverage is. The area with buried depth within 250 cm and the content of SO_4^{2-} lower than 2.2mol(1/2B^{2-})/kg soil belongs to high vegetation coverage region while the one with the content of SO_4^{2-} higher than 79.0mol(1/2B^{2-})/kg soil is desert region.

(8) NO_3^-

Similar with SO_4^{2-}, the less the NO_3^- in the soil, the higher the vegetation coverage is. The area with buried depth within 250cm and the content of NO_3^- lower than 1.0mol(1/2B^{2-})/kg soil belongs to high vegetation coverage region while the one with the content of NO_3^- higher than 6.2mol/kg soil is desert region.

Those ions mentioned above all decrease their content with the deepening of buried depth. Detailed changes are shown in Fig. 2.

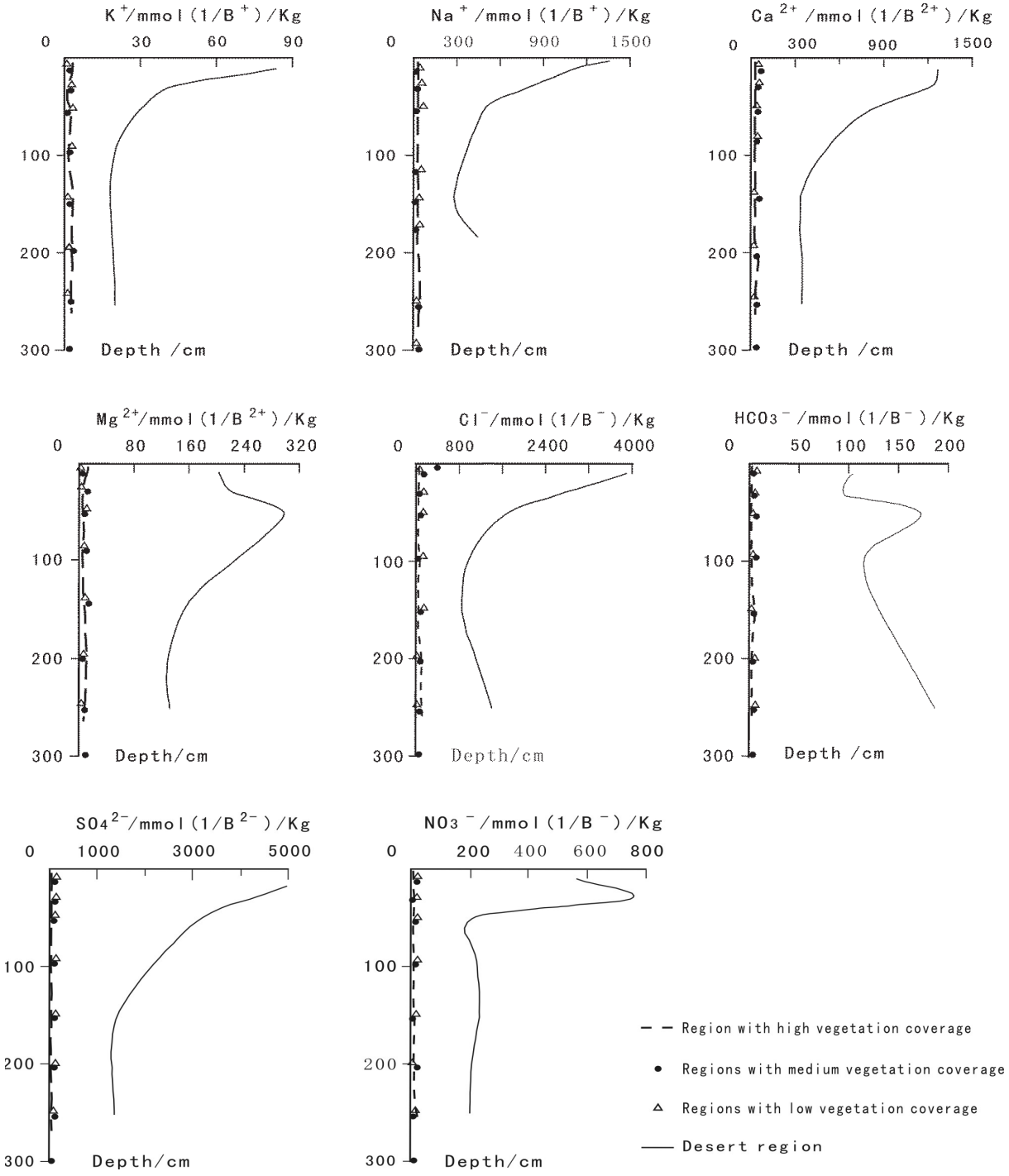

Fig. 2 Curves of relationship between content of soluble salt with depth in soil

3. Analysis on the Growth Environment of Vegetation

The climate is a decisive factor for why the evaporation capacity is higher than the precipitation in the Manas River Basin. The water for growth of local vegetation is mainly recharged by groundwater. Therefore, the growth of vegetation is not only related to the buried depth of groundwater, but also to the soil composition, the degree of acid and alkali of soil, the content of soluble salt ions, etc. Another influencing factor is artificial river closure which makes sharp decrease of water discharge in the downstream section and thus causes frequent cutoff in downstream and end section of the Manas River. These factors make the wetland near the river and lakes degrade into desert area. These deserts are not naturally formed before, but formed under the climate force. In the desert area shown in Photo 5, the shell

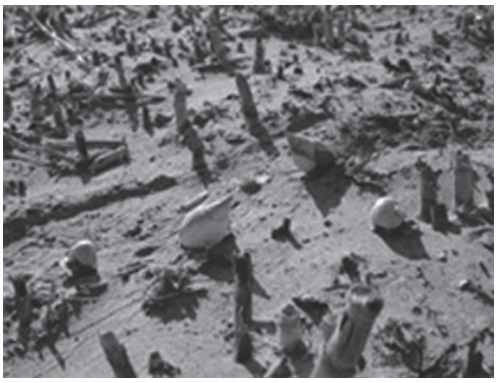

Photo. 5 Desert region around the Manas River

remains of some aquatic shellfish and snails and the root remains of cattail and reed can be found. Thus it can be deduced that this desert area was originally river or lake area. The desolate scene shown in Photo 5 seems to tell us that this area was originally a marsh wetland and due to the decrease of groundwater level and the dry climate, it has become the desolate desert.

4. Conclusions

To sum up, we come to the conclusions as below:

(1) The buried depth of ground water is the decisive factor that influences the vegetation coverage. The Manas River Basin is divided into four regions, i.e., the regions with high, medium and low vegetation coverage and the desert region. The boundary line of buried depth to distinguish the four regions is respectively 2.5 m, 4.0 m and 5.0 m. In the area with the buried depth of shallow groundwater lower than 2.5 m, the vegetation coverage is high. These regions are mainly distributed near rivers or lakes. The area with buried depth of groundwater level lower than 5.0m belongs to desert region.

(2) The water content of soil is an important factor that influences the growth of vegetation. Whether the water content is higher than 10% or not at the area with buried depth at 30cm is an indicator to determine whether the vegetation coverage is high or not.

(3) The soil property is another key factor that determines the growth characteristics of vegetation. In the clayey soil area with water buried depth higher than 50cm and where the water bearing capacity is relatively stronger than that of the sandy soil, i.e., the moisture in this area is not easy to evaporate, the vegetation coverage is relatively higher, and the area of this type is more favorable to vegetation growth.

(4) Then content of soluble salt in the soil is an important factor that determines the growth vigor of vegetation. In the research area, the content of soluble salt ions usually decreases with the deepening of buried depth. In the area with buried depth within 30 cm, the content of soluble salt has relatively higher influence on the vegetation. The respective vegetation coverage of high vegetation coverage region and the medium one are similar, while that in the low vegetation coverage area is much lower and that in the desert area is the lowest.

(5) The vegetation coverage may keep changing. Under the influence of climate or artificial conditions, such as atmospheric precipitation and artificial irrigation, the groundwater level may rise thus to easily improve the vegetation coverage.

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