Soil Water Content Change in Coal Mining Subsidence Region of Mao Wusu Sand Land

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***Abstract*—Soil water content in a region is closely related to plant growth. Coal Mining subsidence gives rise to a change of soil property in Mao Wusu sand land.This study investigated the relationship between the soil water content and the subsidence region of Coal Mining. In different depth in the ground samples of the subsidence region were analyzed for the change of the soil water content in different sinkage. The soil water content of the control region each layer is significantly higher than that of the subsidence region. The soil moisture for1a is reduced from the surface to the bottom, and lower than the 2a and 3a. Affected by the soil freezing in winter, the soil water content each layer in the control area is higher than that in the subsidence area from the surface down to a 1m underground . The soil mass is gradually stabilized as time goes on, and soil moisture has a rising trend with depth. In summer soil water content of the control region is higher than that of the subsidence region from 0 to 65 centimetre; the subsidence region is higher than the control area from 65 to 100 centimetre, and the soil water content for1a is the highest in all Subsidence region .**

***Index Terms*—Mao Wusu Sand Land ,the Water Content of Soil, Subsidence Region, Coal Mining**

I. INTRODUCTION

The water content, also known as soil moisture, is the soil moisture quantity of soil. Generally, it refers to the amount of water released from the soil in drying method under temperature between 105 ~ 110 ℃ [1]. Soil moisture is an important component of soil and the foundation for the analysis of soil moisture condition and dynamic changes. On the one hand, it plays an important role in the process of transformation. On the other hand, it is also the necessary material needed for plant growth. At the same time, it also influences the transfer speed and distance of soil nutrient toward the roots of plants, and then the effectiveness of soil nutrient. It is the active media that influences the structure formation and stability of soil.

The soil water content is affected by meteoric water, soil evaporation, plant absorption, plant transpiration and soil character. For lean soil, a kind of bare sandy ecological system due to the strong activity of sand soil, its biological activity is very weak, especially in the semi-arid and arid areas. Among the restricting factors of sand, moisture distribution and water quantity are the most important elements, and the moisture distribution and balance of sand soil are the foundations of the development and utilization of sand soil areas [2,3].

II. RESEARCH METHOD

The research region is located in Shanxi, Shaanxi, Inner Mongolia provinces at the junction of Erdos coal basin in northeastern Erdos Plateau, located in the southeast edge of Mu Us Sandland Dongsheng coalfield Bulianta coal mine, belongs to the administrative of Yijinhuoluo Banner, Erdos City(E 109 ° 45 ' - 110 ° 40', N 38 ° 50 ' - 39 ° 50'), from the Yijinhuoluo Banner 18 kilometre.

The experiment was carried out from March to October in 2010. In order to minimize soil properties spatial heterogeneity, the sampling region was chosen from the similar parent material, soil forming conditions of biological, climate and topography. The chosen four sand dunes are the same parent material formation and similar to underlying surface conditions (Extension of sand dunes from the east to the west, with an average altitude about 1190m, the average height of 3.0m to3.5m dunes, slope is approximately the same, the windward slope angle of about 11 ° to 14 °, the leeward slope angle of about 30 ° to 34 °, the same plant species, vegetation coverage of about 30 per cent). The first dune underground mining (not collapsed recorded as 0a); second collapsed in windward slope on May, 2009, Lee did not collapsed (denoted as 1a); third in windward slope collapsed on April, 2008, Lee did not collapsed (denoted as 2a); fourth collapsed in windward slope on September, 2007, the leeward slope did not collapsed (denoted as 3a).

III. RESEARCH RESULT

Soil water content had dramatically change in in different depth underground in winter.Fig. 1 shows that the changes in the subsidence area and the control area are basically same. The soil water content in the control area is significantly higher than that in the subsidence region on each layer. The soil moisture of 1a is reduced from the surface to the bottom, and lower than the 2a and 3a. Affected by the soil freezing in winter, water content in the surface of sand dune (from 0 to 20cm) is significantly greater than that in the following layers, this is because the surface soil is frozen, the subsoil water vapor is in the state of cold condensation when they move upward, the soil surface water content is increased, meanwhile block the water evaporation, which is consistent with the results of the spatial variability of the soil moisture in different terrain in Erdos by Lv Yizhong [4]. The 20 ~ 30cm soil water content reduction is affected by evaporation, and the changes in water content in different layers below 40cm are relatively small, 0a, 1a, 2a, and 3a range the order of 1.76 ~ 1.99%, 1.26 ~ 1.35%, 1.42 ~ 1.6% and 1.55 ~ 1.76%. The soil water content on average in the control area is 28.89% higher than that in the subsidence area, the 10cm, 30cm, 50cm, 70cm and 90cm are respectively 43.65%, 25.85%, 28.94%, 16.31% and 24.82% higher than those in the subsidence area.

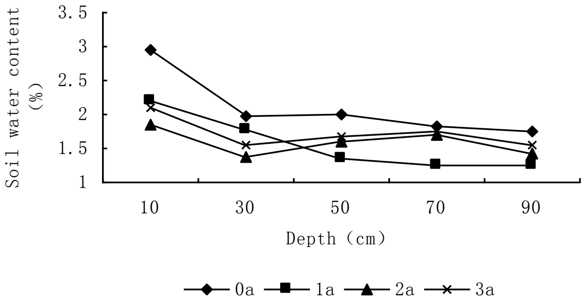

Fig. 1. Changes in soil water content in different depth in winter

Soil water content takes great changes in in different depth in spring. The results of Fig. 2 show that the soil water content variation on each layer in spring as follow: the water content on each layer in the control area is higher than that in the subsidence area from the surface down to 1m. The difference between the control area and the subsidence area is not significantly in 5cm, the change range is 2.50% ~ 3.08%. In 15cm, 25cm, 35cm in the control area, the change range is respectively 5.22% ~ 6.42%, 5.74% ~ 6.76%, 5.52% ~ 5.78%, and 3.16% ~ 5.76%, 3.12% ~ 5.38%, 3.12% ~ 4.92% in the subsidence area. The control area is significantly higher than the subsidence area, and the changes on each layer below 35cm are slow. The average change on each layer in the control area is1.48%, and 1.85% in the subsidence area, of which the average changes of 1 ~ 3a follow the order of 2.27%, 1.81% and 1.66%. It can be seen the average change in water content in the control area is smaller than that in the subsidence area in the vertical level, and the amplitude shows a decrease with the subsidence year. The average water content of soil on the layer within 10 ~ 40cm is higher than that in the layer below 40cm. The control area is more obvious than the subsidence area, and the average water content is respectively 5.93% and 4.24% in the control area and the subsidence area within 10 ~ 40cm; and 5.00% and 3.89% within 40 ~ 100cm. The average water content in the control area is 29.9% higher than that in the subsidence area, and the average water content on each layer of 3a is higher than 1a and 2a. 1a is higher than 2a within 0 ~ 40cm, and all lower than 2a within 40cm ~ 100cm, which shows that the soil is stabilized as the number of subsidence year increases, and deep soil moisture has a rising trend. It is mainly due to the rapid increase in ground temperature during spring, strong evaporation, the thick layer of dry sand (5 ~ 10cm) formed on the surface, which cut the action of the capillary between the surface and the underlying sand dune and restrain the moisture evaporation of the underlying in a certain extent. The soil profile characteristics which is stem upper and wet under forms, and sometimes is affected by the unstable rainfall in spring, there will be the upper layer of dry sand, which is wet in the middle, while relatively drier on the underlying layer. The soil thaws when air temperature rises in the subsidence area, the vertical fractures are well developed due to the interference and mining in different degrees, the soil evaporation area and the evaporation strength increase in varying degrees, which in turn cause serious soil moisture loss in the subsidence area.

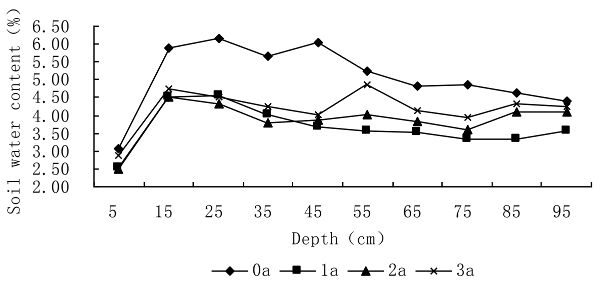

Fig. 2. Changes in soil water content in different depth in spring

Soil water content has change in in different depth in a vertical in summer. During the rainy season in summer, the soil changes frequently and is affected by precipitation. Soil moisture level in summer is higher than in spring because of the rainfall recharge. The moisture of Mao Wusu Sand Land is mainly affected by precipitation. The over 20cm precipitation may be wet sand below 60cm, and the infiltration of water-saturated content is quick, it can make the whole land section maintain a high water content, and more rainwater supply for the soil layer. The results of Fig. 3 show that a day after heavy rainfall in summer, the control area is higher than the subsidence within 0 ~ 65cm; the subsidence area is higher than the control area within 65 ~ 100cm, and the water content of 1a is the highest, the control area and the other subsidence area reduces in varying degrees. The moisture changes of 2a and 3a in different depth are complex due to the disturbance of soil layers in varying degrees, but affected by the strong mining-induced interference, the 1a's moisture change is very small with in different depth, and it is almost a straight line. The main reason is that the soil develops a greater amount of vertical cracks(joints)with the subsidence, the internal or external water vapor of the soil can directly spread from the homogeneous, coarse straight cracks (joints) into the atmosphere or into the soil, and the speed of the moisture diffusion and penetration is much faster than through the curved soil pore clearly. Due to the cracks (joints) of the sample plots 1a, 2a, and 3a are higher growth after a large rainfall, the upper soil evaporation increases, the water-holding capacity of the soil reduces. The soil seepage water transforms into the cracks stream, makes the water infiltration speed of the sample plots 1a, 2a, and 3a be faster than the sample plot 0a, so the soil water content of sample plots 1a, 2a, and 3a is higher than the sample plot 0a within the 65 ~ 100cm; while the average soil water content of the sample plots 1a, 2a, and 3a is lower than the sample plot 0a within the 0 ~ 65cm. At the same time variance test shows that the differences between the 2a, 3a, and 0a are not significant, and due to the soil water content differences before the rain, the difference between 1a and 0a is more significant, this reduces the difference between the control area and the subsidence area together with rainfall in a certain extent. The results of Fig. 4 show that after rainfall15 days in summer, when the soil moisture suffered from the evaporation and seepage, the soil water content within 0 ~ 50cm is all lower than the initial stage of rainfall, the change between the control area and the subsidence area is more complicated compared with the early stage of rainfall within 50 ~ 100cm affected by the infiltration. The change between the control area and the subsidence area is not significant on the soil surface at 5cm. There is about 5cm thick layer of dry sand, the water content of the control area is still higher than the subsidence area within 5 ~ 65cm, the water content of 0a is lower than 1a within 65 ~ 100cm, but higher than 2a and 3a. In other words, the soil water content has rising and falling in varying degrees within 15 ~ 100cm regardless whether in the control area or in the subsidence area, but the total trend is that the water content of the control area first rises and then decreases in different depth; the change of water content in the subsidence area is more complex in different depth, but it shows in general the feature of the water content, lower is higher than the upper. The main reason is the high temperature in summer and the strong evaporation. Due to the quick evaporation and infiltration, dry sand layer is formed after the surface water rapid evaporation, so that the capillary in soil is cut off, so that the lower water cannot rise through the capillary, the formed layer of dry sand shields the water evaporation in lower sand. For the control area, this shielding effect makes the soil hoard the water in atmosphere precipitation and condensation constantly, and transports slow down in non-saturation, and stores in the sand layer in the form of poised capillary water. For the subsidence area, the evaporation and infiltration are much larger than the control area because of the cracks (joints), particularly the layer within 10 ~ 35cm, the soil moisture change is the most dramatic, while dry sand layer plays a certain shielding role, but the impact of cracks (joints) is greater, the soil water content of 1a, 2a, and 3a decreases by 78.09%, 28.14% and 23.32% in this15 days, and the soil moisture increases in the layer within 35 ~ 65cm. The water content in the subsidence area is higher than the control area within 65 ~ 100cm. Tensile force is generated because of the subsidence, produces a large number of cracks (joints), so that the soil pores are larger. The study of Feng Jie et shows that when there are large pores in the soil, the water and solute in the soil reach the deep depth of the soil or groundwater quickly passes most of the soil matrix, and through the large pores. A large number tests of laboratory and field show that the large pore flow is a common existent phenomenon in the soil [5,6]. Therefore, the subsidence make pores larger, the water conductivity rises, the moisture migration accelerates, and the moisture in the deep soil increases. At the same time, due to deep the soil, the evaporation is significantly reduced compared to the upper.

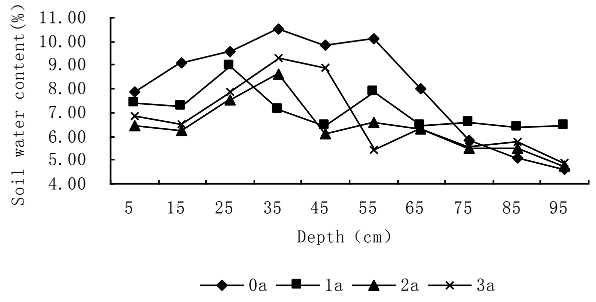

Fig. 3. Changes in soil water content in different depth in summer after raining

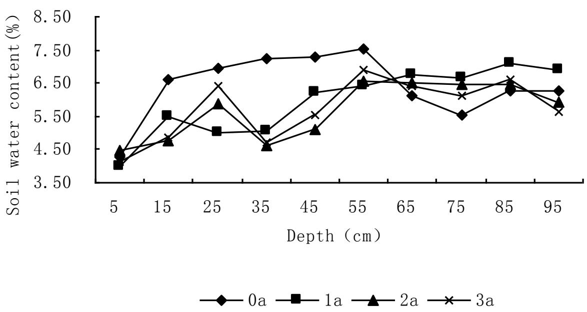

Fig. 4. Changes in soil water content in different depth after rainfall 15 days in summer

Soil water content is different in different fissure density. The relationship between the water content of the soil and fissure density of the soil.The test results of water content in a different crack density and scattered height in middle-slope in the 1 year subsidence land (as the Table 1) show that soil water content is lower when the crack density and scattered height are larger. The correlation analysis shows that the correlation coefficient between the crack density and the soil moisture is -0.972, and the correlation coefficient between the scattered height and the soil moisture is -0.987. It can be seen there is a strong negative correlation between the degree of subsidence and the soil water content. There is no precipitation from March 17th to April 4th ,2010, and the temperature rises rapidly. Seven continuous observations in the slope strewn height of 95cm, 40cm, 10cm and no cracks in middle-slope in the subsidence area in the past year (showed, Fig. 5 and Fig. 6) show that, in the dry season, the soil water content reduces with time overall, and the change in water content in vertical direction is more complex. The soil water content difference is small in different ground-breaking body on the surface, all less than 3%. The water content change of different ground-breaking body is larger within 10 ~ 80cm, in the 80 ~ 90cm. The change of soil body is smaller in the strewn height of 10cm and 40cm, and the difference between them is relatively small, while larger in strewn height of 95cm. The comparative analysis on a high degree of different strewn soil shows that the soil water content on each layer reduces as the strewn height increases as a whole, which shows the basic trend of 95cm> 40cm> 10cm. The change is small in the depth of 5 ~ 20cm and 80 ~ 100cm according to the study on the soil water content of the Mao Wusu Sand land by Guosheng Zhang and others, but large in the depth of 20 ~ 80cm [7,8]. It can be seen that the change of the soil water content in the strewn height of 10cm and 40cm is close to that has not taken soil body, while the difference between the soil in the strewn height of 95cm and those have not taken soil body. View of this, the size of dislocation in the upper and lower soil in the subsidence area directly impacts on the soil water content, the soil water content reduces with the subsidence strewn height increases.

TABLE I. WATER CONTENT OF SANDY SOIL UNDER DIFFERENT FISSURE DENSITY

the crack density (The number of cracks /10m)	water content (%)	the scattered height (cm)	water content (%)
7	4.5	10	5.32
6	5.02	13	5.03
5	5.08	30	4.68
4	5.36	40	4.61
3	5.6	60	4.1
2	5.7	95	3.57

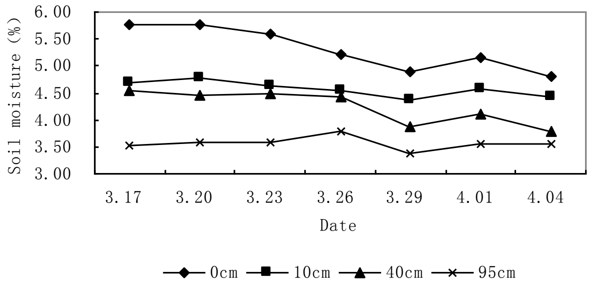

Fig. 5. Changes in Water content of sandy soil under different strewn at random with time

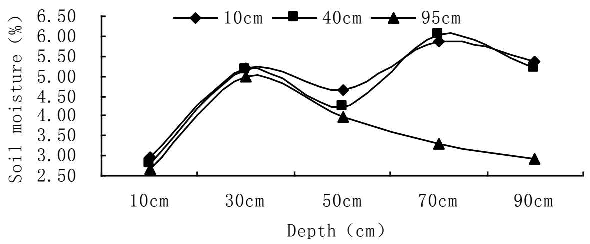

Fig. 6. Changes in Water content of sandy soil under different strewn at random with depth

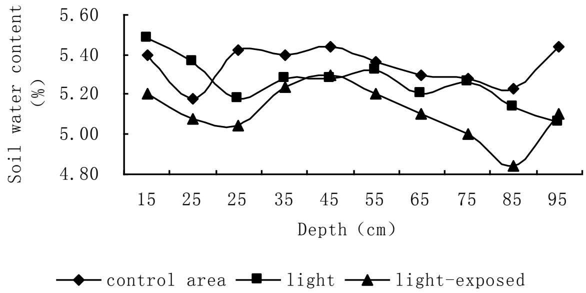

Fig. 7. Changes in sandy soil water content of two sides of fissure in light subsidence area

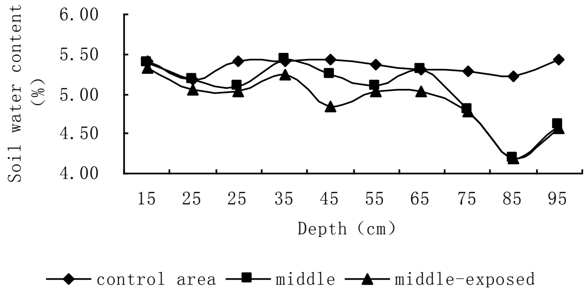

Fig. 8. Changes in sandy soil water content of two sides of fissure in middle subsidence area

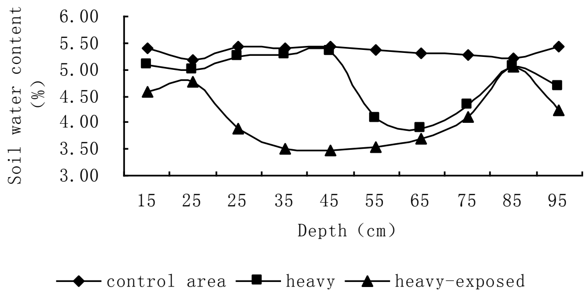

Fig. 9. Changes in sandy soil water content of two sides of fissure in serious subsidence area

Changes in soil water content under different strewn at random with time.In order to analyze the difference of soil water content between both sides of the different strewn crack, it is necessary to select the water content of the mild, moderate and severe strewn field in middle-slope in the 1 year subsidence area. To facilitate the analysis, the relative subsidence side and the exposed side of cracks are classified as "light" and "light-exposed" , "middle" and "middle-exposed" , "heavy" and "heavy-exposed". Experimental time is from March 25th to April 15th, 2011, the water content of all sorts of volumetric is sampled once every 3 days. The experimental area is blizzard in March 2nd to 4th, 2011 before the experimental period, the snowfall is 13.4 ~ 21.4mm. Uneven distribution of snow appears again from the night on 18th to the day on 19th, and snowfall further increases. During the experiment period, the snow melted and the soil environment is relatively moist during the experiment. Fig.7, Fig .8, and Fig. 9 show that the soil volumetric water content of the sample land on both sides of the subsidence cracks is less than that in the control land in the experimental period. The soil volumetric water content declines as the subsidence increases, the change degree of the soil volumetric water content increases, the water content of relative subsidence side is higher than in the exposed side, and the water content shows the law of the control area > light >light-exposed>medium>medium-exposed>heavy>heavy-exposed. It also shows that different layers of the soil profile and the water content change of soil layer are complex within 0 ~ 15cm, the change law of the subsidence area and control area is not obvious, the water content of the subsidence area and the control area fluctuate. The change ranges of light, light-exposed, middle, middle-exposed, heavy and heavy-exposed within15 ~ 95cm in the control area are in the order of 5.18% ~ 5.44%, 5.06% ~ 5.48%, 4.84% ~ 5.30%, 4.18% ~ 5.43%, 4.18% ~ 5.32%, 3.88% ~ 5.33% and 3.48 % ~ 5.04%, respectively. The average change of the control area is less than in the subsidence area. A variance analysis is done for the data of the stratified volumetric water content in both sides of the subsidence cracks in different subsidence degree with the software SPSS11.0, and according to the subsidence side, subsidence degree, stratification and determination date. The results show that the soil moisture distribution of subsidence area is significantly different (P <0.0001), and is respectively as follow subsidence side (P <0.0001), the relative degree of subsidence (P <0.0001) and stratification (P <0.0001). The influence of determination date is not significant, which can be considered as duplicate. The soil surface is mainly affected by the melting snow in varying degrees in the experimental area. The following surface is mainly affected by the result of the long-term comprehensive nature change difference. The difference between the both sides of the same crack (the subsidence side), and the relative exposed side is mainly due to the result of coal mining subsidence.

IV. Conclusion

The soil water content in the control area is significantly higher than that in the subsidence area on each layer. The soil moisture of 1a is reduced from the surface to the bottom, and lower than the 2a and 3a. Affected by the soil freezing in winter. the water content on each layer in the control area is higher than that in the subsidence area from the surface down to 1m. The soil is stabilized as the number of subsidence year increases, and deep soil moisture has a rising trend. In summer the control area is higher than the subsidence within 0 ~ 65cm; the subsidence area is higher than the control area within 65 ~ 100cm, and the water content of 1a is the highest.

Acknowledgment

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