Research on soil quality under traditional drainage and ecological water storage models of saline and alkaline land

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Abstract. This paper aims to study halide under traditional drainage and ecological water treatment of saline-alkali soil through bulk density, porosity, moisture content, soluble and nutrient characteristics in Shaanxi, to analyze the different governance mode of different soil physical and chemical characteristics to provide scientific basis for saline-alkali land management. Saline-alkali land model test was set in Shaanxi Fuping, respectively set up traditional drainage and ecological water treatment, analysis soil bulk density, porosity, electric conductivity, total salt, organic matter, total N, available K, available P and fractal dimension of 0-30 cm soil layer; Analysis soil moisture content and reservoir capacity of 0-160 cm soil layer, and comprehensive analysis the average fractal dimension of soil and soil nutrient average correlation in 0-30 cm soil depth. Results show that: (1) in 0-30 cm soil depth, two kinds of mode, the soil bulk density and porosity appear consistent, the soil bulk density can be reduced, and ecological water storage mode can effectively increase the soil porousness compare with traditional drainage mode. (2) Under the same amount of water, in the 0-160 cm soil layer, the average soil moisture and average water storage capacity under the ecological water storage treatment were 4.47% and 2.57% higher than the traditional drainage treatment. (3) In the 0-30 cm soil layer, the traditional drainage and ecological water storage treatment
significantly reduced the soil pH, conductivity and total salt content before the test, and the ecological water storage treatment decreased significantly; (4) In the 0-30 cm soil layer, the nutrient content of each treatment showed the same trend, which decreased with the increase of soil layer, and the average content of organic matter, total nitrogen, available potassium and available phosphorus under ecological storage treatment was higher than that of traditional drainage treatment. The height was 18.96%, 4.76%, 10.67% and 9.35%, and the difference between treatments was significant (P<0.05). (5) In the 0-30 cm soil layer, the fractal dimension of soil aggregates in dry and wet sieves showed opposite trend, and there was a good linear relationship with soil average bulk density, organic matter, total nitrogen, available potassium and available phosphorus (R²=0.8006~0.9499), the difference was significant (P<0.05). In summary, the ecological water storage treatment can effectively improve soil physical and chemical properties, improve soil stability and soil quality, and achieve good salinity treatment.

1. Introduction
There are many Chinese people and few land. The advancement of urbanization has led to a continuous reduction in land area. It is necessary to find effective arable land resources and remediation and utilization as an important way to maintain the dynamic balance of cultivated land [1-2]. Due to China's national conditions and climate distribution characteristics, soil desertification, salinization and uneven distribution of water resources have become important issues in the development of cultivated land and agriculture in China [3-6]. The current research methods for soil desertification are more diversified, such as increasing organic fertilizer, introducing regional pioneer crops, etc. For saline-alkali land, most of them rely on the construction of drainage facilities to reduce the content of salt in the soil, but this technology has great drawbacks. If a large amount of water is to be drained, water resources are wasted, and the migration of saline-alkali water is promoted, so that the pollution of other water bodies is caused, and the soil bulk density is increased, and the soil permeability is reduced, which is not conducive to crop growth [7-10].

Shaanxi lubotan is a heavy saline-alkali land formed by natural and artificial pumping. The soil in the area is mainly composed of moderate saline soil and severely salinized tidal soil, and the soda saline soil is patchy [11].

By analyzing the characteristics of the natural environment in this region, based on the problem of soil salinization, The traditional drainage mode consumes a large amount of manpower, material resources and financial resources, and needs to quote a large amount of fresh water for salt washing, which is easy to cause waste of water resources and soil compaction; the ecological water storage mode can effectively realize the comprehensive utilization of soil and water resources, avoid increasing soil compaction and effectively reducing water waste. On the basis of comprehensive consideration of the traditional drainage mode, the water storage ecological treatment technology is proposed to achieve water retention, water and soil separation, water and land coexistence, and dynamic balance [12-13].

Soil physical and chemical properties are important parameters for measuring soil structure and evaluating soil quality and production performance. Good soil physical and chemical properties are
beneficial to crop growth and yield improvement and quality improvement [14-15]. At this stage, the use of water storage mode to control saline-alkali land is mainly for its engineering technology, system and construction regulations, but the improvement of soil physical and chemical characteristics under the water storage mode has rarely been reported. By analyzing the soil bulk density, water, salinity and main nutrient characteristics under the traditional drainage and impounding ecological model, this paper analyzes the differences in soil physical and chemical characteristics under different treatment modes, and provides scientific basis and governance model for the appropriate regional control of saline-alkali land Feasibility and accuracy.

2. Materials and methods

2.1. Site description
The trial was conducted at the Fuping pilot base, located in Ducun Town, Fuping County, Weinan City, Shaanxi Province (109°11'47"E, 34°42'07"N). The area is a warm temperate semi-humid climate zone. The average annual rainfall and evaporation are 472.97 mm and 1213.35 mm respectively. The rainfall is mainly concentrated in July-September, accounting for 49% of the annual rainfall, frost-free period of 225 days, and annual average temperature. At 13.4°C, the total annual light energy radiation is 125.9 kcal/cm², which is suitable for the growth of cotton, wheat, corn and other crops.

2.2. Experimental design
The trial was implemented in October 2009. The self-made test device was used to simulate the conditions of the Lubotan land. The length, breadth and height were 23m, 1.5m and 2m, respectively. The bricks and concrete were used for concreting and the water storage and drainage treatment areas were set as Two, a total of four test devices. The test device is composed of a water storage part (drainage part) and a test soil trough. One end is a water storage tank (drainage) and the middle section is an earth tank. In order to prevent soil loss and water mixing, a geotextile is used to separate the two, and the interfaces of the device are treated as waterproof. The test treatment are traditional drainage and ecological storage treatment, that is, water storage treatment is to put quantitative water in the ditch, and use the water-soil dominant role-dispersion to control the movement of soil salinity; drainage treatment The flooding is carried out by flooding with large water, and the water is washed by the convection between the water and the soil, and the amount of water stored in the water storage and drainage is consistent throughout the test period. The salt transport and changes under each treatment are shown in Figure 1.

The test soil samples were selected from the saline-alkaline soil in the Lubotan area, and the unearthed soil in the lubotan area was layered for soiling at intervals of 30 cm. The soil samples were maintained in the original state and backfilled into the self-made test soil tank. According to the test data of the developed area of the test area in the test center of Northwest Agriculture and Forestry University in 2009, the average content of soil organic matter is 0.70%, the average salt content is 4.5g/kg, the average pH value is 9.33, and the average Cl⁻ content is 0.37%. HCO₃⁻ The average content is 0.08%, and the average SO₄²⁻ content is 0.06%. During the experimental period, wheat
varieties were tested: Xiaojing 22, 1000-grain weight: 38g, wheat germination rate was 90.1%, wheat sowing rate was 150 kg/hm², row spacing was 20cm. Seeding using trench drilling.

The fertilizing amount in the experimental plots was: N = 255 kg/hm², P₂O₅ = 180 kg/hm², and K₂O = 90 kg/hm². Among them, phosphate fertilizer, nitrogen fertilizer and potassium fertilizer were diammonium phosphate, urea and potassium chloride.

In October 2009, when winter wheat was sown, the amount of fertilizing materials was distributed according to the district plan. Through artificial soil preparation and deep testing of the test field, the surface formation and the fertilizer were fully mixed, and the experimental fields were all artificially sowed. Wheat is not fertilized during the growing season and winter wheat is irrigated before delivery.

2.3. Sampling and Measurement

(1) Soil water storage and bulk density measurement [16]. In the spring of 2015 after the corn harvest, using soil drilling, sampling interval is 20 cm, soil moisture content, drying method, and calculate the soil reservoir capacity under various processing; Using ring knife soil method 0 ~ 30 cm soil bulk density, soil sampling interval to 10 cm.

(2) Determination of soil aggregate stability [17]. After year spring corn harvest, select test based on diagonal soil sampling method, set up five sampling points, sampling depth and the sampling interval is 30 cm and 10 cm respectively, the soil sampling undisturbed soil samples used in the determination of soil aggregate related indicators. Soil samples without damage are returned to the laboratory for testing, natural air drying after the stones that exist in the soil sample and cleaned sundries and soil mechanical stability determined by dry sieving method respectively, wet sieve method of determination of soil water stability.

(3) Measurement of soil chemical indicators [18-19]. Electric conductivity and total salt content measurement of soil sample is in accordance with Agricultural Chemical Analysis Method of Soil, pH measurement selects Rex pH meter. Organic matters content measurement uses potassium dichromate - concentrated sulfuric acid externally heating; available phosphorus is extracted with sodium bicarbonate, measured with UV/Vis spectrophotometer (700nm); available potassium is extracted with ammonium acetate, measured with flame photometer (M420); total nitrogen is measured with automatic Kjeldahl azotometer (UDK-129).
2.4. Statistical analyses
(1) Soil water storage calculation

\[ SW = \frac{(M_1 - M_2)}{M_2} \times 100\% \]  \hspace{1cm} (1)
\[ W = SW_i \times P_i \times H_i \times 10/100 \]  \hspace{1cm} (2)

SW is soil moisture content, %; \( M_1 \) is wet soil weight, g; \( M_2 \) is dry soil weight, g; \( W \) is the soil water storage, mm; \( SW_i \) is the \( i \)th layer soil moisture content, %; \( P_i \) is the layer of soil quality, g/cm\(^3\); \( H_i \) is the \( i \)th layer soil thickness, cm.

Fractal dimension values were calculated using the equation below by Yang et al. [14]

\[ \frac{M(r < T_n)}{M_r} = \left( \frac{T_n}{T_{max}} \right)^{3-D} \]  \hspace{1cm} (3)

\( \overline{T_n} \) means diameter of the aggregates is in a specific size, \( M(r \leq \overline{T_n}) \) is the mass of aggregates in size less than \( \overline{T_n} \), \( M_r \) is the total mass of aggregates (50 g), \( T_{max} \) is the maximum diameter of aggregates. D value can be obtained by linear regression using equation (3) through least square fitting method.

Using Origin 8 to process the data and figures, and then SPSS (PASW Statistics 18) was used to do the data statistical analysis and the multiple comparisons were done using duncan's new multiple range method (SSR).

3. Results and analysis
3.1. Characteristic parameter analysis of soil bulk density
Different treatment has significant influence on bulk density and porosity of 0-30 cm layer soil (Table 1). Soil porosity is negatively correlated with soil bulk density. Larger bulk density indicates that soil is more compact, so porosity decreases. At 0-30 cm layer, soil bulk density increases as soil depth increases, significantly different also under impounding and drainage, and significantly different between every soil layer \( (p<0.05) \). The soil bulk density of the water storage treatment in the 0-30 cm soil layer was 1.3%~4.2% lower than that of the drainage treatment. Soil porosity at every layer within 0-30 cm under impounding treatment is 3.1%, 4.7% and 1.5% higher than under drainage treatment. By comprehensively analyzing soil bulk density and porosity under impounding and
drainage treatment, it is found that impounding treatment can effectively increase soil porosity at plough layer, increasing soil air and water permeability, conductive to maintaining soil bulk density at lower standard; and drainage treatment increases soil bulk density, intensifying soil hardness.

Table 1. Soil bulk density and soil porosity changes in 0-30 cm soil depth of different treatments.

| Treatments | Soil depth/cm | Soil bulk density/g/cm³ | Soil porosity/% |
|------------|---------------|--------------------------|-----------------|
| Storage    | 0-10          | 1.39±0.07c               | 48.18±2.56a     |
|            | 10-20         | 1.44±0.16ab              | 46.49±5.21b     |
|            | 20-30         | 1.53±0.05a               | 43.48±1.73bc    |
| Drainage   | 0-10          | 1.43±0.13ab              | 46.75±4.21b     |
|            | 10-20         | 1.50±0.04b               | 44.41±1.20ab    |
|            | 20-30         | 1.55±0.03a               | 42.84±0.98c     |

3.2. Spatial characteristics analysis of soil water

In December 2009, the winter wheat was irrigated under the impoundment and drainage treatment. The irrigation amount was the same. In the same year, the wheat harvest was determined to be 0-160 cm soil moisture in the same year, and the soil water storage under the storage and drainage treatment is shown in Figure 2. The soil moisture change trend of 0-160 cm soil layer under water storage and drainage treatment is consistent, in the 0-60 cm soil layer. The soil moisture decreased and the average soil moisture of the water storage and drainage treatments were 20.42% and 19.11%, respectively. In the 60-160 cm soil layer, the soil moisture increased and the average soil moisture was 24.65% and 23.86%, respectively. The average soil moisture of the 0-160 cm soil layer treated with water storage was 4.47% higher than that of the drainage treatment, and there was no significant difference between the treatments. The test results show that: the same amount of water, different treatments, after a long period of water transport, evaporation and utilization, the soil moisture under the water storage treatment is slightly higher than the drainage treatment, and the soil in the field is not easy to be knotted. Under impounding and drainage treatment water storage capacity of soil at 0-160cm layer varies as shown in Figure 3. Under impounding and drainage treatment water storage capacity of soil at 0-160cm layer shows identical trend, namely, at 0-60cm layer, soil water storage capacity both shows decreasing trend, under impounding and drainage treatment water storage capacity of soil at the layer decreases by 21.09% and 28.53% respectively, at 60-160cm layer, under impounding and drainage treatment water storage capacity of soil increase significantly by 26.16mm and 24.35mm respectively, and difference between different treatment is significant ($p<0.05$). At 0-160cm layer, under impounding and drainage treatment mean water storage capacity of soil is 65.36mm and 63.72mm respectively.
3.3. Spatial characteristic analysis of soil salt

The control of soil salinity plays a key role in the growth of crops. For the treatment of saline-alkali land, it is not only necessary to overcome its compaction, improve bulk density and increase soil porosity, and maintain its salt content in an appropriate range [20]. Effect of saline-alkali soil improvement under traditional drainage treatment and ecological impounding treatment is shown in Table 2.

Table 2. Discriptive characteristics of the soil pH, electrical conductivity and salt content.

| Treatments | Soil depth/cm | pH             | Electrical conductivity/(s/cm) | Salt content /(g/kg) |
|------------|---------------|----------------|--------------------------------|----------------------|
|            | 0-10          | 8.29±0.07bc    | 239.85±2.12a                  | 1.77±0.12bc          |
| Storage    | 10-20         | 8.38±0.05ab    | 205.45±3.74d                  | 1.70±0.04bc          |
|            | 20-30         | 8.48±0.05ab    | 203.91±1.44cd                 | 1.40±0.03c           |
|            | 0-10          | 8.35±0.02c     | 234.01±3.00ab                 | 2.32±0.09a           |
| Drainage   | 10-20         | 8.39±0.06ab    | 219.15±2.58bc                 | 1.80±0.05b           |
|            | 20-30         | 8.57±0.04a     | 212.05±2.53cd                 | 1.53±0.06bc          |

At 0-30 cm layer, under impounding and drainage treatment soil pH, electric conductivity and total salt content shows identical trend, pH increases as soil depth increases; electric conductivity and total salt show identical trend, decreasing as soil depth increases; 3 indicators decrease obviously compared to before experiment, and difference is significant (p<0.05). In 0-30 cm soil depth, under impounding treatment soil means pH decreases by 0.64% than under drainage treatment, difference between treatments is insignificant. under impounding treatment 20-30 cm layer soil electric conductivity decreases by 35.95 us/cm than at 0-10 cm layer, drainage treatment decreases by 21.95 us/cm; at 0-30 cm layer, under impounding treatment mean electric conductivity decreases by 2.46% than under drainage treatment. impounding and drainage treatment significantly decrease soil total salt content than before experiment, through 3 year plantation experiment and salt control, at 0-30 cm layer, under impounding and drainage treatment mean total salt content is 1.62g/kg and 1.88g/kg, and impounding
treatment decreases salt content more significantly than drainage, difference between treatment is significant ($p<0.05$). In general, impounding treatment can overall enhance soil quality, decrease soil salt content and pH integrated indicator more than drainage treatment, being a more suitable mode of saline-alkali soil improvement; drainage treatment can also decrease certain saline-alkali degree, less than impounding treatment, and easy to produce soil hardness, difficult to provide appropriate seedbed and growth environment to crops.

### 3.4. Spatial characteristic analysis of soil nutrient

Soil nutrient is indispensably important factor for sprouting and normal growth of crops, and also one of important indicators for evaluating soil fertility [21]. Saline-alkali soil improvement through drainage mode not only effectively improves soil structure, salt content, but also influences chemical property, namely nutrient of soil greatly, but also significantly improving soil nutrient content to meet fertility demand of crop growth (Table 3). Influence of impounding and drainage treatment on organic matters, total nitrogen, available potassium and available phosphorus content of soil at 0-30 cm layer is shown in Table 3, at 0-30 cm layer, under impounding, drainage treatment various nutrient content shows identical trend, namely decreases as soil depth increases. Under impounding, drainage treatment 0-10 cm soil layer organic matters content is 2.03 g/kg and 2.63 g/kg higher than 20-30 cm soil layer respectively; total nitrogen content is 10.79% and 8.93% higher respectively; available potassium content 27.65% and 19.84% respectively, effective phosphorus content 46.52 mg/kg and 42.95 mg/kg respectively. at 0-30 cm layer, mean content of organic matters, total nitrogen, available potassium and effective phosphorus under impounding treatment is all better than under drainage treatment, 18.96%, 4.76%, 10.67% and 9.35% higher respectively, difference between treatment is significant ($p<0.05$). In a word, under impounding, drainage treatment soil nutrient content increases obviously compared to before experiment, decreasing as soil depth increases. Effect of impounding treatment on improvement of soil nutrient content is more significant than drainage treatment, mainly because of different treatment mode. The drainage treatment and salt discharge method mainly adopts flood irrigation, which causes nutrient leaching and loss, and after the straw is returned to the field, the soil structure of the water storage treatment is better, and the water content is high, which is conducive to the decomposition and utilization of the straw. The drainage treatment of the soil is severe, which is not conducive to the decomposition of the straw.

| Treatments | Soil depth/cm | SOM/(g/kg) | T.N/(g/kg) | A.K/(mg/kg) | A.P/(mg/kg) |
|------------|---------------|------------|------------|-------------|-------------|
| storage    | 0-10          | 10.48±0.35a| 0.70±0.05ab| 242.74±1.48a| 58.41±0.80a |
|            | 10-20         | 8.71±0.36bc| 0.62±0.05ab| 185.16±2.68c| 22.63±0.33c |
|            | 20-30         | 8.45±0.50bc| 0.62±0.01b | 175.62±0.34cd| 11.89±0.21d |
| drainage   | 0-10          | 9.24±0.05ab| 0.65±0.04a | 206.95±1.73b| 53.58±0.70b |
|            | 10-20         | 7.38±0.31bc| 0.61±0.03ab| 172.49±1.29de| 20.78±0.60c |
|            | 20-30         | 6.61±0.21c | 0.59±0.02ab| 165.88±0.46e | 10.63±0.12d |
3.5. Stability analysis of soil

Soil fractal dimension is an important parameter indicating soil structure and geometric shape, the smaller the soil coacervate fractal dimension, more stable the soil structure [22]. Using equation (3) to fit calculation of agglomerate dry and wet sieve data, determine soil fractal dimension value (D), at 0-40cm layer, under different treatment fractal dimension of soil coacervate is shown in Table 4. In the 0-30cm soil layer, the fractal dimension of soil aggregates treated by dry sieve method decreases with the increase of soil depth, and the performance trend is consistent. The fractal dimension of soil aggregates is 1.65-2.15, and each Significant difference between treatments (P<0.05) Stability of impounding treatment at every soil layer is 7.02%~11.80% better than drainage treatment; mean stability of impounding treatment at 0-30 cm soil layer is 9.1% than drainage. At 0-30cm soil layer, results of wet screened soil coacervate fractal dimension under every treatment show a trend opposite to that of dry screened, namely every treatment shows it increases as soil depth increases, soil coacervate fractal dimension ranging 2.93-2.98.

| Treatments | Soil depth/cm | D (Dry sieving) | D (Water sieving) |
|------------|---------------|-----------------|-------------------|
| storage    | 0-10          | 1.97±0.01ab     | 2.93±0.21c        |
|            | 10-20         | 1.89±0.29ab     | 2.94±0.11bc       |
|            | 20-30         | 1.64±0.06b      | 2.95±0.05ab       |
| drainage   | 0-10          | 2.15±0.09a      | 2.94±0.07bc       |
|            | 10-20         | 2.39±0.05a      | 2.96±0.04b        |
|            | 20-30         | 1.83±0.04ab     | 2.97±0.01a        |

3.6. Correlation analysis of soil stability and chemical parameters

Correlation analysis between soil physical and chemical index data and soil stability, ie soil fractal dimension under wet sieve method (Figure 3), showed that there is a good linear relationship between soil stability and soil chemical characteristics. The effects of body stability on soil chemical characteristics were significant (P<0.05). Soil bulk density and soil fractal dimension are positively correlative, soil chemical indicators and fractal dimension are negatively correlative. The soil bulk density increases with the increase of fractal dimension, and the correlation coefficient between them is R^2=0.8604, which is significant. As soil stability indicator fractal dimension is larger, various soil chemical indicator namely content of organic matters, total nitrogen, available potassium and available phosphorus shows decreasing trend, correlation coefficient of fractal dimension and various soil chemical property indicators is R^2=0.9499, R^2=0.8472, R^2=0.8286 and R^2=0.8006. The effect of soil stability on soil physical and chemical properties is mainly the impact of different treatments on soil structure, such as increasing soil compaction, moisture content, etc., causing changes in soil bulk density and nutrients, resulting in differences in soil water storage and moisture conservation, affecting soil. Quality and crop emergence, water and fertilizer absorption, and ultimately affect crop growth and yield formation.
4. Discussion

4.1. Influence on soil bulk density

Soil bulk density is one of important indicators assessing soil quality [23]. At present, the research on saline-alkali land mainly focuses on the selection of salt-tolerant varieties, the selection of irrigation methods, and the design of saline-alkali land treatment projects, etc., The use of circulating pressure...
salt and its implementation can change the spatial distribution of salt in the vertical direction and gradually press down the salt, but little research has been reported on the changes in soil physical characteristics [24-26]. Impounding treatment can effectively decrease salt compared to drainage treatment, effectively suppressing soil hardness, maintaining soil bulk density within appropriate range. In aid of straw recycling treatment, it can obviously improve soil structure. Impounding treatment effectively improves soil bulk density, significantly increasing field capacity and improving porosity distribution of soil, Combined with the return of straw, the distribution of solid, gas, and liquid accelerates decomposition of straw and improves soil structure to some extent. Irrigation under drainage treatment intensifies soil hardness and destruction of soil structure, easily forming soil runoff channel, intensifying nutrient loss and reducing water utilization. The research finds that impounding treatment significantly increases soil quality compared to drainage treatment.

4.2. Influence on soil impounding and moisture conservation
Utilization of effective water in soil and conservation of water in drought season are key factors for crop growth [27]. The experiment shows that under impounding, at 0-160 cm soil layer, soil humidity is obviously higher than drainage treatment, and soil water storage capacity and soil humidity show identical trend. At 0-60 cm soil layer and 60-160 cm soil, both show the trend is decreasing first and increasing then. Soil moisture conservation and increase can prevent from soil hardness, conductive to demand of crop growth.

4.3. Influence of soil salt and nutrient
The salt-alkali salt washing process is the physical process of solute migration in the solute-migrating soil in the soil, including: convection, solute molecular diffusion, mechanical dispersion process, ion exchange adsorption at the interface between soil particles and soil solution. Traditional salt wash by drainage realizes rapid dissolution of various salt into water by effectively irrigating fresh water in aid of combination of wash and convection, reducing salt; core technology of ecological impounding mode is to use dynamic variation of impounding pool level, salt concentration and interaction of water body and adjacent soil to create dynamic balance, realizing circulation to suppress increase of salt. Overall objective factor and natural condition are influenced by variation of irrigated groundwater level, rainfall and water recession [28]. The ecological storage salt is based on the water level and salinity of the reservoir. The concentration continues to change and the water body and the adjacent soil salt reach a dynamic balance, which aims to achieve accelerated circulation of salt and alkali soil. Using “impounding without drainage” to improve saline-alkali soil effectively reduces labor, material and financial resources invested in other methods. Most importantly, it effectively avoids and reduces secondary pollution of and harm to natural resource, with broad application prospect and great significance [29-30]. 2 kinds of treatment significantly decreases soil pH and reduces soil content compared to before experiment, and at 0-30 cm layer, effect of impounding treatment reducing soil is better than drainage treatment.

4.4. Soil nutrients are necessary nutrients for crop growth in soil
The treatment of saline-alkali soil improvement not only effectively improves soil structure, soil salt content, but also has a greater impact on soil chemical characteristics, i.e., soil nutrients, it can significantly improve soil nutrient content, meeting fertility demand necessary for crop growth. The research shows that ecological impounding mode increases soil fertility better than traditional drainage treatment, agreeing with research result of Sun Bo et al [28]. In experiment by Han et al [29], it is also found that under impounding treatment, organic matter content in soil is improved, soil quality improves obviously.

4.5. Influence on soil stability and its relativity variation
The fractal dimension of soil can effectively reflect the stability of soil. In the 0-30cm soil layer, the fractal dimension of soil aggregates treated by dry sieve method decreases with the increase of soil depth, and the performance trend is consistent. Under impounding treatment various layer soil is more stable than under drainage treatment. This is mainly because the ecological water storage treatment effectively improves the soil structure, and the water storage mode effectively increases the soil aggregate due to the presence and maintenance of water. Water stability; water straw decomposition accelerates the input of organic matter, which plays a positive role in improving the structure. [30].

The improvement of soil stability is beneficial to increase soil nutrient. The correlation between the average fractal dimension of soil treated with different treatments in 0-30 cm soil layers and soil physical and chemical characteristics under wet sieve method is analyzed. Comprehensive analysis shows that soil mean fractal dimension and bulk density are positively correlative, and \( R^2 = 0.8604 \), difference is significant. Soil mean fractal dimension and mean content of soil organic matter, total nitrogen, available potassium and available phosphorus are negatively correlative, and correlation coefficient ranges 0.80~0.95, difference is significant (\( P<0.05 \)) [31].

5. Conclusion
(1) Ecological impounding and traditional drainage treatment can effectively decrease soil bulk density, at 0-30 cm layer, it increases with the increase of soil layer, and impounding treatment improves soil bulk density and porosity better than drainage treatment, the reduction is 1.3%~4.2% and 1.5%~4.7%.

(2) Under the same amount of water, at 0-160 cm soil layer, under impounding treatment and drainage treatment soil humidity and water storage capacity shows identical trend, and under impounding and drainage treatment soil mean water storage capacity is 65.36mm and 63.72mm respectively, impounding treatment is helpful to water conservation.

(3) The storage and drainage treatment effectively reduced soil salinity and soil nutrient content compared to before experiment, and the effect of ecological water storage treatment on reducing salt and increasing nutrient content was better than drainage treatment.

(4) The soil stability under ecological water storage treatment is higher than that of traditional drainage treatment. Under the wet sieve method, the average fractal dimension of soil in 0-30 cm soil layer and soil physical and chemical properties have good linear characteristics.

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References

[1] Gorji T, Sertel E and Tanik A 2017 Monitoring soil salinity via remote sensing technology under data scarce conditions: A case study from Turkey Ecol. Indic. 74 384-91.
[2] Manandhar R and Odeh I 2014 Interrelationships of land use/cover change and topography with soil acidity and salinity as indicators of land degradation Land 3 282-99.
[3] Wu J, Li P, Qian H and Fang Y 2014 Assessment of soil salinization based on a low-cost method and its influencing factors in a semi-arid agricultural area, northwest China Environ. Earth Sci. 71 3465-75.
[4] Li P, Qian H, Howard K and Wu J, 2015 Building a new and sustainable "Silk Road economic belt" Environ. Earth Sci. 74 7267-70.
[5] Li P, Wu J and Qian H 2016 Regulation of secondary soil salinization in semi-arid regions: A simulation research in the Nanshantaizi area along the Silk Road, northwest China Environ. Earth Sci. 75 1-12.
[6] Yang Z 1997 Land degradation and its control strategies in China China Environ. Sci. 17 108-12.
[7] Li P, Tian R, Xue C and Wu J 2017 Progress, opportunities and key fields for groundwater quality research under the impacts of human activities in China with a special focus on western China Environ. Sci. Poll. Res.
[8] Li P, Qian H and Zhou W 2017 Finding harmony between the environment and humanity: an introduction to the thematic issue of the Silk Road Environ. Earth Sci. 76 105.
[9] Wu J and Sun Z 2016 Evaluation of shallow groundwater contamination and associated human health risk in an alluvial plain impacted by agricultural and industrial activities, mid-west China Expo. Health 8 311–29.
[10] Li P, Qian H and Wu J 2014 Origin and assessment of groundwater pollution and associated health risk: a case study in an industrial park, northwest China Environ. Geochem. Health 36 693-712.
[11] Li P, Li X, Meng X, Li M and Zhang Y 2016 Appraising groundwater quality and health risks from contamination in a semiarid region of northwest China Expo. Health 8 361-79.
[12] Liu J, Luo Z, Jia Z, Fang S and Wang N 2005 Feasibility study of adopting controlled drainage in Yinnan irrigation district based on salt and water balance. T. Chin. Society Agr. Eng. 21 43-5.
[13] Yue W, Yang J, Tong X and Gao H 2008 Transfer and balance of water and salt in irrigation district of arid region J. Hyd. Eng. 39 623-28.
[14] Yang G 1999 A study on water salt of Solonchak in Hetao plan, Inner Mongolia Sci. Silvae Sinicae 35 107-10
[15] Lv D, Wang Q, Wang W and Shao M 2000 Soil water and salt transport features under one dimension infiltration J. Soil Water Conserv. 14 91-4
[16] Wang Q and Wang W 2000 Water and salt transport features for salt effected soil through drip irrigation under film Transactions Chin. Society Agr. Eng. 16 54-7.

[17] Khaledian Y, Kiani F, Ebrahimi S, Brevik E and Aitkenhead-Peterson J 2016 Assessment and monitoring of soil degradation during land use change using multivariate analysis Land Degrad. Dev. 28 128-41.

[18] Lado M, Paz A and Ben-Hur M 2004 Organic matter and aggregate-size interactions in saturated hydraulic conductivity Soil Sci. Soc. Am. J. 68 234.

[19] Taboada M, Barbosa O, Rodríguez M and Cosentino D 2004 Mechanisms of aggregation in a silty loam under different simulated management regimes Geoderma 123 233–44.

[20] Rodrigo Comino J, Ruiz Sinoga J, Senciales González J, Guerra-Merchán A, Seeger M and Ries J 2016 High variability of soil erosion and hydrological processes in Mediterranean hillslope vineyards (Montes de Málaga, Spain) Catena 145 274–84.

[21] Lu J and Li Z 2002 Advance in soil aggregate study Res. Soil Water Conserv. 9 81-5.

[22] Yuan X, Jiao J, Zhu L, Liu M, Li H and Hu F 2011 Effects of earthworm activity on soil aggregates’ stability and organic carbon distribution under different manipulations of corn straw Soils 43 968-74.

[23] Wei Y, Ma T, Wei X, Wang C, Hao M and Zhang M 2016 Effects of cropping systems on distribution of water-stable aggregates and organic carbon and nitrogen in soils in semi-arid farmland of the Loess Plateau J. Agro-Environ. Sci. 35 305-13.

[24] Sun G, Chen F, Li L, Wu F, Xiao X and Zhang H 2007 Effects of tillage on the carbon pool of paddy soil with long-term no-tillage J. China Agr. U. 12 45-9.

[25] Liang A, Zhang X, Yang X and Drury C 2006 Short-term effects of tillage on soil organic carbon storage in the plow layer of black soil in northeast China Sci. Agr. Sinica 3 1287-93.

[26] Vita D, Paolo E, Fecondo G, Fonzo N and Pisante M 2007 No-tillage and conventional tillage effects on durum wheat yield, grain quality and soil moisture content in southern Italy Soil Till. Res. 92 69-78.

[27] Martinez E, Fuentes J, Silva P, Valle S and Acevedo E 2008 Soil physical properties and wheat root growth as affected by no-tillage and conventional tillage systems in a Mediterranean environment of Chile Soil Till. Res. 99 232-44.

[28] Sun G, Chen F, Xiao X, Wu F and Zhang H 2007 Preliminary study on effects of rotational tillage on soil physical properties and rice yield T. China. Soc. Agr. Eng. 23 109-13.

[29] Han J, Xie J, Zhu J and Wang T 2009 Comprehensive method for treatment of Saline lands J. Hydraul. Eng. 40 372-77.

[30] Limon O, Govaerts B, Deckers J and Sayre K 2006 Soil aggregate and microbial biomass in a permanent bed wheat-maize planting system after 12 years Field Crops Res. 97 302-09.

[31] The Chinese academy of sciences institute of Nanjing, soil soil physical and chemical analysis 1983 Shang Hai: Shanghai Sci. Press: 62-126.