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The Effect of the Agricultural Carbon Sequestration and Agrochemical Reduction on the Regional Water Environment Quality

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Abstract: This paper analysed the impact of the agricultural carbon reduction and emission reduction measures implementation on the environmental quality of surface water and groundwater in winter and summer in Henan and Anhui Province project areas by using entropy weight fuzzy matter element analysis method. The result showed that the reduction in the application of chemical fertilizers and pesticides had a certain impact on the improvement of the water environment by using agricultural carbon sequestration technologies.

1. Introduction

With the increasing attention of the international community to climate change, greenhouse gas emission reduction and food security, the research on agricultural soil carbon sequestration and emission reduction technology has received the scientific community attention. Agriculture is a huge source of carbon sequestration and greenhouse gas emission reductions. It has great theoretical significance on assessing the impact of agriculture on global climate change ^[1]. According to the research in 2011 by Wang Xiaobin, the role and potential of Chinese agricultural land management in carbon sequestration and reduction cannot be ignored ^[2].

“Climate Smart Staple Crop Production Project” was funded by the World Bank Global Environment Facility. It started and implemented in 2014, which had great influence in the development of agriculture in China ^[3]. Climate-Smart Agriculture is a kind of agricultural production and development model which can sustainably improve agricultural efficiency, enhance adaptability, reduce greenhouse gas emissions, and achieve food security with higher goals ^[4]. The project planned to be implemented in Anhui and Henan grain crop area in 5 years. Two demonstration counties are to be established with a total demonstration area of 6661 hectares that will reach around 67 thousand hectares until the fifth year. Within the demonstration areas, the expected reduction rate of nitrogen fertilizer application, energy consumption from irrigation and tillage practices and the pesticide usage will be 15-20%, 10-15% and 30%, respectively. Besides, the carbon emissions are to be lowered by 20-30% per unit yield.

After the project was implemented, the chemical fertilizers and pesticides application amount can be significantly reduced. It was not only reduced the agricultural pollution sources entering the project area water, reduced the risk of harmful substances entering the groundwater, but also contributed to the water environment quality improvement in the downstream regions. This article analyzed the water environment quality change in project area and evaluated the impact of project implementation on the



water environment quality by monitoring the water quality around the two project areas in Henan and Anhui.

2. Test methods and arrangements

Select surface water and groundwater in the project area for water quality sampling and monitoring, the principle of selection was shown in Table 1.

Table 1 Monitoring point selection principle and monitoring index	
	Henan
Point selection principle	According to the project area irrigation type, soil classification, planting area, and river distribution.
Monitoring time	Twice a year during the irrigation season and rainy season.
Monitoring index	Surface water: COD _{Cr} , NH ₃ -N, TN, TP Groundwater: COD _{Mn} , NO ₃ -N, TN, TP

During December 2014 to December 2017, six to seven sampling monitoring were conducted in two project areas in Henan and Anhui. It mainly monitored the quality of surface water and groundwater in winter and summer. According to the point selection principle, we selected 1 surface water sampling point and 5 groundwater sampling points in Henan, and selected 5 surface water sampling points and 4 groundwater sampling points in Anhui. The location and name of the sampling points were shown in Figures 1 and 2.

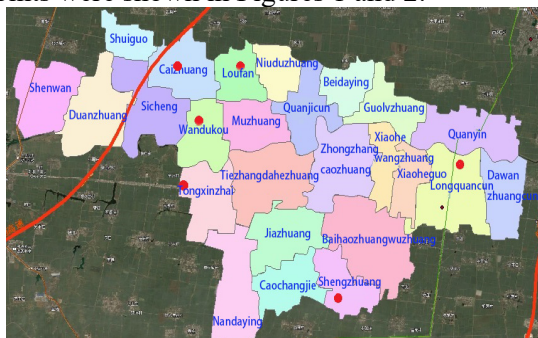


Figure 1 Location of sampling sites in Henan project area.

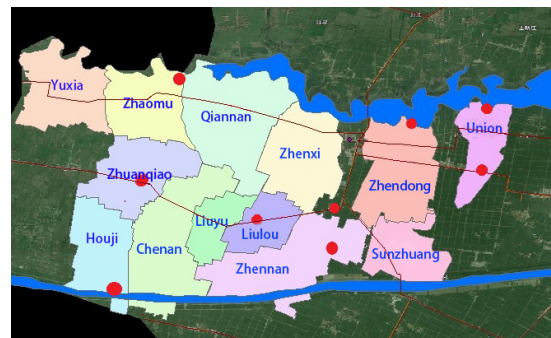


Figure 2 Location of sampling sites in Anhui project area.

2.1 Evaluation method

Comprehensive pollution index should be applied to evaluate the change of environmental quality in different water bodies or the same water body in different periods. In this study, the entropy weight fuzzy matter element analysis method was used to comprehensively evaluate the environmental quality. The fundamental of entropy weight fuzzy matter element analysis method is based on the degree of change in the value of each indicator, the greater the degree of change in the indicator value, the smaller the information entropy value, indicating that the greater the amount of information provided by this indicator, the greater the corresponding weight value. By using the variation of the factor itself, the objective weight of the corresponding weight value is clearly better than the artificially defined weighting algorithm, which avoids artificial scoring and has a strong objectivity. The establishment process of the entropy weight fuzzy matter-element model is as follows.

2.1.1. Composite fuzzy matter elements If R_{nm} is used to represent the n -dimensional complex fuzzy matter elements of m water quality monitoring points and M_i is the i -th monitoring point, C_{ji} is the j th

evaluation index of the i -th monitoring point, and the corresponding fuzzy magnitude is v_{ji} ($i=1,2,\dots,m; j=1,2,\dots,n$) are:

$$R_{nm} = \begin{pmatrix} M_1 & M_2 & \cdots & M_m \\ C_1 & v_{11} & v_{12} & \cdots & v_{1m} \\ C_2 & v_{21} & v_{22} & \cdots & v_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ C_n & v_{n1} & v_{n2} & \cdots & v_{nm} \end{pmatrix}$$

2.1.2. Degree of subordination The corresponding fuzzy values of the individual evaluation indicators are subject to the degree of membership of the fuzzy samples corresponding to the corresponding evaluation indicators of the standard sample, which is called the degree of subordination. Degree of

subordination can be calculated by this formula: $\mu_{ji} = \frac{v_{ji}}{\max_{1 \leq j \leq n} v_j}$

2.1.3. Establishment of standard fuzzy matter elements

2.1.4. Calculation of evaluation index weights Create a judgment matrix

Normalized calculation:

Table 2 Normalization Method:			
formula	Impact assessment factors	Evaluation value range	Features
$a_{ji} = \frac{\max v_j - v_{ji}}{\max v_j - \min v_j}$	$v_{ji}, \max v_j, \min v_j$	(0,1)	The larger the better

Define the entropy:

For the j -th evaluation index of n evaluation indicators with m monitoring points, the definition

entropy S_j is: $S_j = -\frac{1}{l_{nm}} \cdot \sum_{i=1}^m f_{ji} \ln f_{ji}$ In the formula: $f_{ji} = \frac{1+a_{ji}}{\sum_{i=1}^m (1+a_{ji})}$

Define the entropy weight:

After the entropy of the j th evaluation index is defined, the entropy weight definition of the j th

evaluation index is obtained. $\rho_j = \frac{1-S_j}{n - \sum_{j=1}^n S_j}$ In the formula: $0 \leq \rho_j \leq 1, \sum_{j=1}^n \rho_j = 1$

Use the monitoring data in 3 years as a composite fuzzy matter value to calculate the weight values of the indicators of surface water and groundwater in each project area. The weight of the groundwater index in Anhui was 18 columns of composite fuzzy matter values using 4 monitoring factors of 4 sampling points, the weight of the surface water index in Anhui was 24 columns of composite fuzzy matter values using 4 monitoring factors of 5 sampling points. The weight of the groundwater index in Henan was 16 columns of composite fuzzy matter values using 4 monitoring factors of 5 sampling points, the weight of the surface water index in Henan was 8 columns of composite fuzzy matter values using 4 monitoring factors of 2 sampling points. The calculated weight values were shown in Table 3.

Table 3 The weight of each factors in surface water and groundwater in project area

	Henan Groundwater	Henan Surface water	Anhui Groundwater	Anhui Surface water
COD(Mn/Cr)	0.273	0.218	0.238	0.158
NO ₃ -N/NH ₄ -N	0.232	0.285	0.241	0.185
TN	0.224	0.321	0.310	0.414

TP	0.272	0.176	0.210	0.243
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2.2. Comprehensive assessment of water quality

Calculate euclid approach degrees by weight values, the more gets close to 1, the better the water quality is.

$$\varphi_i = 1 - \sqrt{\sum_{j=1}^n \rho_j \Delta_{ji}} \quad (i = 1, 2, 3 \dots m)$$

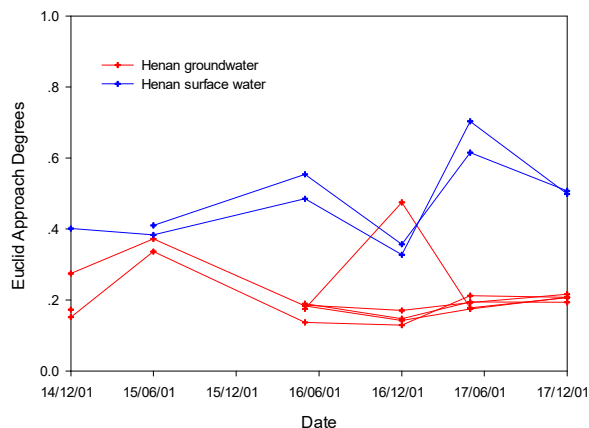


Figure 3 The tendency of euclid approach degrees of groundwater and surface water in Henan project area.

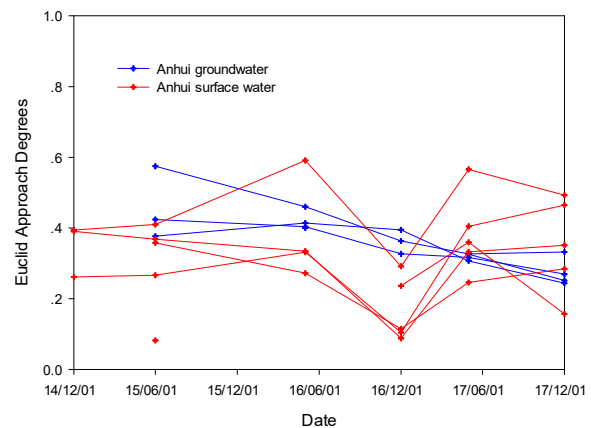


Figure 4 The tendency of euclid approach degrees of groundwater and surface water in Anhui project area.

2.2.1. Water Quality Assessment in Henan Project Area The trend of the degree of euclid approach degrees of the comprehensive evaluation of surface water and groundwater sampling sites in the project area in Henan was shown in Figure 3.

The result can be seen from Figure 3, the surface water quality in Henan project area was getting better and better. From 2014 to 2017, according to the monitoring result in winter, the quality of surface water had an obviously upward trend. From 2015 to 2017, according to the monitoring result in summer, the quality of surface water had an obviously upward trend, too. The surface water quality in summer was better than that in winter because winter belongs to dry period. It also meets the law that agricultural non-point source pollution has a large impact on the dry period of the river. As for summer, it belongs to flood period so that has little effect on water quality.

With the development of the project, although the groundwater quality in Henan project area fluctuated slightly, it generally showed an upward trend. The implementation of the project had a lagged effect on the infiltration of groundwater. So the best result showed in the monitoring in the first summer. The results showed upwards since the second year. The implementation of the project improved the water quality in Henan project area, which showed positive environmental benefits.

2.2.2. Water Quality Assessment in Anhui Project Area The trend of the degree of euclid approach degrees of the comprehensive evaluation of surface water and groundwater sampling sites in the project area in Anhui was shown in Figure 4.

From figure 4 we can see that, the water quality in Anhui surface water showed upward trend in winter and summer. It showed that this project brought positive effects to the surface water environment. However, groundwater quality in Anhui was gradually declined during the project progresses. The reason might due to the good groundwater quality, which almost met the Class I water quality standard in the monitored indicators. The decline was caused by the infiltration of surface pollutants.

2.2.3. Contrast of water quality in two area Comparing the monitoring result of surface water quality in Anhui and Henan area, we can notice that the water quality improvement in Henan was better than that in Anhui. The main reasons are as follows: the project area in Henan belongs to typical northern region, the surface water area is relatively single, and only one surface goes through the project area. The monitoring point is at the exit of the project area, which can represent the non-point source pollution situation representatively. However, the project in Anhui belongs to southern region, which has complexity and variety of water systems. There are three rivers and many ditches flowing through the project area, which is difficult to represent the non-point source pollution.

Comparing the monitoring result of groundwater quality in Anhui and Henan area, we can notice that the water quality improvement in Henan is worse than that in Anhui. In Henan area, the irrigation relies on the groundwater, and the supplement of groundwater is also rely on raining and irrigation. So the project can change the groundwater quality obviously. As for the groundwater in Anhui area, there are many ways to supply groundwater, and the supplement water quality is great, so the groundwater quality showed little change.

3. Conclusions

The implementation of the project showed a positive environmental benefit to the water environment in the Henan demonstration area. During the project implementation, the local water quality was significantly improved.

The implementation of the project showed volatility to the water environment in Anhui demonstration area. According to the change of surface water quality, the project also had positive effects to the water environment.

Comprehensive analysis of the water environment assessments results in the two areas showed that with the use of agricultural carbon sequestration technologies, the reduction in the application of chemical fertilizers and pesticides had a certain impact on the water environment improvement.

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