Study on Microclimate Improvement in Urban Fringe based on Human Comfort-- Taking Shichuan River as an Example

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Abstract. In the context of rapid urbanization, the development of cities has produced many environmental problems. The social structure of urban fringe is complex and the environment is deteriorating. In recent years, urban environment improvement activities have been carried out all over in China, improving the quality of ecological environment and residents' happiness. Taking Shichuan River, Fuping County, Shaanxi Province as an example, this study researches the methods and strategies used in the environmental improvement project of Shichuan River were integrated and analysed, and improves the quality of ecological environment through engineering and technical measures. In this study, by setting different data collection points, the humidity of sampling points at different distances around the Shichuan river was analyzed; the wind speed and other data of the study area were collected, and the regional wind environment was simulated by 3D modelling. The microclimate of the Shichuan river is evaluated by the methods of qualitative and quantitative analysis. This study aims at emphasizing the importance of ecological construction. It provides a positive reference for the improvement of ecological environment in the urban fringe of Northwest China

1. Introduction
Ecological environments are invaluable assets. To protect ecological environment is to protect productivity, and to improve ecological environment is to develop productivity. The construction of green ecological urban area is not only a major problem faced by the transformation of urban and rural construction mode in China, but also directly related to the vital interests of the masses and the long-term interests of the country. In March 2013, the Chinese government announced that it would establish 100 Urban Ecological New Areas of no less than 1.5 square kilometers nationwide. This indicates that China has officially entered the development and construction mode guided by the ecological environment. Compared with large and medium-sized cities, there are a large number of small towns in China, which are the focus of China's new urbanization. However, compared with large and medium-sized cities, the central radiation range of small towns is relatively weak in driving capacity, production
and consumption capacity of surrounding areas. At present, the construction of Ecological New Area in the edge of small towns is still in a long-term blank stage. Therefore, the project puts forward the development mode of the urban fringe complex oriented by ecology, which is of pioneering significance in the process of the construction of ecological cities in China. The establishment of the project is also of great significance to the optimization of land resources and the development of ecological resources in small towns [1-2].

Urban fringe (Stadtrandzonen) was first proposed by German geographer Herbert Lewis in 1936. It refers to a continuous closed ring around the inner city and coincides with it. As an important component of urban regional structure, urban fringe is the transition zone from urban environment to rural environment, and it is the most complex and changeable area in urban and rural construction. The urban fringe mentioned in this project generally refers to the connection between the urban built-up area and the vast countryside, and the transition zone from the urban environment space to the rural environment space [3]. It is a special area formed by the gradual transition, mutual penetration and functional complementarity of urban and rural elements in the process of the city's own near-field promotion and wide area expansion. It is different from the city and the countryside [4-5].

The whole drainage area of Shichuan river is 4478 km$^2$, with a length of 137 km. It flows through Fuping County for 36.4 km, with a northwest southeast trend. Shichuan River (Fuping section) comprehensive treatment project is about 5.2 km in total length, 1.5 km to the West and 3.5 km to the east of Jinlong bridge. The left bank of this section of river is adjacent to the village, and many parts of the river channel are damaged by illegal sand excavation and quarrying, and the domestic garbage is everywhere. All kinds of sewage from the village flows into the river channel, causing serious pollution to the river channel and poor overall environment. In addition, due to the lack of necessary river bank regulation, bank collapse often occurs during flood, threatening the lives and property safety of people on both sides.

Fuping County has a warm temperate continental semi humid and semi-arid monsoon climate, with large temperature difference between day and night, and distinct dry, wet, cold and warm seasons. Due to the influence of terrain, the climate is quite different. According to the rainfall data of Fuping meteorological station from 1960 to 2008, the annual average rainfall of Fuping County is 528mm; the annual distribution of precipitation is uneven and the inter-annual variation is large, and the precipitation from July to September accounts for about 50% of the annual precipitation. The annual average evaporation of water surface is 1229mm. The annual average temperature is 13.1 ℃, the extreme maximum temperature is 40.9 ℃, and the extreme minimum temperature is -15.7 ℃. The frost free period is 226 days on average, the annual average relative humidity is 65%, the annual average wind speed is 3.4m/s, and the maximum wind speed is 20m / s. The maximum frozen soil is 32cm, and the maximum snow cover is 14cm. The annual average sunshine hours are 2352.3 hours, and the annual average total solar radiation is 123.9 kcal / cm$^2$. The overall climate features of Fuping County are: sufficient light, moderate climate, moderate precipitation, hot and rainy seasons. Specifically, it is cold in winter and hot in summer; the temperature rises rapidly and unsteadily in spring, the temperature drops rapidly in autumn, and the cold air activities are frequent; the dry and wet seasons are distinct, and there is little rain in winter and spring, and more wet in summer and autumn; the rate of precipitation change is large, and drought often occurs; there is more cold wave and sand in spring, and more thunderstorm and hail in summer; there is more northeast wind in spring and summer, and more northwest wind in autumn and winter.

2. Methods and Materials

2.1. Study Areas

Shichuan River (Fuping section) comprehensive treatment project area is located at the entrance of Fuping County to the south, about 50km away from Xi'an, the capital of the province. It is the border of high-density central city and the transition zone of low-density suburb, namely the urban fringe area. It
has not only the support of urban functions, but also the infiltration of ecological resources, with unique geographical location.

The study area is a transitional area between the built-up area of small towns and the pure agricultural hinterland, and is affected by two kinds of urban and rural development forces. The rural settlements in the urban fringe have gradually changed from the past agricultural production and villagers' living functions to multiple composite functions, such as production, processing, commerce and trade, farming experience, ecological conservation, sightseeing and leisure, recuperation and vacation, and the second residence of citizens. The villagers' concurrent business situation is obvious, and their income has increased, but there are also disordered and scattered developments of villages, scattered overall spatial layout, and ecological environment. There are many problems, such as poor quality, low land efficiency, weak population infrastructure, disordered rural landscape and the disappearance of rural traditional culture. Before the project, the Shichuan River Basin had been cut off, the riverbed was bare, and there were many weeds and rocks in it. It even became a place for garbage stacking in the surrounding area (Figure. 1). Shichuan River Basin has not only not become the continuation of urban functions, but also become a natural barrier between urban and rural landscape. The poor ecological environment has also been criticized by surrounding villagers, hindering the development of local economy.

![Figure 1](image_url) The situation and ecological environment before remediation (google earth, 2014)

2.2. Ecological Transportation
In the ecological transportation system, bicycle lanes are set up in the project area, and urban public transportation system is connected at the same time. The internal road of Shichuan river ecological park is a bicycle lane, and bicycle signs and parking facilities are set up at appropriate locations to pave the bicycle lane in color and separate it from the motorway through physical partition, so as to build a safe, convenient and pleasant pedestrian traffic system in urban fringe. Encourage urban residents to walk. By setting up the pedestrian traffic signal system, improving the sidewalk lighting system, adding the seats along the street, setting up the road isolation belt, adding the gentle slope, adding the vehicle control signs and other measures to provide a good pedestrian environment for urban residents.

2.3. Water Resource utilization
In the aspect of water resource utilization, the landscape green space in Shichuan river ecological park can effectively regulate and store the ground runoff and water, and realize the low impact development (LID) mode in the urban fringe area through permeable pavement, grass planting shallow ditch, rainwater garden and other ways. Shichuan river ecological park is paved with inverted trapezoid permeable floor tiles, and the permeable materials are used to splice the brick joints; the parking lot is paved with hole-type concrete bricks, which can achieve up to 40% greening while meeting the water permeability of the ground, and infiltrate the rainwater from the ground to the underground. The concave green space and grass planting shallow ditch shall be set, the elevation of the concave green space shall be lower than the elevation of the urban road surface, and the rainwater outlet shall be higher than the green space. When the rainfall is higher than the height of the drain outlet, it will be directly discharged. When the rainfall is lower, it will be naturally infiltrated, which is conducive to the regulation, storage
and infiltration of rainwater [6-7]. Through planting vegetation layer in the surface ditch, a gravel layer with good water permeability is laid at the bottom of the ditch, and the rainwater runoff is preliminarily treated by the function of plant closure and soil filtration to collect, regulate and store the rainwater.

2.4. Roof Greening
The roof greening in the project area is mainly constructed in the form of ecological roof. Through the roof system with small planting volume and light weight plants, the urban greening area is increased, while the roof drainage intensity is effectively reduced, and the roof rainwater runoff is reduced. Its structure includes waterproof membrane layer, light planting soil and greening plants [8-9].

3. Results
The improvement of local microclimate in Shichuan river basin is also reflected in the improvement of surrounding air humidity. In order to clarify the improvement effect, we selected five straight lines perpendicular to the Shichuan River, and arranged a relative humidity monitoring point every 50m on each straight line. According to the terrain limit on the site, each straight line was arranged with 4-7 monitoring points, as shown in Figure 2. The monitoring dates are July 2, 2019, July 9, 2019, July 23, 2019, July 30, August 6, 2019, August 13, 2019, August 20, 2019, August 27, 2019, totally 8 days, and the monitoring time is 14:00-15:00. The surface humidity data (H=1.5 m) were recorded by portable thermometer and hygrometer (GM1361).

![Figure 2. The sample points in 5 different lines](image)

### Table 1. Statistics of humidity in Shichuan river

| Serial Number | Straight distance from river bank (m) | Humidity AVG. (%) | Serial Number | Straight distance from river bank (m) | Humidity AVG. (%) |
|---------------|--------------------------------------|-------------------|---------------|--------------------------------------|-------------------|
| 1             | 0                                    | 42.1              | 3             | 100                                  | 39.6              |
| 1-2           | 50                                   | 39.4              | 3-4           | 150                                  | 39.7              |
| 1-3           | 100                                  | 39.8              | 3-5           | 200                                  | 39.2              |
| 1-4           | 150                                  | 35.4              | 4-1           | 0                                    | 43.0              |
| 1-5           | 200                                  | 37.8              | 4-2           | 50                                    | 41.6              |
| 2-1           | 0                                    | 41.3              | 4-3           | 100                                  | 39.9              |
| 2-2           | 50                                   | 39.2              | 4-4           | 150                                  | 39.4              |
| 2-3           | 100                                  | 39.3              | 4-5           | 200                                  | 37.8              |
| 2             | 2-4                                   | 37.5              | 4-6           | 250                                  | 35.6              |
| 2-5           | 150                                  | 36.1              | 4-7           | 300                                  | 36.1              |
| 2-6           | 200                                  | 34.9              | 5-1           | 0                                    | 42.8              |
| 2-7           | 250                                  | 35.7              | 5-2           | 50                                    | 39.5              |
| 3             | 3-1                                   | 44.8              | 5-3           | 100                                  | 38.2              |
| 3-2           | 0                                    | 43.5              | 5-4           | 150                                  | 39.7              |

*There are five straight test lines totally
The results of five different test lines are shown in Figure 2. By comparing the humidity of different monitoring points in the same straight line, we can find that the humidity along the Shichuan river is significantly higher than the average value around. According to the measurement results, the closer to Shichuan River, the higher the humidity (average 42.8 °C). With the increase of distance, the humidity gradually decreases and finally tends to be stable. The maximum difference of the same straight line can reach 7.4%.

![Figure 2. The sample points in 5 different lines](image)

The ecological oriented development mode is also reflected in the planning and layout of Shichuan River Basin. According to the direction of prevailing wind ( northeast wind), ventilation corridors are set in the building complex, wind flow is introduced, local wind environment is optimized, and the quality of human settlements is improved. In order to verify this assumption, the influence of the building layout on the introduction of wind flow is discussed from the perspective of fluid motion on the premise of neglecting the impact of terrain on the surface wind environment. We built a 3D model in sketch up pro, and simulated the wind flow in the buildings around Shichuan River under the northeast wind and the wind speed $v = 2$ m/s by computational fluid dynamics (CFD)[10]. Results as shown in Figure 4, in the building concentration area of Shichuan River, the spatial layout of the building is at a
certain angle (about 15°), and the angle between the building orientation and the dominant wind direction in summer is controlled between 30° and 60°. A good wind environment is created at the walking scale (H = 2 m), which is conducive to the penetration of prevailing wind. Even in the interior of the building complex, there is no closed dead corner, and there is still wind speed flow in line with human comfort.

**Figure 4. CFD result**

4. Discussion and Conclusion
Based on the main achievements of Fuping County's "12th Five Year Plan" development, the main challenges in the "13th five year plan" development plan include the urgent need to strengthen the ecological construction caused by the fragile ecological environment. Therefore, to create a beautiful ecological environment is one of the development goals of the 13th five year plan of Fuping County. The improvement of ecological environment and the implementation of projects to promote the optimization of human settlements are also the important basis for promoting the development of cultural tourism and the well-being of the people. As the urban fringe, improving the original climate environment and improving the quality of human settlements is one of the important purposes of the project.

In conclusion, the development and construction of Shichuan river ecological park not only plays a positive role in regulating the climate environment within the scope of the river channel, but also improves the climate environment of the built-up area within a certain range around the river channel in summer, creating a more livable living space.

Acknowledgments
This work was financially supported by Internal Projects Fund of Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group (2019-NBYY-15).

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