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Temporal and Spatial Change in Microbial Diversity in New-developed Wetland Soil Covered by *Tamarix chinesis* Community in Chinese Yellow River Delta

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Soil samples were collected from new-developed wetland soil ecosystem of *Tamarix chinesis* plantation in Chinese Yellow River Delta in different months of 2003. Soil characteristics, temporal change and spatial distribution of microbial community composition and their relationship with nitrogen turnover and circling were investigated in order to analyze and characterize the role of microbial diversity and functioning in the specific soil ecosystem. The result showed that the total population of microbial community in the studied soil was considerably low, compared with common natural ecosystem. The amount of microorganism followed as the order: bacteria> actinomycetes>fungi. Amount of actinomycetes were higher by far than that of fungi. Microbial population remarkably varied in different months. Microbial population of three species in top horizon was corrected to that in deep horizon. Obvious rhizosphere effect was observed and microbial population was significantly higher in rhizosphere than other soils due to vegetation growth, root exudation, and cumulative dead fine roots. Our results demonstrate that microbial diversity is low, while is dominated by specific community in the wetland ecosystem of *Tamarix chinesi.*

Key Words : Soil microbial diversity, Ecosystem functioning, New-developed wetland

1. Introduction

Yellow River Delta wetland is the youngest, largest, most extensive and integrated reserve mainly involving in the conservation of new-born wetlands ecosystem and rare and imminent-dangered birds in the warm and temperate zone of China, where interests many researchers working in biodiversity science.

But in the past time, most of the scientific research about animals and plants paid more attention to birds, and less to microbe. To make research easily, in this context, we chose *Tamarix chnesis* as study object, because *Tamarix chnesis* community is a typical wetland plant. Study on soil microbial diversity and its ecosystem functioning can offer soil microbe data for the Yellow River delta rebirth wetland protection. On the other hand, the microbe research bases can be provided in the area.

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2. Research Area

The new-developed wetland soil ecosystem of *Tamarix chinesis* plantation in Chinese Yellow River Delta is of the monsoon climate of warm-temperate zone with the distinct four seasons and climate demarcation line of cold and hot, dry and humid. It has the average annual temperature of 11.9℃,and precipitation of 592.2mm.There are two soil types, fluvial-aquic soil and solonchak soil in this studied area.

Study sites lie in the National Natural Conservation Zone of Yellow River delta. The zone located in the mouth of Yellow River to the sea, facing the Bohai sea in the north, bordering the Laizhou Bay in the east, with the geographical coordinate from 118°33'E

to 119°20' E and from 37°35'N to 38°12' N. The total area is 153000hm^2. It is the Yellow River that formed this delta. The river flows from middle part and is the main fresh water resources of this district. Due to deposition of large amount of sand and mud carried by Yellow River, the Yellow River extends 2.2 km toward the sea each year, forming 32.4 km^2 new lands. In the list of state priority wildlife, there are seven species of birds listed as the first class priority. In the Sina-Japanese Agreement for Bird Protection, there are 152 species of birds in this area. There are 51 species were listed as the protected birds in the Sino-Australian Agreement for Bird Protection. So this conservation zone is one of the important regions to carry out two agreements above and also a key base for bird and bio-diversity protection and environmental pollution monitoring in China, even in the world.

3. Materials and methods

3.1. Soil sampling

Sampling site lies in the shield area of DaWen manage station. This station lies in the Yellow river delta and the Yellow river delta is the one of the important nature bracers. This nature bracer is a protection renascence wetland ecosystem, and its principal part is the precious and rare birds. There are 393 kinds plant in this area. The area of the nature *Tamarix chnesis* wood is 7×10^2hm^2 and the area of the grassplot is 5×10^4hm^2.

Because the plant community is singleness and the field is flat, we choose chessboard method to sample soil in the area that influence factor is small. We choose 10 points to sample soil. The weight of every sample is same. The sampling method of root outer soil is put the sample into the paper bag killed bacterium, after we sample soil using small shovel from the field that its depth is 2~20cm. Before we put the sample into the paper bag, we make the sample equality and get rid of stones and rotted root. The sample method of rhizosphere is digging the soil which is near the root of plant and the distance is 5cm, and the depth is 2~20cm. We must take the sample back to the laboratory and analysis it immediately.

3.2. .Measurement of Soil Factors

The soil properties were determined using standard procedures.

3.3 Soil microbe taking count of and separating

Microbiology routine methods were used to take count of and separating microbe, and the name of the routine method is taking count of and separating with flat board. We use this method to analysis the amount and the character of the main kind microbes.

4. Results and Analysis

4.1. Change of Soil factors characteristics in different seasons

We have measured the soil that we sampled it in the *Tamarix chnesis* community. The result of the experiment is showed in Table 1.

Soil organic carbon mainly comes from incomplete body of animal and plant[1]. It is the energy source of microbe that is supported by other energy source[2]. In the *Tamarix chnesis* community, the content of soil organic carbon the highest in June and October, and in August the content is lower. This condition is close correlation with the developing of the plant upper part, the activity of plant root and the microbe decomposing. Nitrogen content of soil is 0.31~0.53‰,and the value of August is the lowest and the value is higher in other time. We can calculate the ratio of carbon source and nitrogen source, by the content of soil organic carbon and nitrogen. The result shows that the C/N ratio in this community is lower. The plant can absorb the soil ammonium nitrogen directly. And the content of ammonium

Table 1. Main properties of the soil fertility in experimental stand

Month	Sampling Depth(cm)	TOC(‰)	Total Nitrogen(‰)	C/N	pH(H_2O)	Saline Matter(%)
4	2-20	2.21	0.37	5.97	8.1	1.22
6	2-20	3.95	0.48	8.23	7.97	1.15
8	2-20	2.92	0.31	9.42	7.92	0.46
10	2-20	3.78	0.53	7.13	7.77	0.52
12	2-20	1.96	0.46	4.26	7.69	0.57

nitrogen is higher between June and October. In other time the value is lower. Acidity and alkalinity is one of important physical and chemical characters, but most of the soil in this area is alkalescency. The value of pH is 7.69～8.1. And the content of salt is higher in every month of a year, especially in spring the value of Salt content is very high.

4.2. Change of soil microbe characteristics indifferent season

The amount of bacteria is the biggest among the microbe in the area. We can calculate the amount of the soil by the colony having developed in the culture. We can see that bacteria are the most important microbe colony.

In September, the ratio of bacteria is the biggest among the soil microbe, in other time the ratio is lower. The amount of bacteria is 5.28×10^5~8.83×10^5/g.D.S in the rhizosphere and in other place the amount is 4.79×10^4~7.32×10^5/g.D.S. The value of R/S(the ratio of the amount of bacteria in the rhizosphere and the amount of bacteria) is 1.3~24.1, between April and June the difference is distinct, and it is 18.4 and 24.1, in other time the ratio is 1.3~3.5. Maybe this condition is caused by the hearty excreting of plant roots.

Fungi lies in the soil with the configuration of mycelium and spore, most of the fungi like to live in the condition which pH is middling. Its colony amount is far less bacteria and actinomycetes, its biggest amount is 2%, and its amount lower. This state is caused by the soil of *Tamarix chnesis* colony that is alkalescency. In the rhizosphere, its amount is 4.0×10^3 ~5.97×10^4/g.D.S. In other part, the amount is 0.4×10^3~ 3.28×10^4/g.D.S. In June the amount is the biggest, in October the amount is more bigger, and in other time the value is lower. The plant-decomposed leaves that dropped to the field cause it in fall. The R/S of fungi is higher in August and in October the other place have bigger amount than rhizosphere.

Actinomycetes Is one kind of microbe who is supported by other nutrition. It likes oxygen and warmth. It can bear drought and barren, and is one kind of microbe who can often be found in dry soil. The results of research show that the amount of actinomycetes is less than bacteria in *Tamarix chnesis* community, and its amount is bigger than the amount of Fungi. The amount of actinomycetes in rhizosphere is 4.50×10^4~9.36×10^5/g.D.S, and it is 6.9×10^3~7.42×10^5/g.D.S in other place. Because the soil in *Tamarix chnesis* community is leanness and alkaline. The R/S of actinomycetes is smaller than other microbe.

According to the three kinds of microbe, we can calculate the total amount of soil microbe. And the amount of microbe who live in the rhizosphere is 8.27×10^5~1.9×10^6/g.D.S. In the other place of soil, the amount is 7.99×10^5~1.9×10^6/g.D.S. In August, the amount of microbe shows the descending trend. And the character of R/S of the microbe total amount is the same with the bacteria.

4.3. The relationship of three kinds of microbes and the character of ecosystem

The amount of soil bacteria in the *Tamarix chnesis* community is lower than the common amount of other microbes. And in the rhizosphere the amount of bacteria is 1/1000~1/10000, and in other place it is 1/10~1/100 of the amount of other microbe. To Actinomycetes, its amount is 1/100~1/1000 in rhizosphere and is 1/10~1/1000 in the place except rhizosphere. In *Tamarix chnesis* community the amount distribution of soil microbe has bigger difference than the ecosystem of forest field[3] and grass land[4], where environment condition is better than others. According to the low level of the plant variety and the low content of soil nutrition, we can say the *Tamarix chnesis* community is a community type whose ecology condition is worse.

The three kinds of microbes, which live in the Tamarix chnesis community were, compared each other in amount. We can see bacteria>fungi>actinomycetes from Fig.2. This result is the same as the result of Yuqinshao who studied oil wormwood community. Therefore, the amount of actinomycetes is big and the amount of fungi is small and the character of community whose surrounding is worse.

4.4. Relationship between the amount variety character of soil microbe with season changing and the content of soil nutrition

Soil conditions have important influence on the soil microbe amount with the season changing. In August, the amount of soil microbe is small and the content of nutrition is low too; in April and October, the amount of soil microbe is large, and the content of

soil nutrition is high too. There is a same variety law between them. May be, it is caused by the plant, because the plants absorb much nutrition in summer. Therefore, it has influence to microbe developing and reproducing. But in other seasons, the plant absorb less nutrition from the soil than in summer, so the soil nutrition content is high and it can hasten microbe reproducing. There are many factors that can influence microbe communication. According to nutrition condition, it is the element that is lack. This element has the most important function. In Tamarix chnesis community, the content of nutrition is lower, but carbon element and nitrogen element are the important elements, because they are the main factors that can affect the microbial activity.

4.5. The relationships between the amount of soil microbe and soil nutrition in rhizosphere and root outer

According to Table 2 and 3, we can see that three kinds microbes have obvious rhizosphere effect. T test shows that the total amount of microbe in rhizosphere and outside rhizosphere has distinct difference. Rhizosphere effect should be a common phenomenon in nature; the good root condition made by plant growth is the base of soil microbe activity, especially secretion of the plant root support abundant nutrition for microbe[6]. Organic matters, for example, many redeposit metabolize matters ejecting from the root, can accelerate microbe activity and the intergrowth relationship between them.

5. Conclusions

The total amount of soil microbes (including Bacteria, Actinomycetes, fungi) is low in the *Tamarix chinesis* community of in wet soil ecology system in Yellow River Delta compared with normal soil ecosystem. Among the three kinds of microorganisms investigated, the amount of the bacteria is the greatest, the amount of the fungus is the least. But the amount of the Actinomycetes is over the normal level.

The amount of microbes changed according to the seasons. The amount of Bacteria, Actinomycetes and fungus is higher in June or October than that in other months. The change has been affected by the nutrient factors in the soil.

All kinds of Microorganisms display obvious rhizosphere effect especially at the level of total quantity. This rhizosphere effect is even more obvious from April to June.

The distribution of main kinds of soil Microorganisms matches the normal distribution of soil Microorganisms. But there are not many species of soil microorganisms even though the dominant types are obvious.

Table 3. Microbial cell counts in soil[5]

Organisms	Viable cell counts in soil	
	Rhizosphere	Root-free
Bacteria	1.2×10^{9}	5.3×10^{7}
Actinomycetes	4.6×10^{7}	7×10^{6}
Fungi	1×10^{6}	1×10^{5}

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Table 2. Seasonal variations of quantities of soil microorganisms and rhizosphere effect

Month	Bacteria					Fungi					Actinomycetes					Total microorganisms		
	R	S	R/S	R/T	S/T	R	S	R/S	R/T	S/T	R	S	R/S	R/T	S/T	R	S	R/S
Apr	883.4	47.9	18.4	0.80	0.60	4.0	1.6	2.5	0.004	0.02	133.3	37.5	3.5	0.12	0.47	1108.3	79.9	13.9
Jun	789.7	32.8	24.1	0.41	0.20	59.37	32.8	0.031	0.20	0.20	936.1	745.1	1.2	0.48	0.45	1931.9	165.5	11.7
Aug	780.7	611.7	1.3	0.94	0.99	4.2	0.4	10.4	0.005	0	45.0	6.9	6.5	0.05	0.01	827.7	613.6	1.4
Oct	486.5	139.7	3.5	0.46	0.44	13.2	29.7	0.4	0.012	0.09	594.9	124.8	4.7	0.56	0.39	1066.1	315.0	3.4
Dec	527.9	200.9	2.6	0.51	0.34	8.7	4.1	2.1	0.008	0.01	498.2	343.6	1.4	0.48	0.58	1034.5	593.8	1.7
t	2.207					0.331					0.902					3.825		

Attention : t0.05=2.306, t0.01=3.355, R: (Rhizosphere), S: (Root-free), T: Total microorganisms

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