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Distribution Characteristic and Assessment of Soil Organic Matter, Nitrogen and Phosphorus in Soils of New born River Mouth Wetlands

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This paper investigates preliminarily spatial distribution soil organic matter (SOM), nitrogen (N) and phosphorus (P) and its environmental influence in wetland soil of different vegetation landscape in the Yellow River Mouth. The result shows the SOM and total nitrogen (TN), efficient N, efficient P in top layer soils of different vegetation district have significantly different content, The SOM is shown as *Calamagrostis epigeios* wetlands > *Phragmites cmmunis* wetlands > *Tamarix chinensi* wetlands above tidal > *Suaeda salsa* wetlands in high tidal > *Tamarix chinensi* wetlands in high tidal > tidal flats, the arrange of the TN and efficient N content is the same except that the content in *Suaeda salsa* wetlands in high tidal is heavier than *Tamarix chinensi* wetlands in high tidal. In different vegetation landscape wetland types the vertical change of soil nutrients are obvious except for P, gradually decrease from the upper to the lower. This case reflects the function of the vegetation on the wetland development of soil, and proves the wetland soil has the characteristic of new born and bad degree of development. SOM, TN, efficient N and efficient P content in wetland soils have significantly positive correlation, but TP have no correlation with them but efficient P. The contents of TN in wetland soils range from 58~1480 mg/kg, total average content 408 mg/kg, average content of above 30 cm is 625 mg/kg. The range of TP content in the soil is 372~1042 mg/kg, total average is 569 mg/kg, average content of above 20 cm is 611 mg/kg. According the P it occurs mainly as calcium phosphates, and the validity is lower, therefore, N and P in the new born wetlands cannot produce serious impact on the environments at present.

Key words : River mouth New born Wetland Organic matter Nitrogen Phosphorus

1. Introduction

New born coastal river mouth wetlands locate the transition zone between land and sea. It is one of the most abundant district of biodiversity in the world and also is the typical fragile ecotone[1]. This type wetlands is made up of the modern sedimentary that the river and marine reciprocation formed and it is the "source", "gathered together" or "transforming device" for the elements such as C, N, P, etc. SOM is often looked as a sensitive indicator about climatic change and also used for pointing out the response to it[2]. N and P are the key nutrition factor of restricting the ecosystem productivity of wetlands[3] and the main factor of causing water body eutrophication, having important ecological meaning and global environmental meaning. There is a lot of people have studied the distribution characteristic of nutrition in soils of land locked wetland already. But there is less study on new born river mouth wetland[4]. In addition, up till now, the study on N and P of the sedimentary in the Yellow River mouth wetlands, mainly concentrate on the shallow sea are and the wetlands on land near the river mouth was ignored[5,6,7]. So,

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in order to understand correctly the function of wetlands, assess wetlands environmental quality and strength the protection of sea environment, it is very important to study the content levels of new born wetland soil SOM, N and P and its space distribution characteristic. This study can also offer scientific basis for the management of nature wetland, protection of the regional biodiversity and sustainable development of wetlands ecosystem.

2. Study area

Study sites lie in the Yellow River delta national nature reserve. The reserve 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 153,000 hm^2. It is the Yellow River formed this delta. The river flows from middle part and is the main guest water resources of this district. Due to deposition of large quantity 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 land. It is the youngest, largest, most extensive and integrated reserve mainly involving in the conservation of new born wetlands ecosystem and rare and imminent-dangerd birds in the warm and temperate zone of China. In the list of state priority wildlife, there are seven species of birds listed as the first class priority. In the Sina-Japanes Agreement for Bird Protection, there are 152 species of birds in this area. And there are 51 species were listed as the protected birds in the Sino-Australian Agreement for Bird Protection. So this reserve is one of the important regions to carry out two agreements above and also a significant base for bird and biodiversity protection and environmental pollution monitoring in china, even in the world[8].

It is of the monsoon climate of warm-temperate zone here, 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 592.2 mm. There are two soil types, fluvial-aquic soil and solonchak soil in this test area. Due to the young age of terrestrial land, various

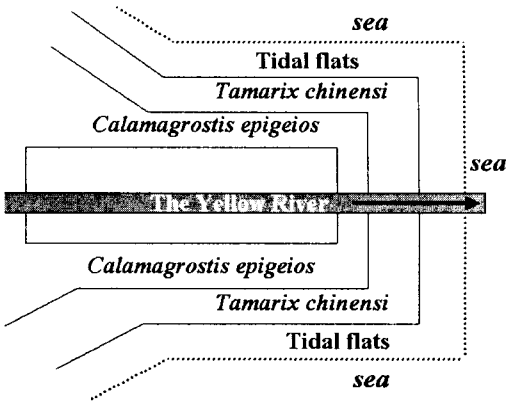

Fig. 1. Vegetation succession and distribution in wetlands (according to reference of Fang 1999).

plant resources are still in the initial stage of succession and development. And it is obvious for law for vegetation succession (Fig. 1). Therefore it formed many wetland types distinguished of regarding different vegetation landscape.

3. Materials and Methods

3.1 Sampling Methods

This study site lies in the area near the mouth of the nature reserve area in Yellow River delta in September 2002, considering that the vegetation succession and the two sides symmetrical distribution characteristic of the Yellow River, from sea to land, the vegetation landscape of wetlands is regarded as the basis which distinguishes the wetland types. At last we decided to sample in A (*Calamagrostis epigeios* wetlands); B (*Phragmites cmmunis* wetlands); E (*Tamarix chinensi* wetlands above tidal); F (*Suaeda salsa* wetlands in high tidal); G (*Tamarix chinensi* wetlands in high tidal); J (Tidal flats), which represents different wetland types respectively and the concrete sampling sites are as Fig. 2 shows.

In each wetland type, choose the most representative and characteristic area as sampling site, take the samples by the method that mixes the samples of several samples and several points, the sampling depth is as 80 cm, every soil section is divided 9 levels according to the unity standard, except that the top 10 cm layer divided into 0~5 cm and 5~10 cm; the others

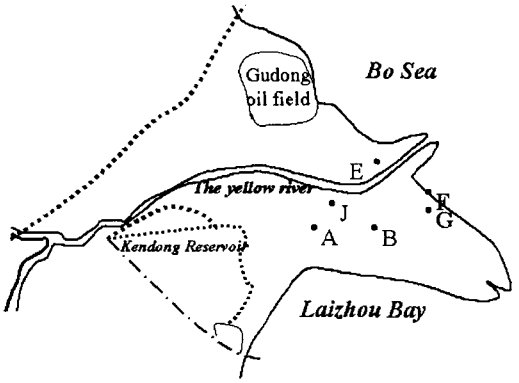

Fig. 2. Sketch map of sampling sites.

regard 10 cm as one layer. We obtained 54 soil samples in total and gathered the advantageous plant samples at the same time. Seek plant incomplete body and stone out from the soil that have been air-drying naturally, pass 1mm sift and install bags for reserve.

3.2 Research Methods

SOM: $K_2Cr_2O_7$ volumetric procedure outside-heating method; TN: Half-trace Kjeldahl method; Effective N: The alkali-solving spreading method; TP: The acid-dissolving-molybdenum and antimony and vitamin C colorimetry; Olsen-P: 0.5M $NaHCO_3$ method.

4. Results and Discussion

4.1 SOM, N and P content and their horizon distribution in soil of wetland

As can be found out from Table 1, except TP, this district new born wetland SOM and N nutrient content is not high, especially the content of the effective nutrient.

The inputting amount of the SOM in the natural soil mainly depends on returning amount of the organic incomplete body and rotten bone coefficient of the organic incomplete body[10], so wetland plant annual-blasted biomass is very important to the accumulation of the earth's surface SOM. In addition, the organic content also has something to do with the soil texture, especially a content of clay of the soil in the soil[11], for example, in *Tamarix chinensi* wetlands soil section the organic content unusual changing may have direct relations with presenting the soil layer of clay among them. The inputting

Table 1. Contents of soil nurture of the new-formed wetlands in Yellow River mouth

Item / Site	SOM /%	TN /mg.kg^{-1}	Efficient N /mg.kg^{-1}	TP /mg.kg^{-1}	Efficien P /mg.kg^{-1}
A-1*	2.05	759	99.7	515	7.49
A-2*	1.92	633	33.93	527	4.32
A-3*	1.94	608	27.31	421	4.47
A-4*	0.90	362	7.25	534	2.83
A-5	1.26	217	7.42	497	2.69
A-6	1.01	201	9.56	483	2.39
A-7	1.36	280	11.28	494	2.2
A-8	1.61	310	10.52	401	2.86
A-9	2.22	332	21.41	489	2.36
B-1	3.57	1480	153.82	604	10.39
B-2	2.66	905	43.29	408	3.49
B-3	1.00	688	37.44	543	2.70
B-4	0.83	388	22.73	570	1.82
B-5	0.79	327	15.06	597	1.60
B-6	0.46	182	11.83	605	1.42
B-7	0.27	175	4.82	492	1.81
B-8	0.43	277	14.36	541	3.09
B-9	0.38	324	27.81	502	2.64
F-1	0.37	355	11.15	715	5.08
F-2	1.07	360	14.45	638	6.01
F-3	1.82	357	10.56	724	6.56
F-4	0.59	422	14.33	508	6.42
F-5	0.39	368	14.36	734	5.63
F-6	1.35	496	17.25	647	6.23
F-7	0.24	231	23.47	553	5.57
F-8	0.41	276	13.37	689	6.21
F-9	0.41	313	12.34	716	5.55
G-1	1.74	574	34.40	498	7.88
G-2	0.69	396	11.82	596	2.97
G-3	0.54	262	12.37	666	5.28
G-4	1.20	413	15.29	646	2.81
G-5	1.02	342	11.40	610	2.39
G-6	0.32	215	6.31	600	2.59
G-7	0.25	208	3.32	638	3.00
G-8	0.28	228	4.75	448	2.73
G-9	0.30	166	4.84	470	3.26
H-1	1.19	720	36.54	739	6.50
H-2	1.07	568	32.85	693	4.72
H-3	1.01	652	28.35	671	6.71
H-4	1.27	731	35.92	554	7.31
H-5	0.75	330	17.92	525	4.79
H-6	0.75	189	32.76	480	3.48
H-7	0.45	143	12.94	372	2.53
H-8	0.41	58	11.45	404	2.03
H-9	0.22	128	40.22	424	2.02
J-1	2.81	1009	82.35	1042	14.75
J-2	1.95	892	62.23	402	9.37
J-3	1.69	753	59.09	597	9.13
J-4	1.03	702	36.69	496	8.15
J-5	0.41	352	22.27	476	2.43
J-6	0.31	188	12.40	676	2.45
J-7	0.33	100	24.24	527	1.97
J-8	0.34	32	12.68	786	2.00
J-9	0.35	64	15.03	521	2.05

*: A-1 is 0-5cm, A-2 is 5-10cm, A-3 is 10-20cm, A-4 is 20-30cm. Analogize in proper order

amount of N in the soil mainly depends on returning amount of the incomplete body of plant and biological N fixations, little from the atmosphere subside partly[12], atmosphere natural storehouse is the final source. But N in the atmosphere must through N bacterium and blue and green algae in wetland soil enter organism. So the N is distributed mainly in the biology-behaving area, especially the distributing area of the root system of plant (0-10 cm). The P in the natural soil stems mainly from the soil parent material and animals and plants' incomplete body recession. Its content is mainly affected by the type of soil and climate condition[13], because in the silt that the Yellow River bring the content of P relatively high, it makes the sedimentary TP of the Yellow River Mouth area have relatively higher contents[14]. The soil of the *Phragmites cmmunis* wetlands studied have accepted the Yellow River water overflowing- deposits in June in the same year, so TP content of the top layer behaves the highest. But from the average of every level, TP content of the tidal flats is highest (up to 658 mg/kg), and after the vegetation appears, TP content is reduced to some extent, which may reflect the purification function of the vegetation on soil P of wetland soil. It remains to study further.

The SOM and TN, efficient N of different vegetation district in 5 cm top layer have significantly different content. The SOM is shown as *Calamagrostis epigeios* wetlands > *Phragmites cmmunis* wetlands > *Tamarix chinensi* wetlands above tidal > *Suaeda salsa* wetlands in high tidal > *Tamarix chinensi* wetlands in high tidal > tidal flats, the arrange of the TN and efficient N content is the same except that the content in *Suaeda salsa* wetlands in high tidal is heavier than *Tamarix chinensi* wetlands in high tidal. This is compatible to the return amount of its annual withered junk and the difference of the moisture conditions.

The diversified index, the abundant degree and the density of the *Calamagrostis epigeios* wetlands is the highest, and its wither junk and the quantity of root system stand is more comparably too, and the content percentage of the composition difficult to resolve are higher than that in the upper part of the plant. Therefore it contributes a lot to the N storehouse and the carbon storehouse of the soil. Not only the species is more single in the *Phragmites cmmunis* wetlands, it withers junk is also more difficult to resolve, so organic content is less than that in the *Calamagrostis epigeios* wetlands. The organic incomplete of the *Tamarix chinensi* wetlands above tidal every year is less than the two that return, with the worst moisture state and the least organic content. *Suaeda salsa* wetlands and *Tamarix chinensi* wetlands in high tidal which lie in inter tidal zone area are often attacked by high tide and some of the withered leftovers on the earth's surface are washed away often, so SOM and N accumulate relatively slow usually. Because the soil in this district formed newly, the time of the vegetation growth is short and the vegetation succession is quick, so the horizontal difference of the soil does not have obvious law under the surface layer.

4.2 Vertical distribution law of SOM, TN, TP in soils of new born wetlands

Through mathematic stat and analysis method, count as independent variable with sample layer of soil (0-5 cm soil layer the values as 1, 5-10 cm as 2, 10-20 cm soil layer value as 3, the rest may be deduced by analogy, altogether the numbers of the independent variable is 9), then carrying on the linear equation and fit, the result showed in the Table 2. Except tidal flats, at each sample site, with the sample layer of soil deepening, SOM and TN take on the downward trend. Though the line relations of the SOM content and level to the soil layers in the *Tamarix chinensi* wetlands on the tide zone is not obvious, they have better binomial fit relation ($y = 0.0656x^2 - 0.6807x + 2.9183$, $r^2 = 0.7332$). In fact the clay layer about 10 cm is found existing in the depth about 60 cm. While taking this sample. It proves that the existence of clay has a great influence on the content of the SOM. The correlation coefficient between the nutrient content of tidal flats and the soil layer is bad, however, correlation is obvious in the soils covered wetland vegetation. This proves from aside that the existence of the wetland vegetation plays a positive role on the accumulation of SOM and N. Except the *Suaeda salsa* wetlands soil lies in high-tidal, it is also found that the relation between TP

Table 2. Linear stimulation of content of SOM, TN and TP in soils to number of soil layers

Items	sites	Equation Linear stimulation	correlation coefficient
Content of SOM y (%) and number of soil layers x	A	Y=1.7156-0.0247x	-0.14018
	B	Y=2.9278-0.3547x	-0.83780
	F	Y=1.0906-0.0703x	-0.35188
	G	Y=1.4086-0.1408x	-0.74523
	H	Y=1.4161-0.125x	-0.92097
	J	Y=2.5336-0.3018x	-0.89781
Content of TN y (mg/kg) and number of soil layers x	A	Y=0.7025-0.0582x	-0.78889
	B	Y=1.1723-0.129x	-0.82054
	F	Y=0.4029-0.01x	-0.35628
	G	Y=0.5151-0.0407x	-0.84897
	H	Y=0.8458-0.091x	-0.90264
	J	Y=1.1363-0.1363x	-0.96911
Content of TP y (mg/kg) and number of soil layers x	A	Y=0.517-0.0065x	-0.39205
	B	Y=0.5463-0.0012x	-0.05129
	F	Y=0.6618-0.0007x	-0.02328
	G	Y=0.6295-0.011x	-0.37049
	H	Y=0.7731-0.0465x	-0.95048
	J	Y=0.6879-0.0148x	-0.20614

Table 3. The matrix of correlation coefficient of N, P in soils of new born wetland

	SOM	TN	Efficient N	TP	Efficient P
SOM	1				
TN	0.77024**	1			
EN	0.695**	0.83463**	1		
TP	0.022011	0.189	0.096866	1	
EP	0.52237**	0.75217**	0.66101**	0.4371**	1

Notice: Significance level is 0.01.

content of soil and soil depth is not good. It proves that TP content of new born wetland soil is determined by soil matrix mainly, sedimentary of the Yellow River and sea, and proves further too that the wetland soil development of this district is relatively bad.

4.3 Correlations among SOM, N and P in the soils of wetlands

The correlation coefficients among SOM, N and P in soil are showed in Table 3. There is well-linear relativity between TN and the SOM. This showed that the organic N is likely to the most important forms existed in this area. There is not well-linear relativity in the TP and the SOMs. This proves that the content of TP in soils is mainly determined to the soil mother materials, in another way, the influence of vegetation on soil does not deepen too, while the development degree of soil is bad. But the content of effective P have certain relativity to the SOM and N content. It shows the improvement of SOM and N content may contribute to the validity of the P.

4.4 Environmental evaluation about the content of N and P in soils

The contents and accumulation of P (or N) in the sedimentary have certain instruction function on the pollution of the river mouth and seashore area[15]. Because the study wetlands in this district are mainly made up of river and sea sedimentary, and some wetland are continually influenced by the Yellow River overflow, so the P (or N) content level in wetland soil can instruct the history and the current situation of the pollution in this area. In addition, this district wetlands lies to interlocked area of the sea and land, so we should pay attention to the contribution that the marine pollution nutrition thing.

According to the guide issued by the Environment and Energy Ministry of Ontario in Canada[16], the density of TN and TP which can cause minimum rank ecological toxicity of effect in sedimentary is respectively 550 mg/kg and 600 mg/kg, with serious rank ecological toxicity effect density of TN and TP is 4,800 mg/kg and 2,000 mg/kg respectively. At present, TN content of wetlands soil studied in the Yellow River mouth is in the range 58~1,480 mg/kg, total average content 408 mg/kg, average content of above 30 cm is 625 mg/kg, higher than 550 mg/kg already, but other most soil layers content are lower than this value. The range of TP content in the soil is 372~1,042 mg/kg, total average is 569 mg/kg, average content of above 20 cm is 611 mg/kg, beyond standard of 600 mg/kg already too, the contents of other soil layers are a little low and changes gentlely (Fig. 3). Thus, according to analysis basis, the natural wetlands in this area have been polluted certainly of N and P.

Because the Yellow River Basin soil property rely mainly on calcium carbonate, majority inorganic P combine with apatite forms[17], in

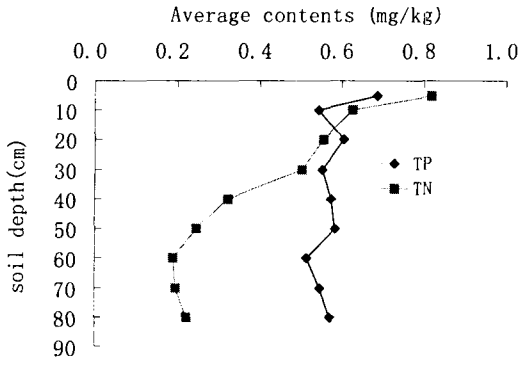

Fig. 3. Average contents of TN and TP in differences soil depth.

addition, according to the studies[6], transformation of P account for 10% TP about only from those natural grain size sedimentary near the Yellow River mouth and the sea, and the P released into water from the under sedimentary are more limited extremely, this may relate to the lower content of Ads-P, Al-P Fe-P Org-P in sedimentary. Because P is usual the limitable factor that causing water eutrophication, and so, though N content level in the soil of this district is high at present, the danger to the environment is may not very much serious.

5. Conclusions

SOM and TN, efficient N, efficient P in top layer soils of different vegetation district have significantly different content. The SOM is shown as *Calamagrostis epigeios* wetlands > *Phragmites cmmunis* wetlands > *Tamarix chinensi* wetlands above tidal > *Suaeda salsa* wetlands in high tidal > *Tamarix chinensi* wetlands in high tidal > tidal flats, the arrange of the TN and efficient N content is the same except that the content in *Suaeda salsa* wetlands in high tidal is heavier than *Tamarix chinensi* wetlands in high tidal. In different vegetation landscape wetland types the vertical change of soil nutrients are obvious except for P, gradually decrease from the upper to the lower. The SOM, TN, efficient N and efficient P content in wetland soils have significantly positive correlation, but TP have no correlation with them but efficient P.

The range of TN content in wetland soils is 58~1,480 mg/kg, and TP 372~1,042 mg/kg, their average content of top layers of soil separately is 625 mg/kg and 611 mg/kg. According the P occurs mainly as calcium phosphates, and the validity is lower, therefore, N and P in the soils of the new born wetlands cannot produce serious impact on the environments at present.

Acknowledgments

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