Study on Soil Heavy Metal Pollution on Both Sides of Jiyin Avenue in Nanjing

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Abstract. More than 30 soil samples were collected from the two sides of Jiyin road in Nanjing, and the contents of   Pb, Cd, Cu and Zn were determined. The evaluation results of single pollution index show that the content of Cu on both sides of Jiyin road exceeds the standard. Except that the content of Zn at 150m in the south of the road, the content of other Zn has exceeded the standard The content of Pb and Cr on both sides of the road does not exceed the standard. The Nemerow comprehensive pollution index of each region is more than 1 and less than 2, which belongs to the range of light pollution.

Keywords: heavy metal; farmland soil; road.

1. Introduction

With the rapid development of the economy and urbanization in our country, the number of private cars has increased rapidly, and traffic flow has risen greatly, which has brought different degrees of heavy metal pollution to farmland soil on both sides of road, affecting soil environmental quality, agricultural products safety and human health[1]. Scholars have studied the heavy metal pollution degree and pollution evaluation of soil in different cities[2-6]. Wang Chu et al. [7] studied the heavy metal pollution in soil on both sides of Chenhai and Beiyan roads in Chongming Island, Shanghai. Rodriguez [8] found that the concentration of some heavy metals in soil decreased rapidly with the increase of distance from the road. In this paper, the farmland soil on both sides of Jiyin Avenue in Nanjing is studied, and the soil samples 50m, 100m and 150m away from the road are monitored to analyze the concentration and spatial distribution characteristics of heavy metals in the land. The single pollution index method and Nemerow comprehensive pollution index method were used to evaluate the soil heavy metal pollution, which provides scientific basis for the effective prevention and control of heavy metal pollution along the road and the reasonable planning and construction of the safe production base of agricultural products.

2. Materials and methods

2.1 Study area and sampling point

Jiyin Avenue is located in the Science Park of Jiangning District, Nanjing. Jiangning District has obvious monsoon climate characteristics. The main soil type in this area is river white soil, which belongs to water-logging type paddy soil with high fertility. This section has various functional areas, large population density and traffic flow.

Both sides of the road in the sampling area of   are mainly agricultural land with less pollution sources. A vertical sampling belt is set for Jiyin Avenue in Jiangning District of Nanjing, and 3
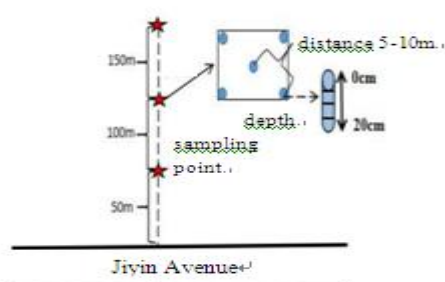
sampling sections parallel to the road are set for each side of Jiyin Avenue. The distance from the road is 50 meters, 100 meters and 150 meters, respectively(Fig.1). For each soil sample, 5 topsoil samples of 0-20cm were collected within 5-10m in the direction parallel to the highway and mixed (sampling by plum blossom method). As a mixed sample, 1kg of soil sample was taken from each point and put into the sample bag with the quarter method after mixing, and the excess part was discarded.

Fig.1 Sketch map of sampling point distribution

2.2 Sample test

Sample pretreatment [8]. In the air drying room, the wet soil sample is poured on the plastic film, spread into a thin layer of about 2cm thick. After air drying, the sample is passed through a 120-mesh nylon mesh screen, and then put into a sealed bag for storage away from light.

Sample digestion and determination[9-10]. The 0.5000g sieved sample was put into a polytetrafluoroethylene digestion tank and digested with a fully automatic graphite digester, making blank experiment at the same time. The dissolved samples were determined by the atomic absorption spectrometer (AA-7000 in Shimadzu, Japan). The contents of Cu, Pb, Cr and Zn in the samples were determined respectively.

3. Evaluation methods

3.1 Single pollution index method

$$P_i = \frac{C_i}{S_i}$$

where P_i is environmental quality index of i pollutant in soil, and C_i is actual measured levels of i pollutant, and S_i is the critical value of allowable i pollutant in soil self-purification capacity[8].

$P_i \leq 1$ indicates that the soil is not polluted by the heavy metal. $P_i>1$ indicates that the soil has been contaminated by the heavy metal, and may cause the edible part of the agricultural product to exceed the limit of pollution[11].

3.2 Nemerow multi-factor index method

$$P_N = \sqrt{\frac{(\frac{1}{n}\sum_{i=1}^{n} P_i)^2 + (\max(P_i)^2)}{2}}$$

where $(\frac{1}{n}\sum_{i=1}^{n} Pi)^2$ is average value of each pollution index in soil.

Table 1 Soil quality grading based on pollution indices

Nemerow comprehensive pollution index[12] is the most commonly used method to calculate

classification	PN	contamination level	pollution level
1	PN≤0.7	safety	clean
2	0.7＜PN≤1	alert	slight cleaning
3	1＜PN≤2	light pollution	crops began to become contaminated
4	2＜PN≤3	medium pollution	crops were moderately polluted
5	PN＞3	heavy polluting	seriously polluted

pollution index. The soil quality classification of PN is shown in Table 1.

4. Results and discussion

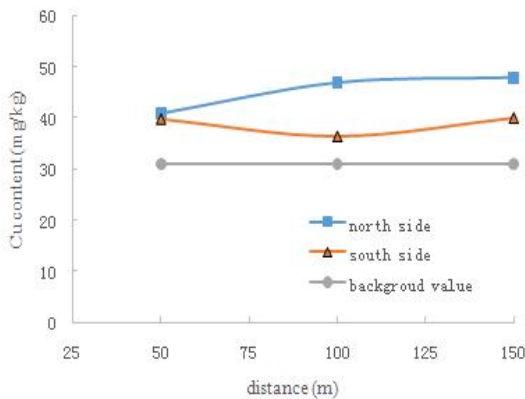## 4.1 Heavy metal pollution on both sides of the road

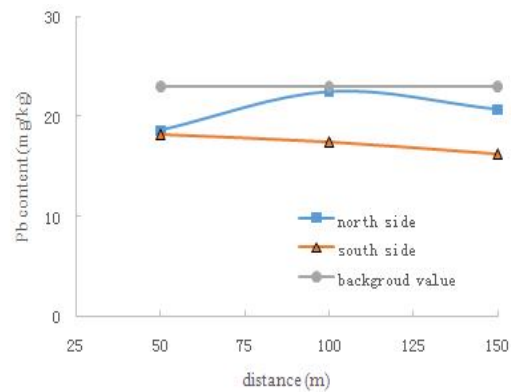Fig.2 changes of Cu content in soil from road level
Fig.3 changes of Pb content in soil from road level

From Figure 2, it can be seen that the Cu content on both sides of the road is higher than the local background value, and the Cu content on the south side of the road appears to be the lowest value at 100m. Fig.2   also shows that the Cu content on the north side of the road is higher than that on the south side, and an upward trend with the increase of the distance from the road.

It can be seen from Figure 3 that the Pb content on both sides of the road is lower than the local background value, and the Pb content on the south side of the road shows a decreasing trend with the increase of the distance from the road. The Pb content on the north side of the road reaches the maximum value at 100 meters, and the Pb content increases first and then decreases with the increase of the distance from the road.

As can be seen from Fig.4, the Cr content on both sides of the road is lower than the local background value. Cr content on the south side of the road gradually decreases with the increase of the distance from the road. The Cr content on the north side of the road first increased and then decreased with the increase of the distance from the road. There is a peak at 100m from the road.
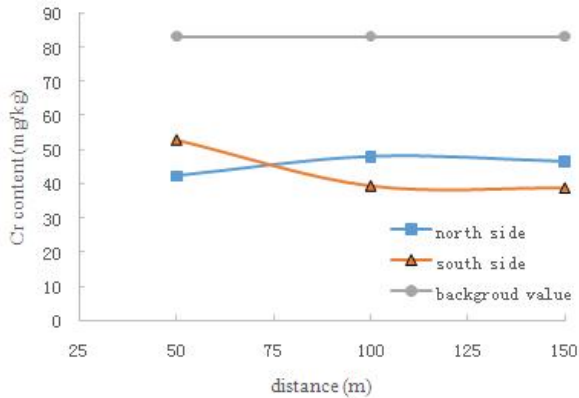
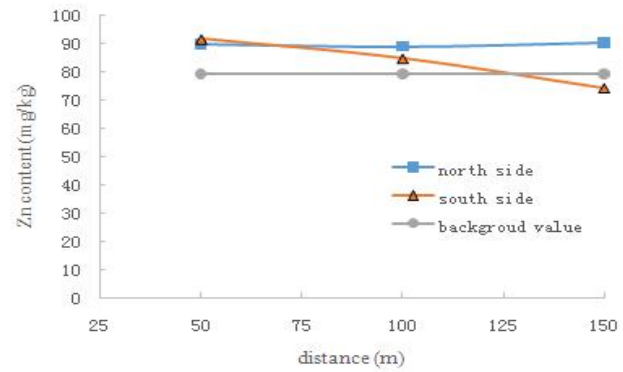Fig.4 changes of Cr content in soil from road level

Fig.5 changes of Zn content in soil from road level

Figure 5 shows that the Zn content at 150m away from the south side of the road is slightly lower than the local background value, and the other Zn content is higher than the local background value.The Zn content in the south side of the road decreased with the increase of the distance from the road.The content of Zn in the north side of the road did not change much in the horizontal direction, and basically remained the same.

Wind speed and wind direction are the important factors affecting the diffusion of heavy metal particles emitted along highway traffic. Under normal circumstances, the range of heavy metal particles in the windward direction of the road is lower than that in the downwind direction. According to the spatial distribution of the contents of four heavy metals in farmland soil on both sides of the sampling area, the four heavy metals measured were all higher in the north than in the south, except that Cr and Zn are lower in the north than in the south.

This is mainly because the north wind prevails in Nanjing in winter. The samples in winter are studied in the paper, so the pollution of roads to the north is greater than that to the south.

From the spatial distribution, some heavy metals on both sides of the road show exponential distribution, others show skewed distribution, and both distributions exist simultaneously. The main reason for this phenomenon is that the distribution forms of heavy metals on both sides of the road are different under the combined action of traffic flow, terrain and road conditions, prevailing wind direction and other climatic conditions, land use types, vegetation cover mode and other geographical environment and human factors[13].

4.2 Analysis of heavy metal pollution on both sides of the road

Table 2   results of heavy metal evaluation in soil

item	Pi(50m)	Pi(100m)	Pi(150m)	PN(50m)	PN(100m)	PN(150m)
Cu (Road South)	1.28	1.17	1.29			
Pb (Road South)	0.79	0.76	0.71	1.13	1.03	0.98
Cr (Road South)	0.63	0.47	0.47			
Zn (Road South)	1.16	1.07	0.93			
Cu (Road North)	1.31	1.51	1.54			
Pb (Road North)	0.81	0.98	0.90	1.14	1.30	1.31
Cr (Road North)	0.51	0.58	0.56			
Zn (Road North)	1.13	1.12	1.14			

The soil background values of Cu, Pb, Cr and Zn in Nanjing were 31, 23, 83 and 79mg/kg respectively[11]. The evaluation results based on this background value are shown in Table 2. The single pollution index Pi of Pb and Cr on both sides of the road is less than 1. 0, which indicates that the content of Pb and Cr in the soil does not exceed the background value, and it is non-polluted soil. Pi of metal Cu in soil is greater than 1.0, which belongs to polluted soil. It indicates that copper

pollution occurs at some points in the study area. Except for Pi of Zn at the south side of 150m, Pi of Zn at other sampling points is greater than 1. 0. Combined with Nemerow pollution index, it can be seen that Zn is slightly polluted, indicating that there is a pollution source of zinc. Heavy metal compound particles such as Cd, Zn, Pb and(Ni are produced by automobile exhaust emission, gasoline discharge, brake and wear of tires, brake pads and roads on roads[13]. Vehicle exhaust emissions can cause heavy metal pollution in the soil on both sides of the highway, and heavy metals such as Pb, Cd, Cu and Zn can be released by vehicle combustion or wear.

It can be seen from Table 2 that the Nemerow comprehensive pollution index PN in each region is greater than 1 and less than 2 based on the soil background value in Nanjing. According to Table 1, PN is greater than 1 and less than 2, which means that the soil is lightly polluted, and crops begin to be polluted, and should be paid attention to and managed.

5. Conclusion

Through the research and analysis of heavy metal pollution in the soil on both sides of Jiyin Avenue in Nanjing, it is found that the pollution in the north of the road is greater than in the south. The maximum content of Pb and Cr appears at the sampling point of 100m on the north side of the road. The spatial distribution of heavy metals on both sides of the road shows the coexistence of exponential distribution and skewed distribution, which is mainly influenced by climate, topography and vegetation. The single pollution index of Cu on both sides of the road is greater than 1, and the soil on both sides is polluted by Cu. The single pollution index of Pb and Cr on both sides of the road is less than 1, which is lower than the background value. The PN values of heavy metals in soil on both sides of the road are greater than 1 and less than 2. Combined with the analysis of individual pollution index and Nemerow pollution index, it can be seen that the soil in this area is slightly polluted and should be protected and treated accordingly.

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