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Investigation on Soil Pollution in a Shut-down Brick and Tile Plant

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Abstract: The spatial distribution and pollution of heavy metals, inorganic substances, volatile organic compounds, semi-volatile organic compounds and other pollutants in the soil were investigated by collecting soil samples from a potential risk area of a shut-down brick and tile plant. Based on the second type of land use screening standard in the "Standard for Risk Management and Control of Soil Pollution in Soil Environmental Quality Standard (Trial)" (GB36600-2018), the status quo of soil pollution in the plot was evaluated by using Nemerow compound index method. The results show that: the daily operation of the brick and tile plant has not caused obvious pollution to the soil condition in the plot, and the whole soil condition of the site is safe and clean.

1. Introduction

In recent years, the pollution problem left by the relocation or shutdown of urban industrial enterprises has aroused extensive attention from the society, and has become one of the hotspots of research at home and abroad [1-3]. The burning of clay bricks will lead to environmental pollution, damage to cultivated land, and consumption of a large amount of energy, etc. [4]. In 2011, the General Office of the National Development and Reform Commission issued the "Guidance on Renovation of Wall Materials in the 'Twelfth Five-Year Plan'" that clay bricks are restricted in urbans and solid bricks are forbidden in counties. But before the prohibition was enacted, large number of brick and tile plants was in production, and the risk of soil contamination remained even after several years of suspension due to the lack of environmental protection measures. Taking a shut-down brick and tile plant as an example, this paper conducts the soil pollution investigation work. This paper reflects the spatial pollution distribution of characteristic pollutants within the plot through the identification of key areas in the brick and tile plant, and analysis of monitoring data. Scientific evaluation and investigation of whether the risk of the plot is acceptable can provide a decision basis for the plot planning and utilization, and provide a reference for soil pollution investigation of similar plots.

2. Materials and methods

2.1 Overview of the research area

The research plot covers an area of about 14.39 km^2. In 1972, the plot was a small kiln plant. In 1981, it was a county-level brick and tile plant, and it was suspended in 2016. During the historical production period of the brick plant, the layout in the plot includes staff living area, substation, billet yard, billet preparation yard, brick and tile kiln, and borrow pit. The investigation plot is currently planned to be used for commercial service facilities in villages. Therefore, the soil pollution risk screening shall be conducted according to the selection value of Class II land specified in "Standard for Risk Management and Control of Soil Pollution in Soil Environmental Quality Standard (Trial)" (GB36600-2018) [5].

The raw materials used for brick baking in the brick plant are clay and coal cinder. The clay is directly collected from the borrow pit in the plot. The coal cinder is generated during the roasting process. Then, water is added and thick mud is stirred, and put them into the mold to make the brick billet. After drying, the brick billets are sent to the brick baking kiln for roasting to make the finished bricks. The fuel used in the roasting process is coal. The production process of the brick plant is shown in Figure 1.

During the production and operation of brick and tile plant, the waste gas is mainly produced by crushing and fugitive dust, fuel combustion waste gas, and internal combustion of brick billet. The combustion waste gas is discharged in an exhaust pipe with height of 60 m. The pollutants produced are mainly red metal, polycyclic aromatic hydrocarbons, sulfide, and fluoride [6, 7]. After entering the atmosphere, these pollutants will enter the soil of the investigation plot through the dry and wet sedimentation of the atmosphere.

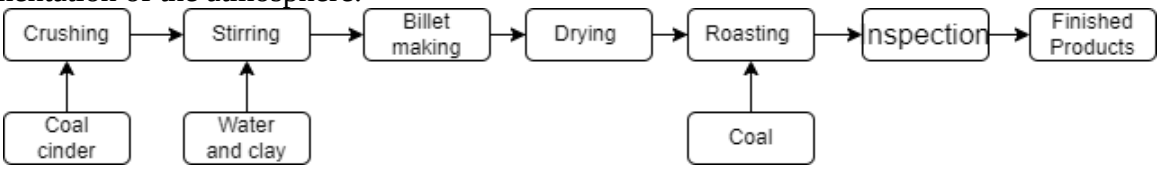

Figure 1 Production process flow chart of brick plant

In conclusion, during the production and operation of brick and tile plant, coal-fired waste gas collection and treatment may not be adequately discharged and ground seepage prevention is not tight. Under the action of atmospheric dry and wet sedimentation, precipitation leaching, vertical infiltration, and subsurface runoff, it may cause pollution impact on soil and groundwater environment of the plot. Potential pollutants include polycyclic aromatic hydrocarbons, petroleum hydrocarbons, and fluoride.

2.2 Sample distribution and collection

This soil pollution survey conducts the layout of monitoring points based on the "Technical Guidelines for Investigation of Soil Pollution Status on Construction Land" (HJ25.1-2019), "Technical Guidelines for Risk Control and Remediation Monitoring of Soil Pollution on Construction Land" (HJ25.2-2019), "Technical Guidelines for Investigation and Evaluation of Soil Environment of Construction Land", and site survey results [8, 9]. According to the current situation of the plant area, considering the influence of vertical downward migration of pollutants under the action of rainfall or self-gravity and horizontal migration with rainwater, and wind reasonably arranged in each potential pollution area. See Table 1 for the plane layout of 33 monitoring points in total. The collection of soil samples shall be carried out according to the requirements of HJ/T166-2004 "Technical Specifications for Soil Environmental Monitoring". The collected

samples shall be brought back to the laboratory in time and the sampling records shall be made.

Table 1: Situation of Preliminary Layout of Monitoring Points

Functional zone	Number of Distributed Points	Point distribution basis
Living area	1	Due to the distance from the brick baking kiln, and the possibility of vertical contamination by itself is low
Substation	1	
Billet yard	14	Due to the proximity to the brick baking kiln and large area, 14 monitoring points shall be set up
Billet preparation yard	2	Two monitoring points are arranged due to proximity to the brick baking kiln
Brick and tile kiln	6	Since coal combustion is involved in the brick baking kiln area and it is easy to collect coal ash, the possibility of pollution to soil is high. 6 monitoring points are arranged, and 2 monitoring points are in the kiln.
Earth heap	2	Judging whether there is pollution in the earth heap
Borrow pit	3	Due to the far distance from the brick baking kiln, and the possibility of vertical contamination by itself is low
Control Point	4	Located outside the investigation plot that are not affected by the investigation plot

2.3 Analytical methods and items

According to the pollutants controlled in GB36600-2018, combined with the analysis on the process flow, raw and auxiliary materials, intermediate products, and the use, storage and transport of final products in the facilities of various areas of the site, it is decided to monitor the inorganic pollutants and organic pollutants in the soil samples at each site, and 48 soil test items are determined for this work, including: ① Heavy metals and inorganic substances: As, Cd, Cr6+, Cu, Pb, Hg, Ni, 7 items in total; ② Volatile Organic Compounds (VOCs): No. 8 to 34 in Table I of GB36600-2018, 27 items in total; ③ Semi-volatile organic compounds (SVOCs): No. 35 to 45 in Table I of GB36600-2018, 11 items in total; ④ Other characteristic pollutants: Ph, petroleum hydrocarbons (C10-C40), Fluoride (soluble), 3 items in total.

3. Evaluation criteria and evaluation methods

3.1 Evaluation criteria

The survey and evaluation standard adopts the screening value of Class II land in the “Standard for Risk Management and Control of Soil Pollution in Soil Environmental Quality Standard (Trial)” (GB36600-2018).

3.2 Evaluation method

Nemerow compound index method [10] was used to evaluate soil pollution.

Nemerow compound pollution index method (P) reflects the effect of each pollutant on soil environmental quality, considering the mean value of single pollutant index and also reflects the influence of high concentration pollutants. The calculation formula is as follows:

$$P_i = \frac{C_i}{S_i} \quad (1)$$

$$P = \sqrt{\frac{{P_{i,m}}^2 + {P_{i,a}}^2}{2}} \quad (2)$$

In Equation (1), P_i represents the single factor index; C_i represents the test value of pollution index i; Si represents the standard value of pollution index i, i.e., the screening value of Class II land in GB36600-2018. In Equation (2), P represents the Nemerrow index; $P_{i,m}$ represents the maximum value of the single factor index of each pollution index; $P_{i,a}$ represents the average value of the single factor index of each pollution index.

Nemerow index is divided into five grades, which are described as follows: ①P<0.7, indicating that the soil is clean; ②0.7≤P<1, indicating that the soil is alert level; ③1≤P<2, indicating light soil pollution; ④2≤P<3, indicating middle level pollution; and ⑤3≤P, indicating severe soil pollution.

4. Pollution assessment

Based on the limit standard of Class II land use screening value in the "Standard for Risk Management and Control of Soil Pollution in Soil Environmental Quality Standard (Trial)" (GB 36600-2018), the evaluation results are shown in Table 2.

Table 2: List of Evaluation Results

Methods	Contaminants	Minimum Standard Index	Maximum single standard index	Degree grading of pollutants	Corresponding Factor of Maximum Standard Index
Single factor index method	Heavy metals (7 kinds)	0	0.6175	Pollution-free	Nickel
	Volatile Organic Compounds (9 kinds)	0	0	Pollution-free	/
	Semi-volatile organic compounds (17 species)	0	0	Pollution-free	/
	Petroleum hydrocarbons (C10-C40)	0	0.014	Pollution-free	Petroleum hydrocarbons (C10-C40)
	Fluoride	0.0011	0.111	Pollution-free	Fluoride
Methods	Contaminants	Standard Index Average	Nemerow Compound Pollution Index	Degree grading of pollutants	Corresponding point of maximum standard index
Nemerow Compound Pollution Index Method	Heavy metals (8 kinds)	0.0288	0.374	Safe cleaning	T14
	Volatile Organic Compounds (9 kinds)	/	/	Safe cleaning	/
	Semi-volatile organic compounds (17 species)	/	/	Safe cleaning	/
	Petroleum hydrocarbons (C10-C40)	0.0082	0.0113	Safe cleaning	T2
	Fluoride	0.0135	0.079	Safe cleaning	DB1

The single factor pollution index of heavy metals, volatile organic compounds, semi-volatile organic compounds, petroleum hydrocarbons (C10-C40), and fluorides in the soil was less than 1 without pollution. According to the evaluation result of Nemerow compound pollution index method, the Nemerow index of all samples submitted for inspection is 0-0.374, and the overall soil condition of this site is safe cleaning.

5. Conclusion

Investigation of soil pollution status is a preliminary survey of soil pollution. The data provided can make us know more clearly the level and spatial distribution of pollutants in the investigation

plot, which is an important reference basis for subsequent risk assessment and soil restoration. Through the investigation and analysis of soil pollution in abandoned brick plant plot, the main conclusions are as follows:

(1) The detection indexes of all the soil samples submitted for inspection in the abandoned brick plant plot did not exceed the screening value of Class II land in “Standard for Risk Management and Control of Soil Pollution in Soil Environmental Quality Standard (Trial)” (GB36600-2018).

(2) The Nemerow index of all samples submitted for inspection of the abandoned brick plant plot is 0-0.374, and the overall condition of the soil at the site is safe cleaning.

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