Warsaw University of Technology

FACULTY OF BUILDING SERVICES,
HYDRO AND ENVIRONMENTAL ENGINEERING

The impact of heavy metals in soils in the area of the smelter

Principles of Soil Diagnostic Techniques - Computer exercises

2020-1-4

Student ID: 309319
Student name: Zhiqi Wang

Data set	B
Metal analyzed	Cadmium

1. Introduction

In this project, my aim is to diagnosis of the area around the selected smelter with a visualization of soil contamination performed in the GIS program.

The soil near the heavy industry area is easily polluted. Various smelters discharge a considerable amount of heavy metals. They are discharged into the environment through waste gas, waste water, and waste residues. The heavy metals attached to the soil layer cause the soil heavy metals to exceed the standard and then be enriched in the organism, affecting biological health.

Among them, the heavy metal cadmium content is very low in the natural environment under normal conditions, but with the gradual increase of cadmium production in recent years, cadmium is widely used in the electroplating industry, chemical industry, electronics industry, nuclear industry and other fields **[1]**. Soil cadmium pollution has also received increasing attention.

Cadmium is a by-product of the zinc smelting industry. The main sources of pollution are lead-zinc ore, and non-ferrous metal smelting, electroplating, and factories using cadmium compounds as raw materials or catalysts. It is more easily absorbed by crops than other heavy metals. When the environment is polluted by cadmium, Cadmium can be enriched in organisms and enter the human body through the food chain causing chronic poisoning **[1].**

This time I choose the Głogów smelter area in Poland to visualize the content of Cadmium in soils in the area of impact of the smelter. The test results, in the form of the concentration of Cadmium for each soil sampling site, were collected in a database. After drawing a simulated map, I will analyze the cadmium pollution in this area and give the corresponding solutions.

2. Map

2.1 First I grabbed the existing data and got the first map(Fig 1) by using different colors to distinguish the land uses of this area.

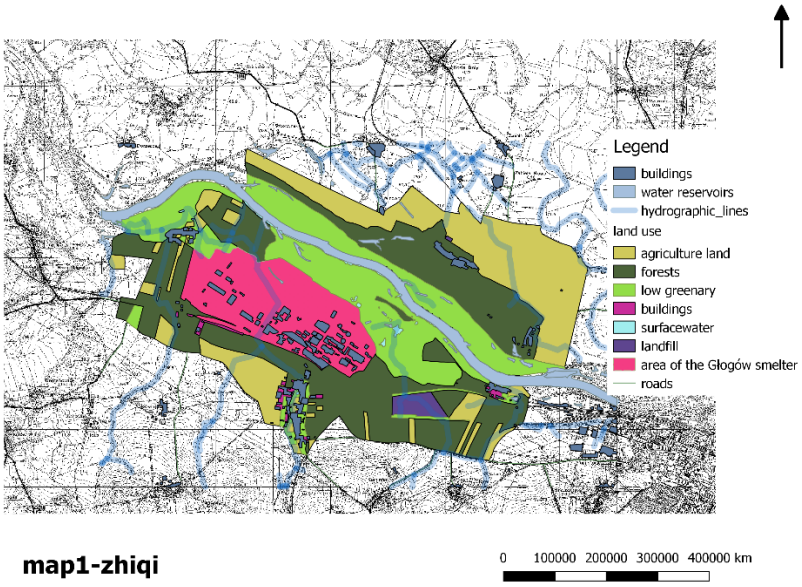

Fig-1 The map of the smelter area with marked regions

2.2 Next, on the basis of the previous map, I added the data of cadmium concentration in the soil which distributed in this area, and divided the pollution level into four levels according to the concentration. The degree of pollution is indicated by the difference in color and monitoring point size.

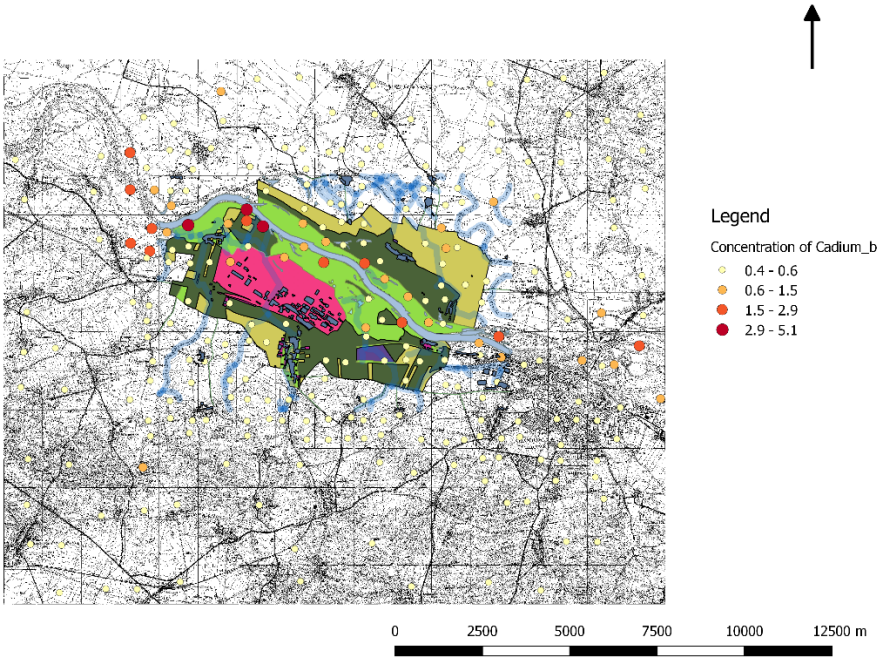

Fig-2 Map of cadmium pollution in smelter area

2.3 But because the above classification of my own cadmium concentration is not scientific, so this time I used the standard cadmium concentration classification.
Based on literature, the following table shows that I classified the cadmium concentration in the soil into 5 grades, and commented:

Class	Concentration [mg/kg]	Polluted level	Color in map
I	0-2	Clean	(green)
II	2-3	Relative polluted	(yellow)
III	3-10	Heavy polluted	(orange)
IV	10-15	Very heavy polluted	(red)
V	>15	Crazy polluted	(black)

Following this standard grading system, I redrawn a map of cadmium pollution in this area, and obtained the following map:

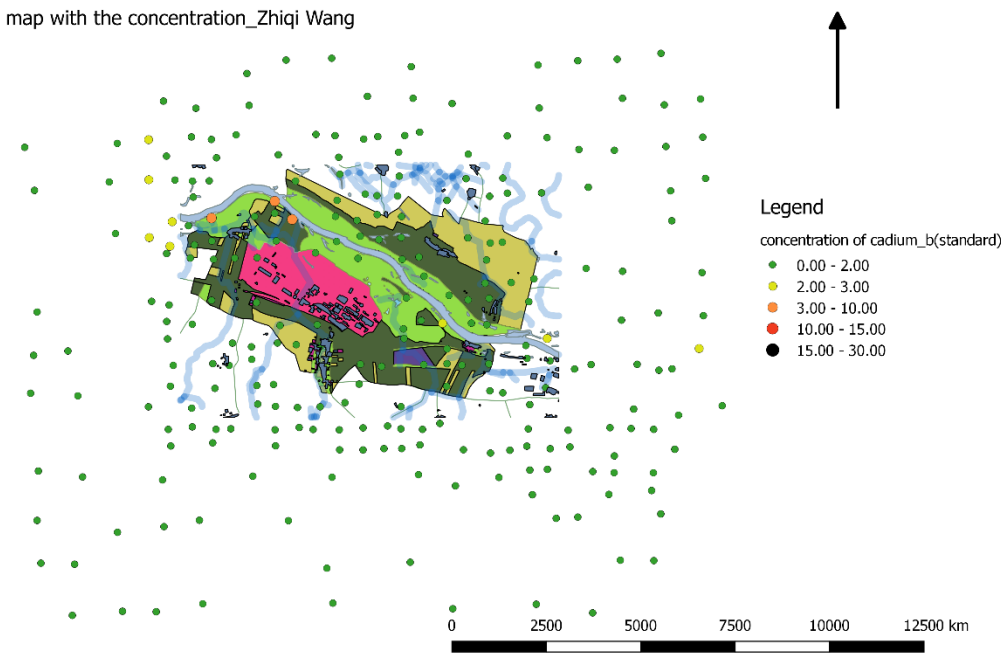

Fig-3 Map of cadmium pollution in smelter area under Standard concentration classification

It can be seen from this map that most of the monitoring points are green and not exceeding the standard, the overall pollution situation is not serious, and only a few monitoring points near the river bank have exceeded the standard.
For more accurate analysis, next step I tried to grasp the pollution of cadmium on soils of different uses, group the soils in different regions and analyze them.

2.4 According to the standard, I divided the area around the smelter into 4 groups, in order to more clearly observe and summarize the pollution degree of heavy metal Cd to the soil in various regions:

NO.	REGIONS
GROUP 1	Buildings
GROUP 2	Agriculture
GROUP 3	Forests, low greenery
GROUP 4	Landfill, smelter

Then I can draw a brief analyzation of the Cd contamination of these 5 groups of regions. The degree of contamination is shown in below:

- **Group 1**: all green
- **Group 2:** all green
- **Group 3:** Most sample are green, but there are 3 sample heavy polluted(orange) in the upper left of the map where near to the river, and one sample in the bottom right of the map where near to the river is relative polluted(yellow).
- **Group 4**: all green

(There are also several relatively polluted monitoring points in the upper left corner of the map, but they are not considered because they are not in the 5 groups of regions under analyzed.)

2.5 To further modify my map, I introduced the interpolation method and compared the two methods TIN with IDW.

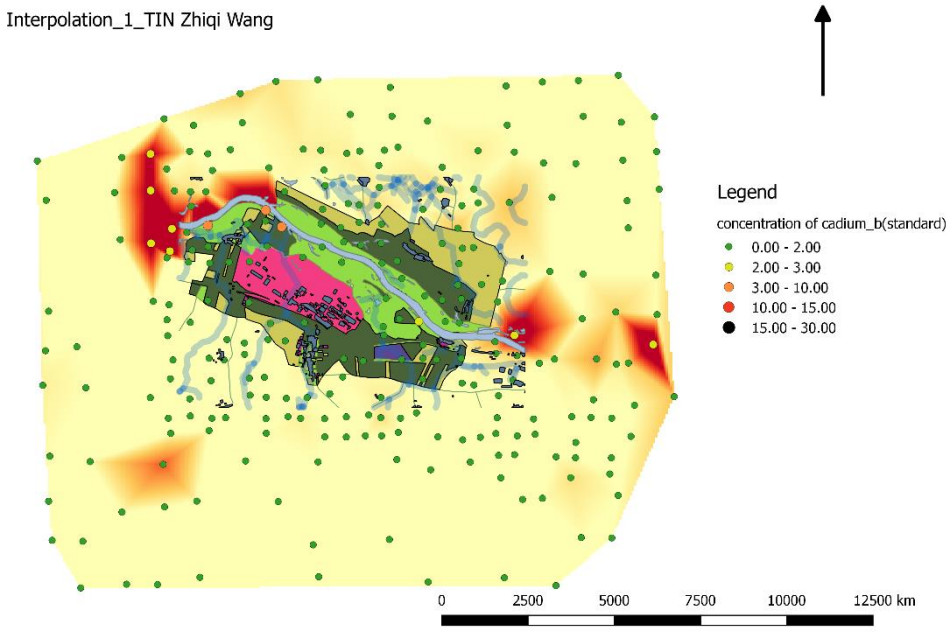

Fig-4 Map of Cadmium pollution distribution in smelter area under TIN method

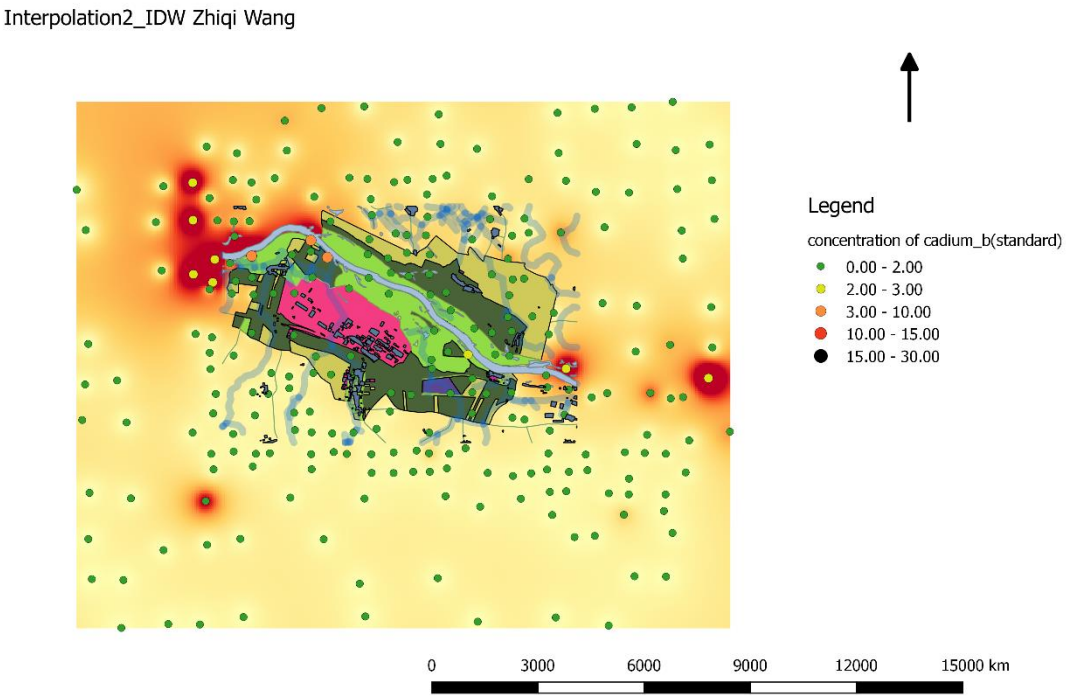

Fig-5 Map of Cadmium pollution distribution in smelter area under IDW method

By comparing these two maps, I got the following observations:
The TIN map connects the polluted monitoring points with the surrounding points, and displays the pollution degree of the area surrounded by these points in color. The IDW map displays a single polluted point by color, and the size of its color coverage shows the pollution level of this monitoring point. These two maps each have their own practical areas, but in the perspective of our project, I think the IDW map can more accurately show the pollution level of heavy metals in the smelter area.

In general, the cadmium monitoring points that exceed the standard are basically in the north of the smelter and near the river, so I have the following speculations about this situation:
1) The river was at the downwind of the smelter, so that the excess cadmium discharged into the air by the smelter drifted northward with the wind and then landed in the soil;
2) The cadmium waste water from the smelter is dumped in the river water, so that the river bank soil is more likely to exceed the standard.

3. Solution

3.1 Introduction

Cadmium is a highly toxic heavy metal, it is widely distributed in the earth's crust, with an average concentration of about 0.1 mg / kg. In the environment, cadmium has strong chemical activity, large mobility, concealment, and long-lasting toxicity. It cannot be decomposed by most microorganisms in the soil, so it will continue to accumulate in the soil,

so soil remediation has become a necessary technology.

The source of cadmium pollution in the soil is extensive, and atmospheric deposition is one of the main reasons. Gases and dusts containing heavy metals such as cadmium generated during industrial production, smelting, and mining processes enter the soil through atmospheric or rain and snow deposition, the wind and wind directions derivative effect; Besides, industrial sewage is also the main source of soil heavy metal pollution.

3.2 Method [2]

The currently developed soil remediation technologies can be divided into three categories: physical remediation, chemical remediation, and biological remediation. Next I will list several common soil remediation methods, analyze their advantages and disadvantages, and finally determine which methods are most suitable for our project.

- **Physical repair**

1) Guest soil method: Use fresh soil with better texture and fertility to replace the soil that has been polluted by cadmium, so that the ecological environment in the polluted area can be quickly repaired.

Although this method is fast and efficient, it does not solve the soil pollution, and the amount of engineering is large, easy to cause secondary pollution.

2) Electric repair is a new type of physical repair technology, which uses electrodes inserted at both ends of cadmium-contaminated soil, and transfers cadmium-contaminated soil to the cathode or anode chamber for treatment through the action of electric field and electromigration.

The repair cycle is short and the removal High efficiency, but large investment and high energy consumption are not suitable for large-area heavy metal contaminated soil remediation.

- **Chemical repair**

It is an effective in situ repair technique, which mainly includes leaching and chemical fixation techniques.

Among them, the in situ fixation technology is to put chemical reagents into the soil, so that cadmium and chemical reagents in the soil undergo adsorption, precipitation, complexation and other reactions to form insoluble or poorly mobile, low-toxic substances, thereby reducing the mobility and bioavailability of cadmium. The study found that limestone has a good solidification effect on soil heavy metals.

The method has moderate treatment effect and simple operation, but only changes the occurrence state of cadmium during the repair process, which easily leads to secondary pollution of the soil.

- **Bioremediation**

Among them, phytoremediation is the use of the cadmium accumulation characteristics of certain plants to transfer acid-soluble cadmium in the soil to the above-ground part through the absorption of plant roots, thereby achieving the restoration of cadmium-contaminated soil.

This method is inexpensive, can avoid secondary pollution, and can achieve secondary use of heavy metals, but has a long cycle and is harsh on natural conditions.

3.3 Suggestion:

Because the area surveyed by our project is large and covered by vegetation, repair methods that require a large amount of engineering, such as power at both ends, are not applicable, and large-scale movement of soil will also damage the natural environment. So I think the in situ repair method should be preferred.

Besides, because the area of serious pollution is near the river, the use of chemical reagents must be careful to avoid infiltration into the river and causing water pollution. And because the pollution level in this area is not serious, no urgent repair is needed, so I recommend the use of phytoremediation based on the current factors. The required remediation plants can be selected according to the local ecological environment.

4. literature

[1] https://baike.baidu.com/item/%E9%95%89%E6%B1%A1%E6%9F%93

[2] GAO Yu, CHENG Qian, ZHANG Meng-jun, ZHU Zhen-yu, HU Ting-ting, YANG Yu. Research Advance on Remediation Technology of Cadmium Contaminated Soil. Biotechnology Bulletin, 2017, 33(10): 103-110