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Heavy Metals In Livestock Land Of Chau Thanh District, Soc Trang Province, Mekong Delta - Vietnam

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Abstract:
Background*: Soil is one of the essential resources of humanity, is the place to produce products for human feeding. However, the overexploitation has polluted the soil environment. At present, the environmental status of the resource land is not fully known, especially in the Mekong Delta, in Southern Vietnam.*
Materials and Methods*: This study was conducted on an area of 186 ha in Chau Thanh District, which is a livestock land without any government planning. A total of 38 soil samples were taken from 0 - 30 cm depth. Heavy metals such as: As, Cd, Pb, Cu, Zn were measured by using the Flame Atomic Absorption Spectrophotometry method (TCVN 8246: 2009; EPA Method 7000B). To produce the spatial distribution of heavy metals we used the Kriging method and GIStechnique.*
Results*: Resultsshowedthat concentration of Asfrom1.02-61.32mg/kg,Cd:0.02-1.05mg/kg;Pb: 2.8 - 31.93 mg/kg; Cu: 18.38 - 70.6 mg/kg; Zn: 27.42 - 111.9 mg/kg. This shows that the soil in the livestock land is accumulating of heavy metals in the level of near -pollution to pollution (according to National technical regulation QCVN 03-MT: 2015/BTNMT). Maps of heavy metals were also established to provide for managers to make decisionmaking easily.*
Key Word*: Heavy metals, Kriging, GIS technique, Mekong Delta.*

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I. Introduction

The data on the soil environment is very important and the scientific basis for the rational and sustainable planning of agricultural land. Besides, it implements the regulation of environmental soil and upgrades the standards of soil environment assessment.

In the Mekong Delta, heavy metals in soil are the information need to implement for the soil data set. Because, heavy metals of the soil will affect crop yields and quality. Most importantly, heavy metal concentrations of the soil are readily present in the food chain, affecting plants and animals, especially human health [1, 2, 3, 4].

The Mekong Delta is the largest rice area in VietNam, which is providing food for the whole country and the top 3 export of the world. In the Summer-Autumn crop of 2020, The Mekong Delta cultivated 1.54 million hectares of rice; production of about 9 million tons, about 3.9 million tons of rice is exported [23]. This is the great potential of this area. However, in order to maintain that potential, we need to update data of soil to make the appropriate adjustments for planning and protecting the enviromental soil.

There are studies of soil data in this area, the data are separate points, and the heavy metal concentration of the soil does not meet standards for the assessment of soil quality. This study will supplement these gaps. Soil data were analyzed from samples collected in the field. To produce the spatial continuous distribution we use the geostatistic method, combined with Geographic Information System (GIS) technology to produce maps, descriptive statistical methods identify a source of heavy metals in the soil [5, 6].

Geostatistics and GIS technique allow more accurate information and faster, that is why they have been widely used in numerous studies for determination of spatial distribution and behaviour of pollutant in enviroment [7, 8, 9, 11, 12]. Kriging method is one of the most commonly used methods for spatially interpolation in environmental studies [10, 13] that has been successfully described the spatial variability of certain soil parameters and predict value for unknown points/areas [8, 12, 14].

The aims of study are: (1) to provide data of the soil environment; (2) to apply geostatistics and GIS technique to mapping heavy metals concentration of soil in the study area.

II. Material And Methods

Study area

The study area is the livestock area along 1A Highway, located in Ho Dac Kien commune, Chau Thanh district, Soc Trang province, Mekong delta, VietNam (figure 1). This is a livestock land without any government planning. These activities cause environmental pollution, affecting the health of the people. Survey area: 186 ha. Land use: rice land, rural residential land and perennial cropland. Terrain: Altitude from 0.2 to 0.7m. This area has a tropical climate with two distinct seasons: The rainy season lasts from May to November and the dry season lasts from December to April.

Soil sampling

Total of 38 soil samples with 0 – 30 cm depth were taken from the fields. Sampling points were selected randomly over the study area. They are stored in polyethylene bag for transport; air-dried for several days at room temperature and then analyzed in the laboratory for chemical analysis following the guidance of Vietnam standard (TCVN 6647:2007) [18].

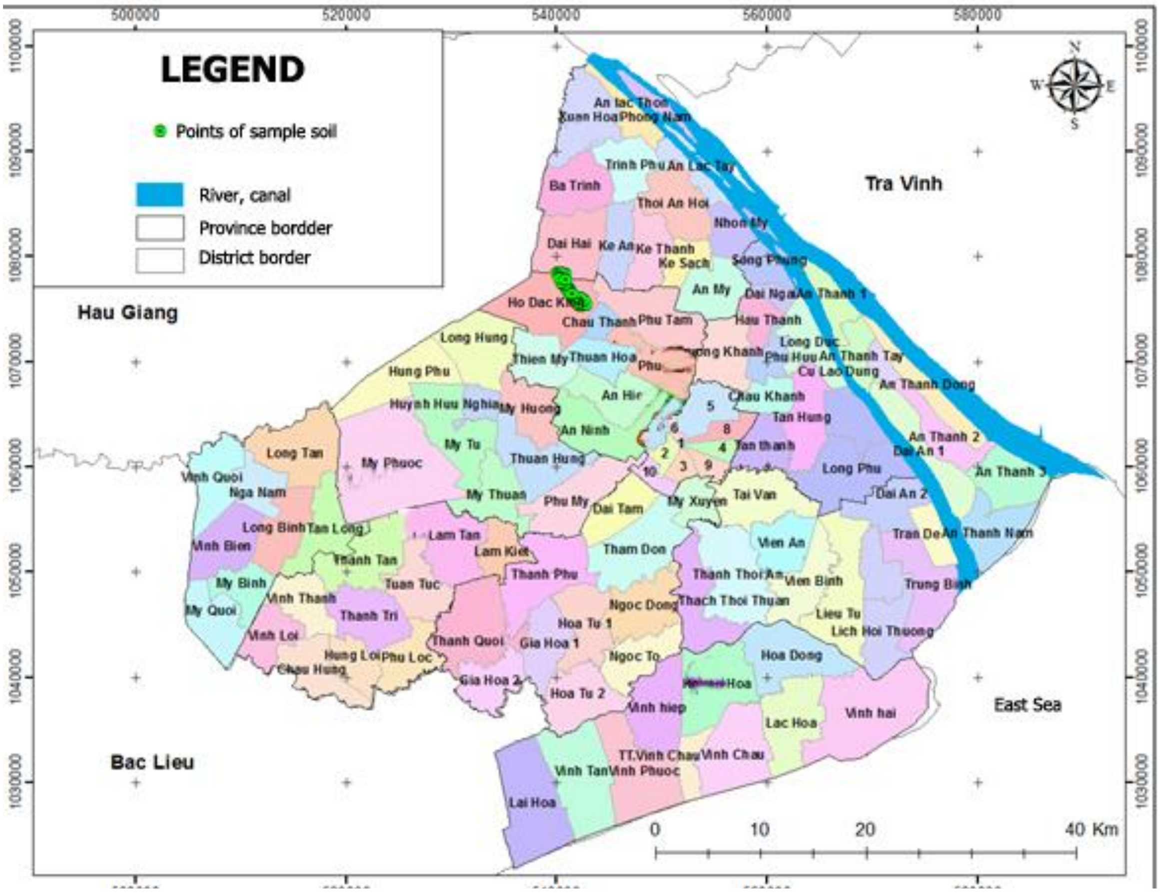

Fig.1. Soil sampling points of the study area

Methods

Total heavy metal concentrations

The total heavy metal concentration was measured for 5 main elements: arsenic (As), cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) following the procedure. The soil samples were air-dried at room temperature (20-25^{o}C) for several days then milled to a particle size of < 2 mm after dried.

The total concentrations of heavy metal were determined using Flame Atomic Absorption Spectrophotometry method (TCVN 8246:2009) [17].

Statistical and Geostatistical analyses

Parameters such as minimum, maximum, mean, standard deviation and coefficient of variation were calculated by the descriptive statistics. In order to calculate the spatial distribution of 5 heavy metals, Ordinary Kriging interpolation method was used, and then combined with GIS techniques to produce content maps of 5 heavy metal elements.

Ordinary Kriging is a linear spatial interpolation that estimates spatial data at unknown location using a weight function of adjacent data points [16]. The general equation for estimating the z value as a point is:

$$Z_0 = \sum_{i=1}^{n} Z_x W_x \qquad (1)$$

Where Z_0 is the estimated value, Z_x is the known value at point x, W_x is the weight associated with point x. And n is the number of sample points used in estimation. The weight can be derived from solving a set of simulation equations. For example, the following equations are needed for a point (0) to be estimated from three known point (1, 2, 3).

$$W_1\gamma(h_{11}) + W_2\gamma(h_{12}) + W_3\gamma(h_{13}) + \lambda = \gamma(h_{10}) \qquad (2)$$
$$W_1\gamma(h_{21}) + W_2\gamma(h_{22}) + W_3\gamma(h_{23}) + \lambda = \gamma(h_{20}) \qquad (3)$$
$$W_1\gamma(h_{31}) + W_2\gamma(h_{32}) + W_3\gamma(h_{33}) + \lambda = \gamma(h_{30}) \qquad (4)$$
$$W_1 + W_2 + W_3 + 0 = 1.0 \qquad (5)$$

Where $\gamma(h_{ij})$ is the semivariance between known points i and j, $\gamma(h_{i0})$ is the semivariance between the *i*th known point and the point to be estimated, and λ is a Lagrange multiplier, which is added to ensure the minimum possible estimation error.

Once the weights are solved, Eq. (1) can be estimated z_0

$$z_0 = z_1W_1 + z_2W_2 + z_3W_3..$$

III. Result

Heavy metal concentration in livestock land

The descriptive statistic for data is showed in the Table 1. Total concentrations of heavy metals as follows: As (1.02 – 61.32 mg/kg), Cd (0.02 – 0.15 mg/kg), Pb (2.8 – 31.39 mg/kg); Cu (18.38 – 70.6 mg/kg); and Zn (27.42 – 111.9 mg/kg).

The data showed that the concentration of heavy metals As exceeded national technical regulations, heavy metals copper reached close-pollution levels, cadmium, lead and zinc were below national technical regulations QCVN 03-MT: 2015/BTNMT [16].

Table 1: Descriptive statistical of five heavy metal concentration (mg/kg)

n = 38

	As	Cd	Pb	Cu	Zn
Mean	18.00	0.07	14.00	28.89	56.46
Standard Deviation	3.01	0.01	1.18	1.31	3.06
Coefficient of variation (%)	16.72	14.3	8.43	4.53	5.42
Min	1.02	0.02	2.80	18.38	27.42
Max	61.32	0.15	31.93	70.60	111.90
Close-pollution (70 % the allowable limit)	10.5	1.05	49	70	140
QCVN 03-MT:2015/BTNMT (Agricultural land)	15	1.5	70	100	200

Heavy metal of Arsenic

The value of arsenic concentration was 1.02 - 61.32 mg/kg. There were 5.26% of samples at the level of close pollution and 44.73% at the pollution level according to National technical regulation QCVN 03-MT: 2015/BTNMT [16]. So the livestock land in Soc Trang province is contaminated with heavy metals of arsenic. Histogram and map of heavy metal arsenic is shown in Fig. 2 & 3.

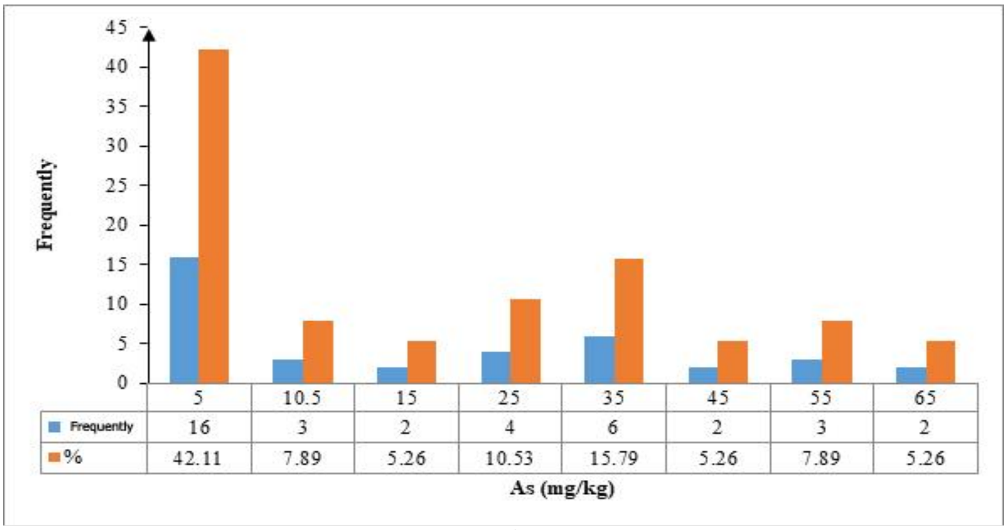

Fig. 2: Histogram of As concentration

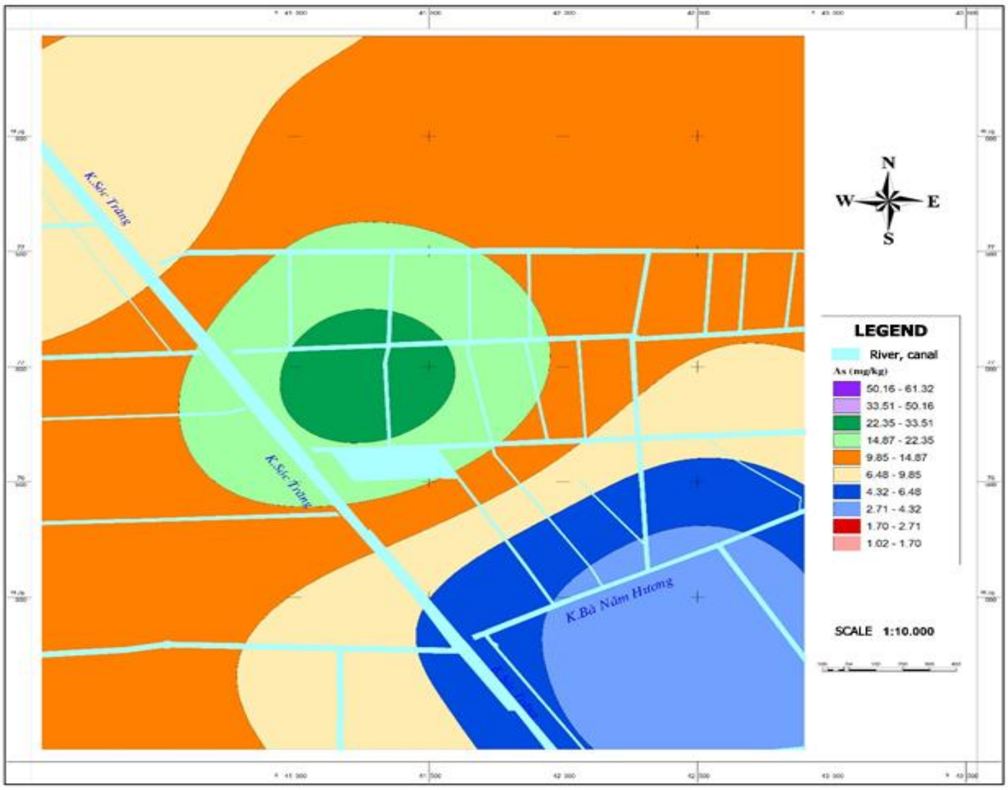

Fig. 3: The spatial distribution map of As concentration

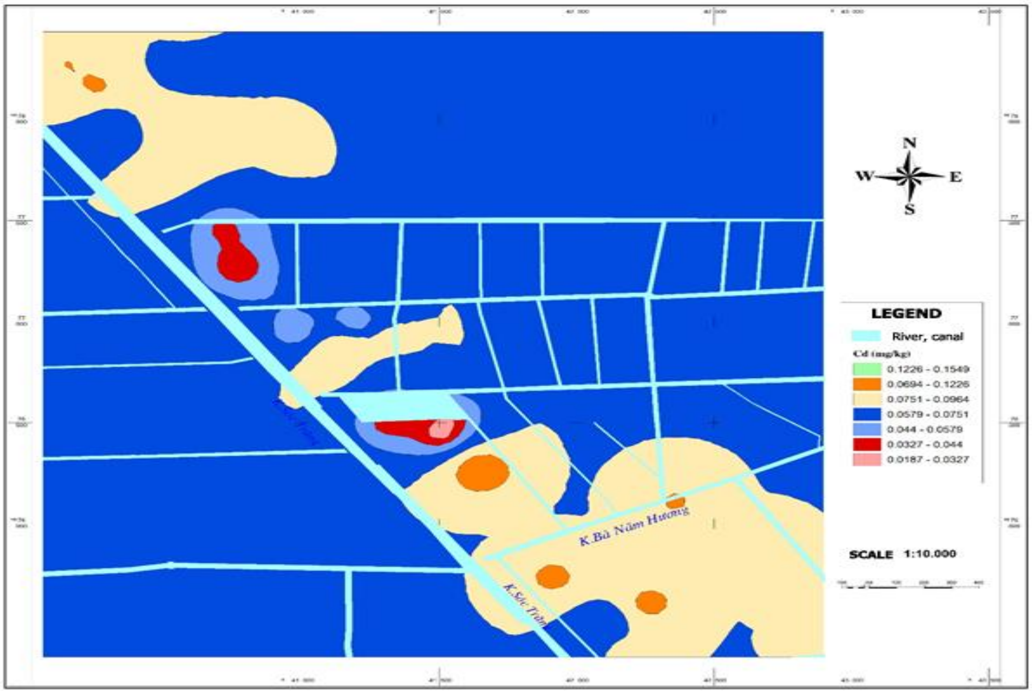

Fig. 4: The spatial distribution map of Cd concentration

Heavy metal of Cadmium

The value of cadmium concentration was from 0.02 - 0.15 mg / kg. All of the samples were below national technical regulation of QCVN 03-MT: 2015/BTNMT [16]. The map of Cd concentration is shown in Fig. 4.

Heavy metal of Lead

The lead concentration value was from 2.8 - 31.93 mg/kg, below National technical regulation of QCVN 03-MT: 2015/BTNMT [16]. The high value of lead concentration is concentrated in the intersection of the Trung Hai canal and National highway 1A and a part of Chua Moi canal (Fig. 5).

Heavy metal of Copper

The copper concentration value was from 18.38 - 70.60 mg/kg. Almost all of the sampling points were below National technical regulation. One point of concentration value was at the near-pollution according to National technical regulation QCVN 03-MT: 2015/BTNMT [16].

Like the distribution of other heavy metals, the high-value concentration of copper is concentrated on the along of National Highway 1A and the intersection of Ba Nam Huong canal and National Highway 1A (Figure 6).

Heavy metal of Zinc

The value of zinc concentration was from 27.42 - 111.9 mg / kg. All points were below National technical regulation of QCVN 03-MT: 2015/BTNMT [16]. Distribution of high value of zinc concentration is along the intersection of National Highway 1A and Nam Hai canal (Figure 7).

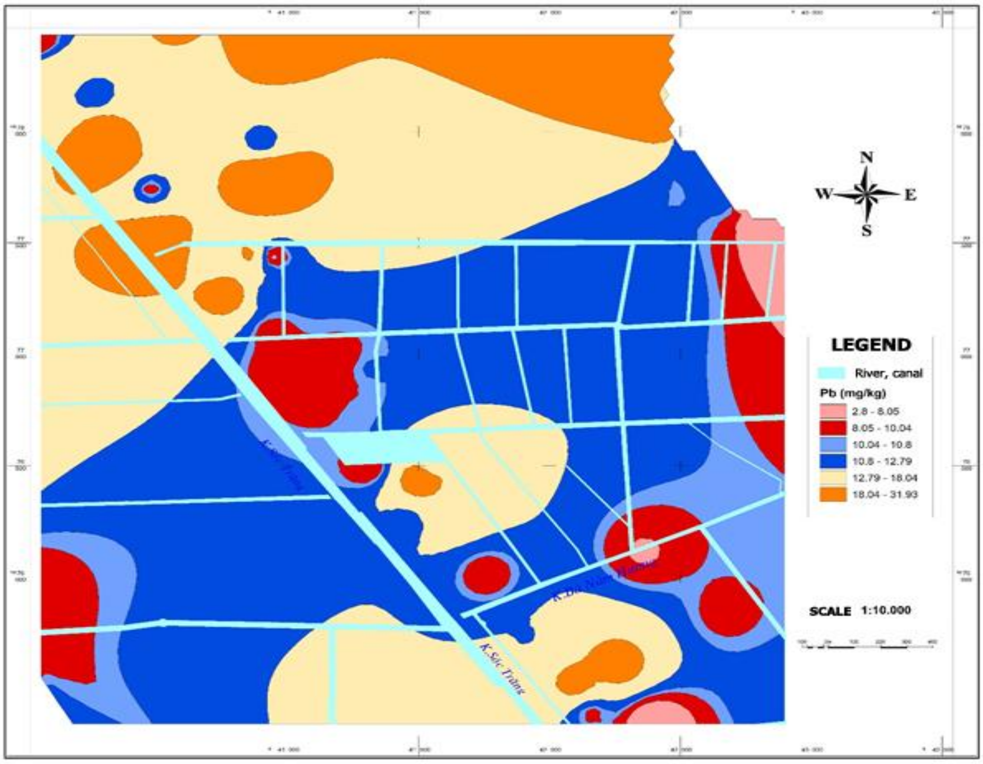

Fig. 5: The spatial distribution map of Pb concentration

Fig. 6: The spatial distribution map of Cu concentration

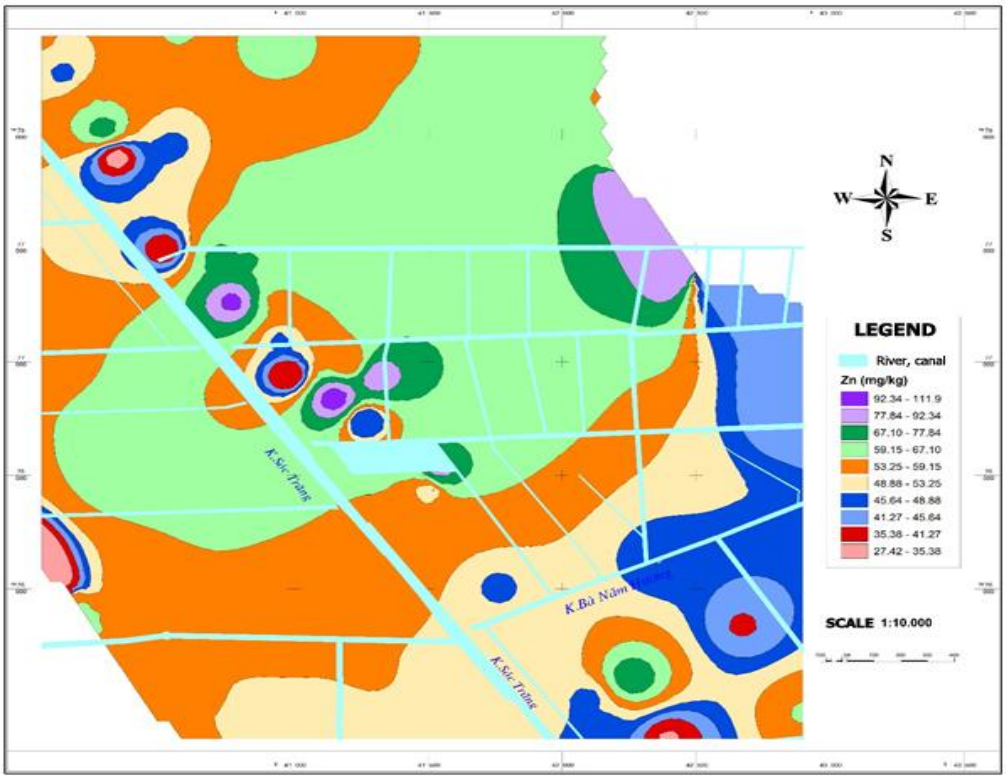

Fig. 7: The spatial distribution map of Zn concentration

IV. Conclusion

Result of study has added 190 values of heavy metals in the soil. This will the primary source of information for livestock land planning in Soc Trang province and also reference data for areas in Mekong Delta, which have similar soil environmental properties.

The arsenic heavy metal concentration showed more than 44% of the total samples exceeded National technical regulations on the allowable limits of heavy metals in the soils QCVN 03-MT: 2015/BTNMT (2015). Other heavy metals were below National technical regulations on the allowable limits of heavy metals in the soils QCVN 03-MT: 2015/BTNMT (2015).

The study also successefully applied geostatistic methods and GIS techniques to map heavy metal concentrations for helping managers make decisions easily

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