Evaluation of Metal Contamination in Soil Samples Around Thermal Power Plant in Turkey

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Abstract. Thermal power plants lead to major environmental problems such as the generation of acid gases and fly ash. Heavy metals contained in fly ash have potential risks for human health and soil and water ecosystems. Therefore, it is of great importance to study the heavy metal contamination of soil around the coal-fired thermal power plants. In this study, the concentrations of Cr, Ni and Hg in surface soil samples from the area around the Kangal lignite-fired thermal power plant (LFTPP) were analysed by using energy dispersive X-ray fluorescence (EDXRF) spectrometry to assess the contamination level of soils. The average metal concentration of Cr, Ni and Hg was found as 713.2 ppm, 610.1 ppm and 1.7 ppm. Each soil sample contamination with Cr, Ni and Hg was estimated using ecological parameters such as the enrichment factor (E_F), contamination index (C_F) and Nemerow integrated pollution index (I_{PL}). The average value of E_F and C_F estimated for Cr, Ni and Hg were found as 1.8, 2.2 and 4.3, 8.6, 10.5 , 20.7, respectively. The results indicate that the soils around Kangal LBPP were moderate polluted to very strongly polluted with Cr, Ni and Hg. The I_{PL} values varied from 9.2 to 119.3 with an average value of 17.7. The evaluation result of I_{PL} revealed that the soil samples were very high polluted.

INTRODUCTION

Turkey is a major part of its energy needs, provide lignite coal to thermal power plants use as fuel.When assessed in this respect, the quality of the lignite coal is important. In areas where power plants are located, knowing the metal values in agricultural land is of great importance for human health. Metal pollution on agricultural soils does not only endanger the eco-environment of agricultural land, but also poses a serious threat to all living things in that ecosystem [1]. Metals are known to enter the human organism through the respiratory, digestive system and skin [2-3]. It is not so easy to throw these metals out of metabolism, which easily enters the organism, and accumulates in the organism over time. These accumulations in humans cause disease or cancer cells that require treatment on a day-to-day basis [4]. In this study, the concentration of chromium, nickel, and mercury metal in the soil around the coiling lignite deposit was determined by using the X-ray fluorescence of the energy distribution.

MATERIAL AND METHOD

Sample Preparation and XRF Analysis

Hundred and forty soil samples collected around the lignite plant were brought to the Kastomonu University Central Working Laboratory Sample Preparation Part with plastic bags. After the samples were freed from foreign substances, they were homogenized and stored in a 80 degree celcius flask, their moisture was evaporated and each specimen was labeled. For XRF measurements, 50 gr of each sample was sampled and pressed. Analyses of the metals in the soil samples were performed using an EDXRF spectrometer (Spectro Xepos) equipped with a thick binary Pd/Co alloy anode X-ray tube (50 W, 60 kV) [5].

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Ecological Parameters

Different approaches have been developed in assessing the metal pollution dimension that the effects of industry, agriculture and human activities in a region have created in the earth .These approaches are divided into two groups:

1) Methods based on total concentrations,

2) Methods that depend on whether an element is reactive or not. One of the methods based on total concentrations is the quantitative index method. There are many useful indexes and factors in this method. The evaluation parameters used in this study are as follows.

The enrichment factor (E_F) is widely used to determine the proportion of metal enriched in the soil as a result of human activities and it was estimated using the following equation based on the standardisation of a measured element against a reference element [7] . The amount of metal analyzed in this study was normalized with Cu of the same sample and equation 1 was used to calculate the enrichment factor of the respective metal.

$$E_F = \frac{\left(C_n / C_{Ref} \right)_{Sample}}{\left(C_n / C_{Ref} \right)_{Earth}} \qquad (1)$$

Where C_n is the concentration of any element or metal and C_{Ref} is the concentration of a reference element or metal in the examined environment.

Contamination factor (C_F), in order to evaluate the value of metal corrosion in working soil samples, this factor was also calculated. For this, the concentration of metal contained in each sample was calculated by the ratio of the average shale value of the same metal. The average shae value for each metal is avaliable in the literature [8]. The contamination factor given in equation 2. C_n is the concentration of each metal in the soil samples.

$$C_F = \frac{(C_n)_{Sample}}{(C_n)_{Background}} \qquad (2)$$

Nemerow integrated pollution index is used to compare the pollution values of different stations. All metals worked are considered as an integrated index since this index is collected and can be easily understood by all. Nemerow integrated pollution index (I_{PL}) was used to assess the metal contamination levels of soil and estimated using the following equation 3 [9-10].

$$I_{PL} = \sqrt[n]{\prod_{i}^{n} C_{Fi}} \qquad (3)$$

The results of calculations made based on three indices (Enrichtmen factor, Contamination factor and Nemerow factor integrated pollution index) are given in Table 1.

RESULT AND DISCUSSION

The results of ENXRF analysis for Cr, Ni and Hg are 713.2 ,610.1 and 1.7 ppm, respectively. Using these values, metal contamination in the soil was determined. The enrichment factors used to determine metal contamination were calculated as 1.8, 4.3 and 10.5 for Cr, Ni and Hg, respectively. The five contamination categories are recognized on the basis of the value of E_F [11]. The contamination factors for the same metals were calculated as 2.2, 8.6 and 20.7. Five classes were established based on the value of C_F [12]. The Nemerow integrated pollution index (I_{PL}), which can be seen in combination with all metals, was calculated as 17.7 . The categorization of each index is given in Table 1. The analyzed metal pollution in the soil and its evaluation are shown in Table 1. It can be said that the metal density of Cr, Ni and Hg is considerably high in the soil studied as a result of the integrated index Nemerow integrated pollution index where all the metals studied are collected in a integrated index.

TABLE 1. Ecological parameters and classification

Ecological parameter	Value	Contamination category (soil quality)
Enrichment factor (E_F)	$E_F < 2$	Deficiency to minimal enrichment (DME)
	$2 \leq E_F < 5$	Moderate enrichment (ME)
	$5 \leq E_F < 20$	Significant enrichment (SE)
	$20 \leq E_F < 40$	Very high enrichment (VHE)
	$E_F \geq 40$	Extremely enrichment (EE)
Contamination factor (C_F)	$C_F < 1$	Low contamination
	$1 \leq C_F < 3$	Moderate contamination
	$3 \leq C_F < 6$	Considerable contamination
	$C_F \geq 6$	Very high contamination
Nemerow integrated pollution index (I_{PL})	NIPI < 0.7	Class 1 (non-pollution)
	0.7 ≤ NIPI < 1	Class 2 (warning line of pollution)
	1 ≤ NIPI < 2	Class 3 (low level of pollution)
	2 ≤ NIPI < 3	Class 4 (moderate level of pollution)
	NIPI ≥ 3	Class 5 (highlevel of pollution)

CONCLUSION

The assessment of metal pollution on agricultural soils is crucial for all living things, including those livings on it. In this study, concentrations of Cr, Ni and Hg metals were determined in soil samples taken around Kangal lignite fueled thermal power plant. Contamination caused by these metals was evaluated under the heading of enrichment factor, contamination factor and Nemerow integrated pollution index. As a result, it was determined that there was serious contamination of Cr, Ni and Hg metals in the working soil.

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