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INCREASED HEAVY METAL CONCENTRATIONS IN THE SOILS NEAR ELECTRIC POWER GENERATORS IN SAMARRA CITY (IRAQ)

Purpose. To determine the concentration levels of various heavy metals and carbon in the soils of four Samarra City areas that are close to pollution sources (electric power generators).

Methodology. A pollution source is sampled at a distance of 5, 10, 15, and 20 meters. The concentrations of iron (Fe), lead (Pb), copper (Cu), cadmium (Cd) metals, as well as carbon, are then determined.

Findings. It has been determined that the iron and copper concentrations are within the permissible limits prescribed by the United States Environmental Protection Agency. However, the soils contaminated with cadmium and lead in concentration exceed the permissible limits. The metal concentrations increase with distance from the source. The metal concentration is low at a distance of 5 m from the pollution source, then it increases at a greater distance. Moreover, metals are found in soils at a distance of 10 m, then their concentration further increases at a distance up to 20 m. Concentrations of metal and carbon at a distance of 20 m are the highest.

Originality. This study determines the concentration level of heavy metal contaminants, as well as the impact of electric power generating waste on the metropolis. According to the study, the concentration of these components increases around electric power producers.

Practical value. The concentrations of heavy metals in soils increase as the distance from the source of pollution increases.

Keywords: *heavy metals, soil, power generators, cuprum, cadmium, plumbum, ferrum, carbon*

Introduction. Pollution, which is one of the most serious problems at present, is a result of human exposure to numerous environmental pollutants caused by the immense development of technology. Industrial pollutants unknown before have since persisted. This study aims to investigate the effect of heavy metals. Soil contamination by heavy metals have become a major apprehension because of their toxicity to the environment and human life [1]. Studying the heavy metal concentration is important not only in the context of soil contamination but also in waters and rivers [2, 3]. According to the United States Environmental Protection Agency (USEPA), the pollution of soil by heavy metals has caused health issues in approximately 10 million humans.

The modern development of the global economy has also led to an increased number of heavy metals in soils, both in terms of type and content [4, 5]. Chromium (Cr), cadmium (Cd), and lead (Pb) are common metals causing the pollution of soils [6]. Heavy metals can be divided into essential and non-essential types. Essential heavy metals, such as Cr, copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), and zinc (Zn), are considered essential micronutrients but become toxic when taken in excess quantities. Non-essential heavy metals, such as Pb, Cd, and mercury, are highly poisonous for living organisms [7, 8].

Heavy metals are natural components of soil, but human activities have increased these metals' concentrations. Heavy metal sources in soils include the excessive application of sewage sludge, agrochemicals, bio-solid industrial wastewater, and manure [9, 10], and their accumulation causes severe health problems in humans, animals, and plants [11, 12]. Heavy metals enter soils as two different sources, namely, through anthropogenic and geological activities [13, 14]. Industrial, smelting, mining, agrochemical, and fuel manufacturing units are examples of anthropogenic input points of heavy metals in non-agricultural and agricultural soils [15, 16].

The pollution of soil has become a global environmental problem due to the increasing industrialization and activities of humans [17]. Different from organic matter, heavy metals are extremely toxic because they are not biodegradable (i.e., they only can change their oxidation states) and are insistent in the environment, with a half-life of more than 20 years [18, 19]. Heavy metals in soil lead to unhealthy environmental conditions because these metals leach and are non-degradable [20, 21].

Heavy metals are released into the atmosphere through the discharge of dust and gases from production and the transport of energy and constructed materials. In the atmosphere, heavy metals take the form of aerosols, then they penetrate soils through precipitation [22–24]. Micronutrient (Fe, Zn, Mn, Cu, Co, and Ni)-deficient soils are nourished by elements for the healthy growth of crops and plants [25]. Cd and Zn are essential micronutrients in soils. However, in high concentrations, Zn is poisonous to plants, whereas Cd rarely causes phytotoxicity [26]. In soils, Pb transforms rapidly into lead phosphate and becomes unavailable to plants [27]. Thus, apart from mining and agriculture, human activities entailing industrial production are another example of pollution caused by heavy metal accumulation [28].

The main aims of this research are:

- to investigate the concentrations of heavy metals and carbon in the study area;
- to explain the extent of increase and decrease in the concentration of heavy metals and carbon in relation to the source of pollution.

Materials and Methodology. The study area included selected places near sources of pollution (diesel generators) in Salah al-Din Governorate, Samarra District, as shown in Fig. 1. The Arc GIS program was used in this research.

Geologically study area (Samarra city) is located in unstable shelf in the end of foot hill zone and upper Mesopotamian zone. quaternary sediments covered surface area and include alluvial fans sediments that appear as Stratigraphic sequences of gravel, sand, silt, clay and gypsum deposits.

Several selected areas of Samarra City near the pollution sources were studied. We collected soil samples from four locations in Samarra City. Moreover, in each location, four samples

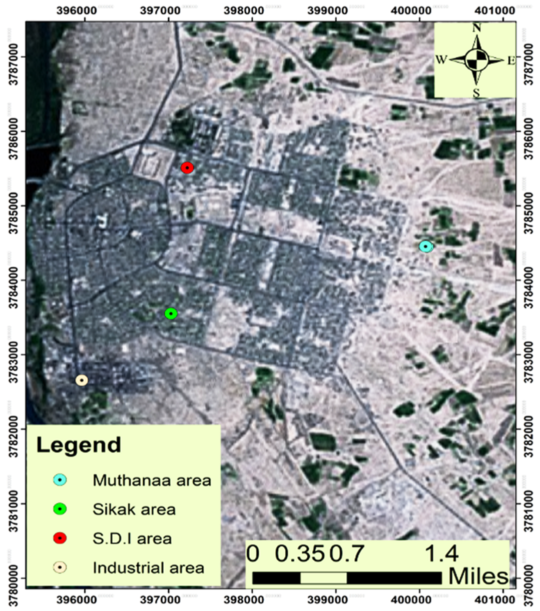

Fig. 1. Location Map of the Chosen Area in Samarra City

at different distances from the pollution source were taken. The samples were measured for their concentrations of heavy metals and carbon by the Applied Chemistry Laboratory of the College of Applied Science of University of Samarra by using specialized instruments. The results are shown in Table 1.

The chemical compositions were determined by setting a number of influencing factors, including the mineralogy of rock types [29].

Result and discussion. The Samarra Drug Industry (SDI) area presented the lowest Cd concentration at 7.8 ppm in the soil of Site 8 located near the pollution source and the highest Cd concentration at 11.5 ppm at Site 20 at a farther distance from the pollution source. The permissible limit for environmental pollution is 0.99 ppm according to the US-EPA. The presence of Cd, whose range was from the lowest to the highest concentrations in this research, could explain the soil contamination caused by the pollution sources in the study area.

Table 1

Concentrations of metals depending on the distance from a pollution source

No	Study area	Distance from pollution source, m	Site	Cu	Pb	Cd	C	Fe
1	S.D.I Area	5	8	19	66	8.7	17.2	34
2		10	18	12	86	9.4	31.5	57
3		15	19	11	84	11.2	34.6	53
4		20	20	10	87	11.5	33.2	50
5	Industrial Area	5	5	12	42	7.1	19.7	26
6		10	9	22	42	5.8	21.3	38
7		15	10	28	42	6.1	23.2	30
8		20	11	27	47	7.4	22.6	34
9	AL Sikak Area	5	7	20	80	8.4	17.3	29
10		10	15	26	59	8.7	29.8	34
11		15	16	29	58	9.6	30.1	39
12		20	17	11	90	10.1	30.6	58
13	AL Muthanaa Area	5	6	17	44	7.3	17.5	25
14		10	12	27	40	7.8	22.1	36
15		15	13	26	50	9.2	29.6	32
16		20	14	26	54	8.6	28.5	37

The lowest Fe concentration was 34 ppm at Site 8 near the pollution source, whereas its highest concentration reached 57 ppm at Site 10 at a farther distance from the pollution source. The Fe concentration was higher than the permissible percentage of environmental pollution according to the US-EPA. Meanwhile, the Pb percentage was the lowest at 66 ppm in the soil of Site 8 near the pollution source and the highest at 87 ppm at Site 20 farther from the pollution source. The Pb percentage was higher than the 35.5 ppm allowed by the US-EPA for environmental pollution. The trend shows that even the lowest concentration in the sampled soil is higher than the permissible level, indicating the clear Pb contamination of the soil by the pollution sources (Fig. 2).

The lowest Cu concentration was 10 ppm in the soil of Site 20 located far from the pollution source, whereas the highest concentration was 19 ppm at Site 8 near the pollution source. Both values were within the permissible limit of environmental pollution according to the US-EPA. Meanwhile, the lowest carbon concentration was 17.2 % in the soil of Site 8 near the pollution source, whereas the highest concentration was 34.6 % at Site 19 farther from the pollution source. The pollution trend due to carbon appears to be gradually increasing in relation to distance; that is, pollution is less likely near the source, but carbon rises and falls to the ground, and it accumulates in the soil at a much farther distance.

This study finds that the pollution caused by heavy metals and carbon is traceable to the generators. The metal concentrations increase as one moves away from the source. They ascend and form in the air a few meters away from the source, and they finally land on ground surfaces. The damage caused by the pollution of heavy metals is most prominent in the farthest areas, i.e., on buildings near the source or in locations 10 m or farther away from the source (US Environmental Protection Agency Standards for the Use or Disposal of Sewage Sludge, 1993).

In the industrial area, the lowest Cd concentration was 5.8 ppm in the soil of Site 9 located near the pollution source, whereas the highest concentration was 7.4 ppm at Site 11. The permissible limit for environmental pollution is 0.99 ppm according to the US-EPA. This trend indicates that soil pollution due to Cd, whose range was from the lowest to the highest concentrations in this study, was caused by pollutants emitted by engines (Fig. 3).

The lowest Fe concentration was 26 ppm at Site 5 near the pollution source, whereas the highest concentration was 38 ppm at Site 9 far from the pollution source. The value range is higher than the permissible percentage of environmental pollution of the US-EPA. In addition, the lowest Pb percentage was 42 ppm in the soil of Site 5 near the pollution source, whereas the highest value was 47 ppm at Site 20 located farther from the pollution source. The permissible percentage is 35.8 ppm for environmental pollution according to the US-EPA. The increasing trend of Pb pollution in the sampled soils was higher than the US-EPA prescription.

The lowest Cu concentration was 12 ppm in the soil of Site 5 near the pollution source, whereas the highest concentration was 28 ppm at Site 10 located farther from the pollution source. The values were higher than the permissible limit for environmental pollution according to the US-EPA.

The lowest carbon concentration was 21.3 % in the soil of Site 9 near the pollution source, whereas the highest concentration was 23.2 % at Site 10 located farther from the pollution source. The pollution due to carbon appears to gradually increase as one moves farther away from the source; that is, pollution is less likely in areas near the source, but carbon rises to the air and then falls to the ground where it accumulates at a farther distance (US Environmental Protection Agency Standards for the Use or Disposal of Sewage Sludge, 1993).

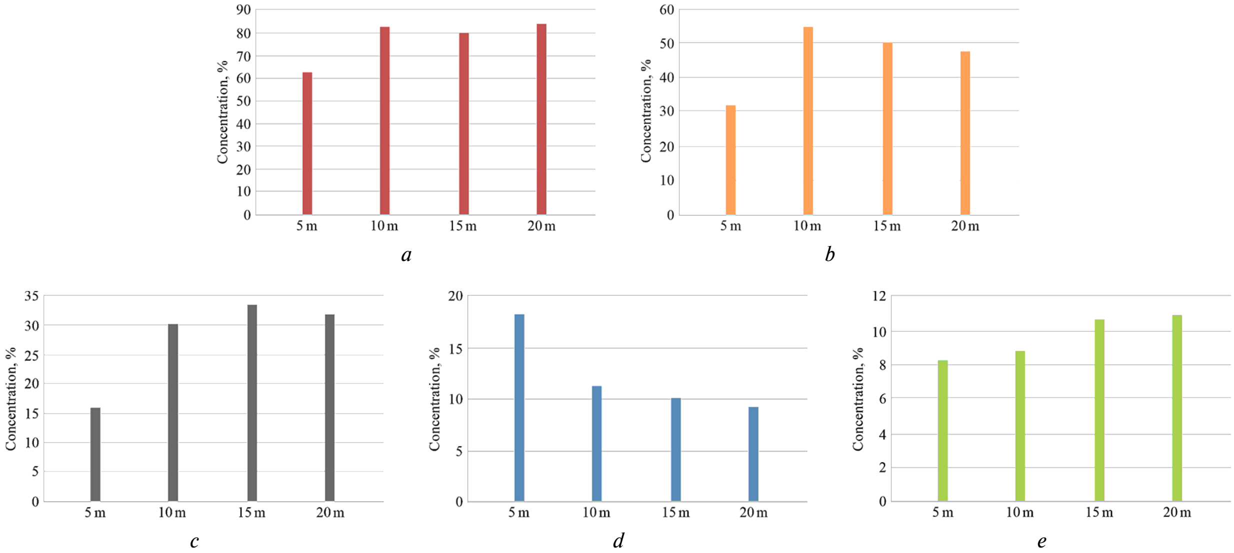

Fig. 2. Concentration of heavy metals and carbon in the SDI area

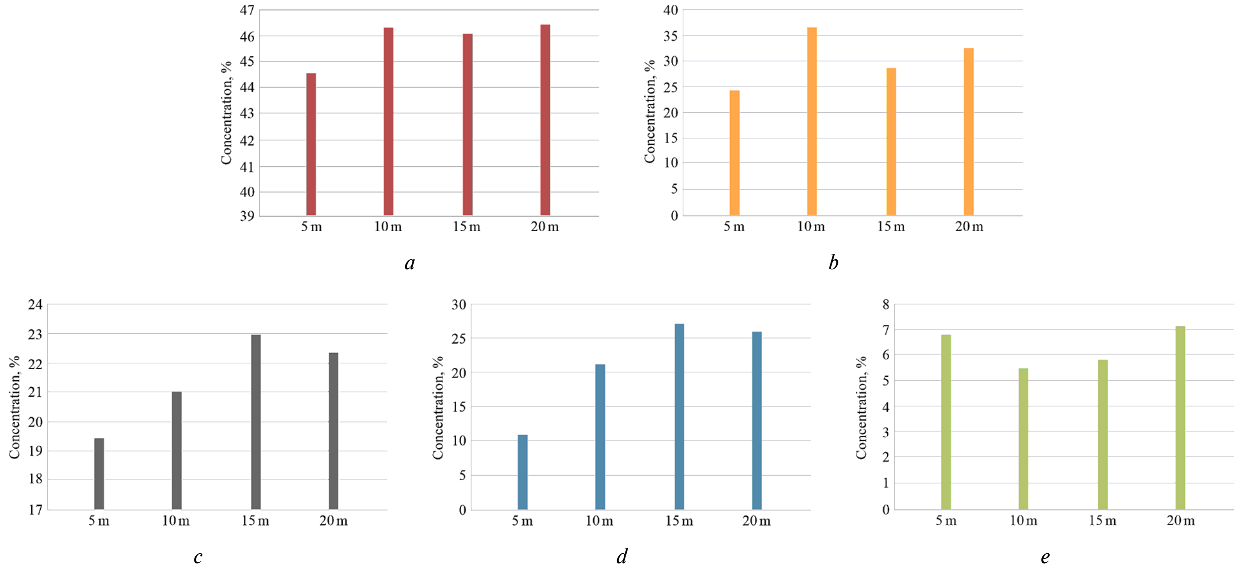

Fig. 3. Concentration of heavy metals and carbon in the industrial area

The Sikak area presented the lowest Cd concentration of 8.4 ppm in the soil of Site 7 near the pollution source, whereas the highest Cd concentration reached 10.1 ppm at Site 17. The permissible limit for environmental pollution is 0.99 ppm according to the US-EPA. The trend indicates that soil pollution due to Cd, whose range was from the lowest to the highest concentrations in this study, was caused by pollutants emitted by engines (Fig. 4).

The lowest Fe concentration was 29 ppm at Site 7 near the pollution source, whereas its highest concentration was 58 ppm at Site 17 far from the pollution source. The values were higher than the permissible percentage of environmental pollution according to the US-EPA.

The lowest Pb percentage was 58 ppm in the soil of Site 16 near the pollution source, whereas the highest value was 90 ppm at Site 17 located farther from the pollution source. The permissible proportion is 35.8 ppm for environmental pollution according to the US-EPA. The trend verifies the increased pollution due to Pb in the sampled soils. Moreover, the Pb values were higher than the allowable limit for environmental pollution as prescribed by the US-EPA.

The lowest Cu concentration was 11 ppm in the soil of Site 17 near the pollution source, whereas the highest concentration was 29 ppm at Site 16, which is distant from the pollution source. The values were higher than the US-EPA's permissible limit for environmental pollution.

The lowest carbon concentration was 17.3 % in the soil of Site 7 near the pollution source, whereas the highest concentration was 30.6 % at Site 17 located farther from the pollution source. The pollution trend appears to gradually increase with distance; that is, pollution is less likely in areas near the source, but carbon rises and falls to the ground where its concentration is higher at farther distances (US Environmental Protection Agency Standards for the Use or Disposal of Sewage Sludge, 1993).

The Al-Muthanaa region presented the lowest Cd concentration at 7.3 ppm in the soil of Site 6 near the pollution source, whereas the highest concentration reached 9.2 ppm at Site 13. The US-EPA's allowable limit for environmental pollution is 0.99 mg/kg. The trend indicates that soil pollution due to Cd, whose range was from the lowest to the highest concentrations in this study, was caused by pollutants emitted by engines (Fig. 5).

The lowest Fe concentration was 25 ppm at Site 6 near the pollution source, whereas the highest concentration was 37 ppm at Site 14 far from the pollution source. The values were higher than the permissible percentage of environmental pollution according to the US-EPA.

The lowest Pb percentage was 40 ppm at Site 12 near the pollution source, whereas the highest value was 44 ppm at Site 6

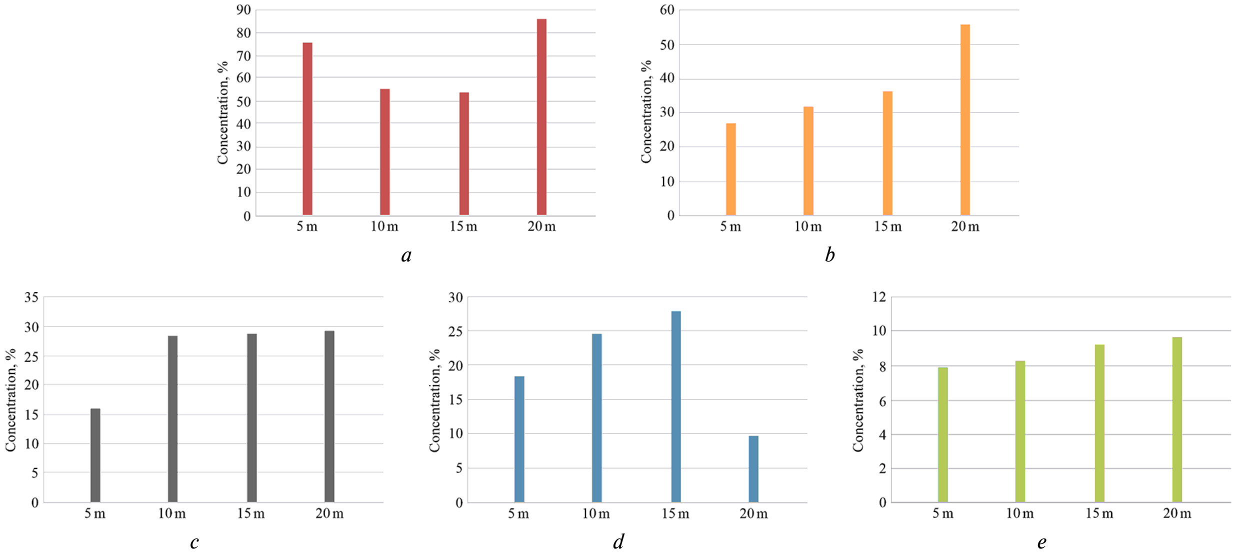

Fig. 4. Concentration of heavy metals and carbon in the Sikak area

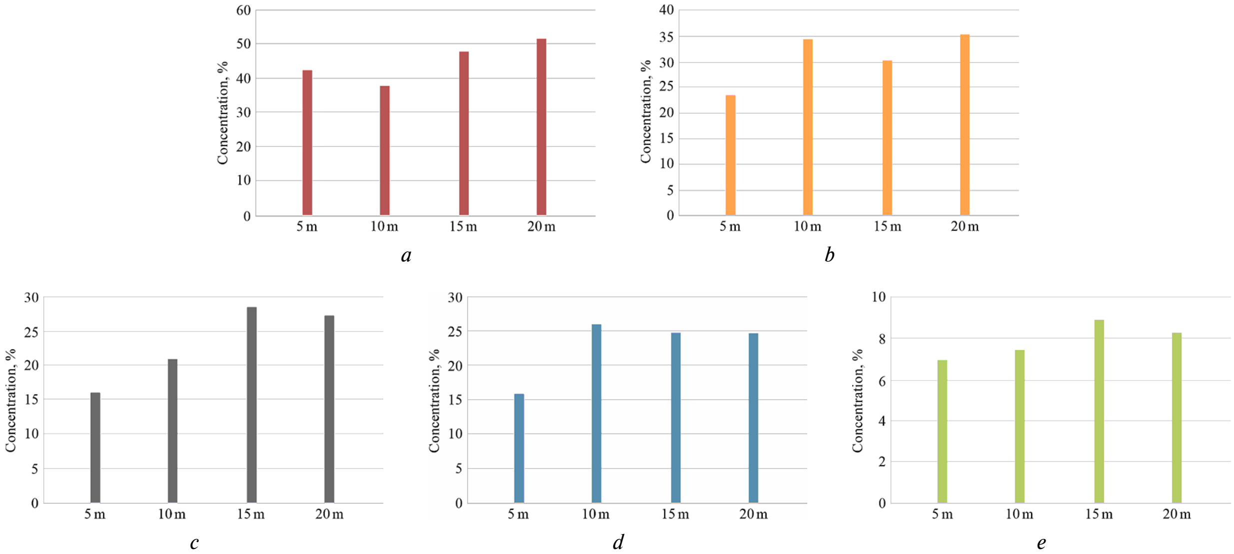

Fig. 5. Concentration of Heavy Metals and Carbon in the Al-Muthanna area

located farther from the pollution source. The permissible proportion of environmental pollution according to the US-EPA is 35.8 ppm. Thus, the pollution caused by Pb in the sampled soils exceeds the allowable limit for environmental pollution.

The lowest Cu concentration was 17 ppm in the soil of Site 6 near the pollution source, whereas the highest concentration was 27 ppm at Site 12, which is distant from the pollution source. The values were higher than the permissible limit for environmental pollution according to the US-EPA.

The lowest carbon concentration was 17.5 % in the soil of Site 6 near the pollution source, whereas the highest concentration was 29.6 % at Site 13 located farther from the pollution source. The pollution appears to be gradually increasing; that is, pollution is less likely in areas near the source, but carbon rises and falls to the ground where its concentration rises at a farther distance (US Environmental Protection Agency Standards for the Use or Disposal of Sewage Sludge, 1993).

Conclusions. The quantities of heavy metals in polluted soil rose the farther one traveled away from the source of contamination, according to this study. Where there is little pollution in the immediate vicinity of the source due to the rising of engine smoke, heavy metals descend to the ground and have an influence on a significant number of dwellings. It was evident and prominent around these generators, where the contamination caused by cadmium and lead concentrations was known.

Copper and iron concentrations were higher than those according to the US Environmental Protection Agency's pollution guideline. Carbon concentrations rise as one gets further away from the source of pollution, similar to metal concentrations. As a result, the effects of heavy metals must be investigated in various locations, as well as the effects of distance from pollution sources (such as electric power generators) to demonstrate the amount to which these pollutants reach residences in the vicinity of these engines, which must be located far from the population.

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Підвищення концентрації важких металів у ґрунтах поблизу електрогенераторів у місті Самарра (Ірак)

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Мета. Визначення рівнів концентрації різних важких металів і вуглецю у ґрунтах чотирьох районів міста Самарра, що знаходяться поблизу джерел забруднення (електрогенераторів).

Методика. Із джерела забруднювача відбиралися проби на відстані 5, 10, 15 та 20 метрів. Потім визначалися концентрації заліза (Fe), свинцю (Pb), міді (Cu), кадмію (Cd), а також вуглецю.

Результати. Визначено, що концентрації заліза й міді знаходяться в межах допустимих, що встановлені Агентством з охорони навколишнього середовища США. Проте забруднені кадмієм і свинцем ґрунти за концентрацією перевищують допустимі межі. Концентрація металу збільшується з віддаленістю від джерела. Концентрація металу низька на відстані 5 м від джерела забруднення, потім зростає на більшій відстані. Причому метали виявляють у ґрунтах на відстані 10 м, потім їх концентрація ще більше зростає на відстані до 20 м. Концентрації металу й вуглецю на відстані 20 м найбільші.

Наукова новизна. У цьому дослідженні визначено рівень концентрації забруднюючих речовин важких металів, а також вплив відходів виробництва електроенергії на мегаполіс. Згідно з дослідженням, концентрація цих компонентів зростає навколо виробників електроенергії.

Практична значимість. Концентрації важких металів у ґрунтах збільшуються в міру віддалення від джерела забруднення.

Ключові слова: *важкі метали, ґрунт, електрогенератори, мідь, кадмій, свинець, залізо, вуглець*

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