Evaluation of (Ni, Cr, Cu) Concentration in the Soil of Diyala Utilizing GIS Techniques

Jaafar S. Muhammad¹, Kareem A. Jasim², Auday H. Shaban³,⁴a)
¹Department of Physics, College of Science, University of Diyala, Iraq.
²Department of Physics, College of Education, Ibn Al-Haitham College of Sciences, Pure, University of Baghdad, Iraq.
³College of Science, University of Baghdad, Iraq.
⁴auday.h.s@ihcoedu.uobaghdad.edu.iq

Abstract. The investigation of pollution’s elements became the hot topics for the researchers. The current work aims to evaluate the concentration of some heavy elements Copper, Nickel, and Chrome (Cu, Ni, Cr) respectively. The study area of this research is Diyala province / Iraq. The base approach for this work is collecting 25 samples of soil to be studied. The samples were collected from (industrial, residential, agricultural) areas, with an average sample rate for each region with a depth (20 cm). After collecting the samples, they were sorted and compressed to prepare them for measurement by dispersive X-Ray Fluorescence. Analysis after obtaining the results, they are compared with the global determinants (WHO). Through these results, we find that a noticeable increase in the element (Ni) in Aleazim corking Khanaqin, Al-Rashidiya and Mohammed Sakran, while the highest concentration of (Cr) was recorded in jadidat alshat, Najana, Al-Rashidiya and Diyala Bridge. The (Cu) concentration was recorded high in the Aleazim Dam regoin, Aleazim, Muqdadiya, hayi Mezid, Al-Khalis, Rashidiya, Mohammed Sakran and Diyar Bridge. The residential and industrial areas were indicated an increasing in concentration of the investigated elements, while the areas with good vegetation have the lowest concentrations of these elements.

Keywords: Cu, Ni, Cr, heavy metals, soil.

Introduction

The general meaning of heavy elements are those elements with a density greater than (5g/ cm³) [1]. Soil in many regions of the world is exposed to pollution by toxic heavy elements as a result of human activity in many areas, especially industry and agriculture, adding phosphate fertilizers, manufacturing and mining. These activities are a great source of air pollution that loaded the air particles with heavy elements, so these particles are deposited directly on the soil surface, then by rain it will transported into the soil. The soil pollution is affected on the plants that been cultivated in this area. The pollutant elements are enter the plants which will be harvested to get into the food chain, and that increases the risks to human health [2].

There is an element of nickel (Ni) in the earth's crust at a rate (50 ppm). It is one of the eighth elements in the periodic table after iron and cobalt. Ni is a metal with a silver-white glossy color and an atomic number of 28 and atomic weight 58.6934 and a boiling point of 2730 ° C and a melting point of 1455 ° C and a specific density of 8.9 g / cm³. Nickel has oxidation states (4+, 3+, 2+, 0, -1) but the more common oxidation state is Ni²⁺. The other characteristics of the nickel is polished, malleable, well conducting for heat and electricity, and have a resistant to corrosion. Also, nickel metal possesses ferromagnetic properties and that nickel powder are flammable when interacts with air.
Exposure to nickel lead to inflammation of the nasal cavity, bronchitis, and decreased lung function, shortness of breath, lung cancer, and paranasal sinuses and cause respiratory damage [4]. There are many ways that Ni affects the humans, such as drinking water, eating foods, inhaling cigarettes smoke and air that containing nickel from waste fuel combustion and industrial activities.

Chromium (Cr) is present in the earth's crust (100 ppm) which is a metal with a bright white color, solid, brittle, and corrosion-resistant. It has atomic number 24 and atomic weight 51.9961 g/mol, its density is 7.18 g / cm³. The boiling point is 2670 °C, and its melting point is 1860 °C, [5]. Chromium is found in nature, either in the form of chromium (single) or as it is bound with other minerals to form the positive hexavalent chromium ion (Cr⁶⁺). The hexavalent chromium ion has the ability to penetrate tissues more than the trivalent chromium ion (Cr³⁺) [6]. Chromium is used in the industry of Stainless Steel, also is used as a wood preservative and a fungicide, and is used as a (sterile) substance in the field of medicine. The triple chromium ion is used as a catalyst and a force agent in the tanning industry [6]. Chromium is found naturally in rocks, soil, plants, animals, and volcanic gases, and from burning oil, coal, and burning garbage [5]. Inhalation of dust containing chromium and the resulting from the plants leads to severe damage to the nasal tissue, which leads to perforation of the nasal septum. Also, the vapors of chromium metal are harmful as they cause asthma, shortness of breath and coughing and lead to lung injury, as well as inhaling large amounts of chromium dust Lead to lung tumors [7].

Copper (Cu) is found in the Earth's crust (20 ppm). Atomic number 29, and atomic weight 63.54 g/mol, density 8.55g/cm³, melting point 1083 °C, and boiling point 2310 °C. This element found individually or in the form of oxides, purified by electrolysis. The copper properties are soft, malleable, interacts with the atmosphere to forming a type of rust known as copper oxide, which is green. It is a toxic substance, and copper is generally slow to react with dilute acids. Conversely, exposure to high levels of copper can lead to a number of harmful health effects. Human exposure to copper occurs mainly from the consumption of food and drinking water. Some members of society may be more susceptible to higher negative effects from copper due to genetic predisposition or disease [8]. Excessive human accumulation of copper may lead to irritation and erosion of the mucous membrane, damage to the liver, kidneys, central nervous system, irritation of the digestive system and possible necrotic changes and may occur in the liver and kidneys [9]. Table (1), represents the general permissible limit for the presence of elements (Ni, Cr, Cu) in the soil of WHO [10].

| WHO(mg/kg) | Ni | Cr | Cu |
|-----------|----|----|----|
| 50        | 100| 20 |

**Table 1. (WHO) limits for (Ni, Cr, Cu) concentration**

Geographic Information Systems (GIS)

It is the science that is defined by collecting, processing and analyzing spatial data. There are several programs used for geographic information systems, including those that operate on a directional information system such as ArcGIS and that operate on a cell system such as ERDAS. The trend system is more suitable for storing high-precision data such as ownership and boundary maps, so it is preferable in these cases to choose programs that run on the vector information system [11, 12].

Interpolation

Spatial interpolation is the process of using points with known values to estimate values at other unknown points. For example, to create a precipitation map for a country, you won't find enough weather stations to cover the entire region. Spatial interpolation can estimate temperature at locations without data recorded using temperature readings known at nearby weather stations calculated using internal interpolation. In GIS, spatial interpolation of these points can be applied to create a vector surface with estimates values. The results of the interpolation analysis can then be used for analyses the whole area and for modelling. There are many methods for implementation in ArcGIS. Inverse Distance Weight (IDW) interpolation method, is one of many methods of interpolation. The sample points are weighted during interpolation such that the influence of one point relative to another declines with distance from the unknown point you want to create [13, 14].

Study Area

Diyala Governorate is located to the east of central Iraq as shown in figure 1. Iraq located with the zone-38N with respect to UTM projection. The provinces have international borders with Islamic Republic of Iran. Sulaymaniyyah, Salahuddin, Baghdad and Wasit provinces are surrounding the study area. The governorate is famous for the Hamrin Mountain. It extends (44.27728 to 46.03448) eastern and (32.953 to 35.085) northern. On the basis of this location, the governorate occupied an area of (17774 km²). Diyala locate at 57km to the north of Baghdad [15].
Modeling and working methods

The work in the current study is divided into three phases: the first stage is the field work to collect the samples through a borehole instrument. Table (2), illustrated the location were the samples collected.

| ID | Location name       | East    | North   | Elevation m |
|----|---------------------|---------|---------|-------------|
| 1  | kalar               | 45.32916| 34.57248| 835         |
| 2  | mandhiria           | 45.4333 | 34.20412| 656         |
| 3  | Aleazim Dam         | 44.55443| 34.53553| 470         |
| 4  | injanah             | 44.60147| 34.42877| 289         |
| 5  | khaniqin            | 45.27905| 34.2664 | 815         |
| 6  | Aleazim             | 44.5172 | 34.20332| 248         |
| 7  | khan oil            | 45.35477| 34.17022| 747         |
| 8  | Alnay               | 44.54785| 34.054  | 188         |
| 9  | Hamrin Hills        | 45.06267| 34.06082| 458         |
| 10 | almqladay           | 44.9569 | 33.9823 | 155         |
| 11 | Imam Wes            | 45.14028| 33.9359 | 187         |
| 12 | hay mazid           | 44.741  | 33.80382| 124         |
| 13 | mandeley            | 45.54053| 33.74133| 373         |
| 14 | Canaan              | 44.7976 | 33.6936 | 127         |
| 15 | cintar beqwb        | 44.61293| 33.7459 | 101         |
| 16 | alkhalis            | 44.52183| 33.84487| 102         |
| 17 | jadidat alshat      | 44.4009 | 33.68145| 87          |
| 18 | Rashidiya           | 44.4148 | 33.6878 | 84          |
| 19 | Mohammed sakran     | 44.45653| 33.56708| 91          |
| 20 | almaemil            | 44.525  | 33.4947 | 99          |
| 21 | qzanyh fend         | 45.50671| 33.2367 | 151         |
| 22 | qzanyh cinter       | 45.54952| 33.65292| 250         |
| 23 | Baldrooz fatmyh     | 45.1333 | 33.5044 | 144         |
| 24 | diyala bridge       | 44.5184 | 33.2326 | 73          |
| 25 | almadayin           | 44.5803 | 33.0968 | 95          |

The second stage is the laboratory that consists of preparation of the samples, measurements, and analysis. The third stage is the spatial information processing, which estimate the concentrations at the entire area. 25 soil samples were
collected from Diyala governorate at a depth of 20 cm. These samples were taken from many regions (industrial, residential, agricultural). The samples were configured by numbering the nylon bags that consists of the samples. Then the samples were transferred to the laboratory for the purpose of preparing them for measurement to and study heavy elements (Cr, Cu, Ni). The work’s procedure were summarize by drying the samples in the sun for several days. Then grinding the samples separately: very fine grinding using a ceramic mortar for two hours. The soil samples were compressed using a hydraulic press, and finally the concentration of heavy elements in the samples were examined using the X-Ray Fluorescence (XRF) [16-20].

Results and discussion

The results gained from the XRF are the concentrations of each elements in the samples. These data were illustrated in table 3. The results shows the variations of the presence of the elements at different locations. The variation of the concentration is a reflection of the pollution degree in that area due to the presence of industrial activities or any human activities.

| ID | Ni ppm | Cr ppm | Cu ppm |
|----|--------|--------|--------|
| 1  | Nill   | Nill   | Nill   |
| 2  | Nill   | 78.719 | Nill   |
| 3  | 72.026 | 86.010 | 35.301 |
| 4  | 36.022 | 120    | Nill   |
| 5  | 52.154 | Nill   | Nill   |
| 6  | 42.325 | 89.233 | 31.051 |
| 7  | Nill   | 52.010 | Nill   |
| 8  | 41.698 | 100    | Nill   |
| 9  | 37.057 | 100    | Nill   |
| 10 | 46.822 | 59.747 | 49.645 |
| 11 | 31.535 | 100    | Nill   |
| 12 | Nill   | 65.578 | 36.956 |
| 13 | Nill   | 78.559 | Nill   |
| 14 | 41.778 | 69.830 | Nill   |
| 15 | Nill   | 49.226 | Nill   |
| 16 | Nill   | 55.561 | 25.787 |
| 17 | 50.373 | 140    | Nill   |
| 18 | 60.063 | 130    | 28.398 |
| 19 | 73.540 | 75.184 | 30.305 |
| 20 | Nill   | 88.307 | Nill   |
| 21 | 44.662 | 72.320 | Nill   |
| 22 | 52.506 | 74.540 | Nill   |
| 23 | 34.655 | Nill   | Nill   |
| 24 | 39.858 | 110    | 37.289 |
| 25 | Nill   | 64.518 | Nill   |

The geographic information analysis provides the ability to estimate the variables all over the studied area by using interpolation functions. There are many methods of interpolation, such as Kriging, Global polynomial, Local polynomial, Inverse Distance Weight (IDW), etc…. The IDW interpolation method was chosen to be applied on the collected data. Figure 2 represents the estimate concentration of nickel at the studied areas. Through the estimation map it will be considered the area of each class by utilizing contour procedure in ArcGIS software.
The highest concentration of nickel was recorded in the area of Mohammed Sakran (73 ppm), Aleazim Dam region (72ppm), Baquba and Khanaqin, it was recorded (52ppm), but in Rashidiya, it was recorded (60ppm). The reason for the rise of an element of Nickel in these areas is due to the formation nature of the land, as well as the reason for throwing industrial waste containing nickel waste.

The highest Concentration (Cr) were recorded in jadidat alshat which reached (140 ppm), while in Rashidiya (130 ppm), and in Anjana (120 ppm), were recorded in Diyala Bridge (110 ppm), and these four regions are high compared to the (WHO) Organization. The adult (100 ppm) as for the rest of the regions, the concentration of chromium was within or less than the required level as shown in Figure 3, which indicates the presence of chromium in the study area. Most of the areas that recorded the height of the Chromium element are agricultural areas and contain a good vegetation cover, watering of these lands by the Tigris and Diyala rivers. The height of the Chromium element in these lands is due to the excessive use of chemical fertilizers that contain this element.
Figure 3. Distribution of Cr concentration.

The highest in copper height was recorded in the Aleazim Dam, where it reached (35 ppm), in the bone, it was recorded (31 ppm), in Muqdadiya, (49 ppm), in the hayi Mezid recorded (36.956ppm), in Rashidiya, it was recorded (28.398 ppm), and Mohammed Sakran (30.305ppm), and the highest rise was recorded in Diyala Bridge (37,289 ppm). As for the rest of the regions, there was no copper presence and copper (Figure 4) representing the copper sites and concentrations in the studied areas. Copper increases in territories where the PH is less than 7, relatively few in 8 - 7 PH, and the deficiency becomes severe in PH more than 8. It also increases the copper to the presence of fertilizers that contain a higher copper concentration.

Figure 4. Distribution of Cu concentration.
Conclusion
Low concentration of most heavy elements in depth (20 cm), indicating that there is no movement and transmission of these elements across the soil layers. showed that soil samples were contaminated with nickel as it reached (73,540) compared to the permissible limit (50 parts per million) in the area of Muhammad Sakran and the highest concentration of chromium as it reached (140 parts per million) compared to the limit allowed by the World Health Organization (100 ppm) in a new region, the highest concentration of copper in the Muqdadiya region, where it reached (49,645 ppm) compared to the allowable limit of the World Health Organization (20 ppm).

The soil is mostly contaminated with chromium, nickel and copper due to the use of agricultural pesticides and fertilizers the chemical contains these elements. The reason for the rise of an element of chromium in these areas is due to the formation nature of the land, as well as the reason for throwing industrial waste.

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