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Estimation and Study of Contamination by Elements (Ni, Cu, Mg, Sn) in Dust of Areas Near Fuel Stations in Najaf Governorate

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Abstract

The research focused on studying and determining the levels of pollution in dust collected from various stations in the city of Najaf near fuel situations represented by four Fuel Situations (Soor Alnajaf Situation, Reebal Situation, Alkarar Situation, and Alqudus Situation). For this, we selected four situations for the current study to determine the levels of pollution and compare them with the internationally permitted levels of elements (nickel, copper, and magnesium). Air pollution is one of the most dangerous types of pollution because it is difficult to control and address. However, air pollution has recently become a focus of attention as one of the most serious environmental problems facing the world, given its importance to our lives. Scientific studies and literature related to the concentration of heavy metals have focused on many important aspects of scientific research and have identified the role of industrial pollutants and smoke from fuel stations in increasing the concentration of many toxic heavy metals. To reduce this pollution, numerous studies have been conducted to investigate the relationship between the concentration of heavy metals and many common diseases resulting from heavy metal pollution. To determine the concentration of heavy metals (Ni, Cu, Mg) in dust samples, we used a method to analyze and detect the concentration of metals in dust.

Keywords: Heavy metal contamination, dust pollution, fuel stations, Najaf Governorate, nickel, copper, magnesium, air pollution

INTRODUCTION

Heavy metals are mixed and present for long periods in the dust surrounding fuel stations as a result of dust particles being carried into the air by fuel stations and reaching neighboring areas. Contamination also occurs from fuel leaking from fuel stations onto the ground. Due to climatic factors and high winds, these polluting elements are transported to neighboring areas, groundwater, and surrounding environments [1, 2]. They appear as suspended colloids or are fixed by organic or mineral particles. Dissolved ketones of heavy metals are easily attracted and retained by clay, organic compounds, iron and manganese hydroxides, and other minerals or carbonates. Therefore, they accumulate on surface sediments or are absorbed by aquatic plants. Therefore, their concentration in surface sediments or in plants is evidence of water pollution by these elements, as sediments act as a potential source of pollution in the environment, acting as both a carrier and a reservoir [3].

Heavy metals are transported by wind from fuel station areas to neighboring areas, which has a significant impact on the pollution of water tanks and soil in areas near these stations, as well as the pollution of residential areas, agricultural crops, food, and the environment in general. These heavy

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metals enter the natural cycle and move between parts of the environment and its living and non-living components. Their molecules in the air are subjected to a dilution process due to their vertical and horizontal dispersal, concentrating them until they settle on the ground and contaminate the soil and water. This leads to their concentration in the aquatic environment through living organisms, from where they are transferred to other organisms in the water and on land [4–6]. Their concentration reaches its highest levels in animals at the top of the food chain, especially humans. Human poisoning by heavy metals occurs because of their direct entry into the body through air, water, or food as biochemical compounds, or by their accumulation in the human body at low concentrations over long periods of time (occupational poisoning) or exceeding the permissible concentrations (accidental entry at very high concentrations) [7–9].

EXPERIMENTAL PART

Collecting Soil Samples from Areas Near Fuel Stations

Samples were collected from four areas near fuel stations in Najaf in dry polyethylene containers (Figure 1). Digestion was performed to measure the percentages of remaining element ions (Ni, Cu, Mg, Sn) in the samples from four Fuel Situations (Soor Alnajaf Situation, Reebal Situation, Alkarar Situation, and Alqudus Situation). 20 ml of deionized distilled water was added to the sample to eliminate traces of exchanged elements and the acid used. The samples were then centrifuged at 2000 rpm for 20 min to remove the wash water. The sediment was then transferred quantitatively to a Teflon beaker, avoiding any loss of the sediment. The test tube was then rinsed several times with deionized distilled water to remove any sediment residues adhering to the tube walls. The wash water was then added to the beaker containing the sample. The sample was evaporated until almost dry at 20°C. 5 ml of a mixture of concentrated nitric and hydrochloric acids was then added to the sediment (1:1), and evaporated at 20°C until almost dry. Then, 2 ml of a mixture of hydrochloric acid (HCl) and perchloric acid ($HClO_4$) was added in a ratio of 1:1. After that, the solution was evaporated until almost dry. The precipitate was dissolved in 30 ml of hydrochloric acid (0.5 N). The solution was left for 10 min, after which it was separated by centrifugation for 30 min at a speed of 2000 rpm. The solution was placed in a volumetric flask (36 ml). The precipitate was washed twice with deionized water. The rinse water was added to the volumetric flask after the precipitate was separated. Then the volume was completed to 36 ml and the solution was placed in clean, labeled plastic bottles for examination with a flame atomic absorption spectrometer [8–11].

Heavy Element Ion Measurement in Samples

Four Soil samples from four areas near fuel stations in Najaf were collected to measure the percentages of remaining element ions (Ni, Cu, Mg, Sn) in the samples. Heavy element ions were measured in the studied samples using a Shimadzu (Flame Atomic Absorption Spectrophotometer)-7000AA after standard solutions of the tested elements were prepared to determine heavy metals (Figure 2). The solution was passed through an atomic absorption spectrometer, after which a graph representing concentration versus absorption was obtained. This graph is used by the device to read the concentrations of metals (lead and zinc) in the dust samples to be measured, which were prepared as mentioned earlier. The result obtained is the concentration of the elements in the studied sample, estimated in ppm. The solution was passed through an atomic absorption spectrometer, after which a graph representing concentration versus absorption was obtained [12–15]. This graph is used by the device to read the concentrations of metals in the dust samples to be measured, which were prepared as mentioned earlier. The result obtained is the concentration of the elements in the studied sample, estimated in ppm.

Calculating Heavy Element Concentrations

Heavy element concentrations were calculated from the calibration curve, by graduated concentration solutions to determine the percentage of pollution.

Electrical Conductivity

Electrical conductivity was measured using a HANNA conductivity meter after calibration with standard solutions. The results are expressed in microsiemens/cm.

Figure 1. One of the selected fuel stations.

Figure 2. Flame atomic absorption spectrometer.

RESULTS AND DISCUSSION

Determination of Heavy Metals Concentrations in Selected Samples

Flame atomic absorption spectroscopy is a well-known technique for determining metal concentrations in environmental samples. It is also an easy-to-use technique. In this technique, thermal energy is sufficient to separate chemical compounds into free atoms. Under proper flame conditions, most atoms remain in their lowest state and are able to absorb light within the wavelength of analysis. The ease and speed of determining element concentrations make atomic absorption spectroscopy one of the most common methods for metal analysis [16–19]. The concentrations of heavy elements (Ni, Cu, Mg, Sn) were estimated using a flame atomic absorption spectrometer at wavelengths 250, 246, 240, and 262 nm, respectively. Standard solutions were prepared by serial dilution of the Stock solution of the standard materials. Selectivity in AAS is very important, as each element has a different set of energy levels, resulting in very narrow absorption lines. Therefore, choosing the right monochromator is vital to obtaining a linear calibration curve (Beer's Law). The bandwidth of the absorbed species must be wider than that of the light source, which is difficult to achieve with a conventional monochromator [20]. The monochromator is a very important part of the AAS spectrometer because it is used to separate the thousands of lines generated by each of the elements in a sample. The monochromator is used to select the specific wavelength of light absorbed by the sample and exclude other wavelengths. Choosing the specific wavelength of light allows the specific element to be identified when other elements are present. The light selected by the monochromator is directed to a detector, and the photomultiplier tube converts the light signal into an electrical signal proportional to the light intensity. The flame atomic absorption technique requires liquid samples that are transformed into a mist and mixed with combustible gases, such as acetylene-air or acetylene-nitrogen oxide [21–24]. The flame ignition temperature ranges from 2811 to 2111°C. During combustion, the atoms of the element under study are transformed into free, unexcited atoms as they drop to the ground state. Light is absorbed at a wavelength specific to each element. To obtain the wavelength of the element under study, light is emitted from a lamp whose negative electrode is made of the element itself, and then passes through the flame [25–28]. Using a photomultiplier, the amount and intensity of the absorbed element can be measured from the solution. This is directly related to the concentration of the element in the sample (Table 1, Figures 3–6).

Table 1. Assessment of concentrations of heavy metals in selected fuel situations by flame atomic absorption spectrometry.

Fuel situations	**Concentration of heavy metals (ppm)**			
	Ni	***Cu***	***Sn***	***Mg***
Fuel Situation-1: (Alkarar)	6.27	7.97	9.22	6.93
Fuel Situation-2: (Reebal)	4.96	4.77	7.81	4.83
Fuel Situation-3: (Soor Alnajaf)	4.72	5.45	6.02	6.17
Fuel Situation-4: (Alqudus)	5.38	7.11	7.92	6.78

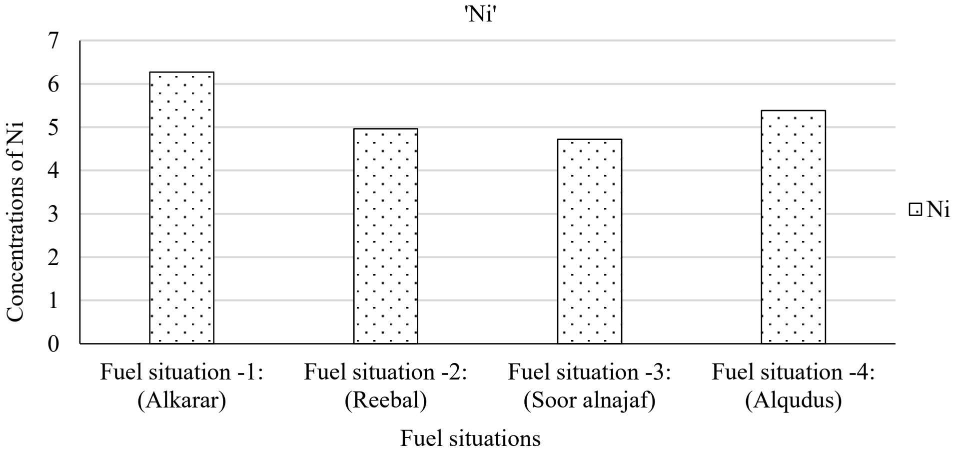

Figure 3. Concentration of Ni in fuel situations.

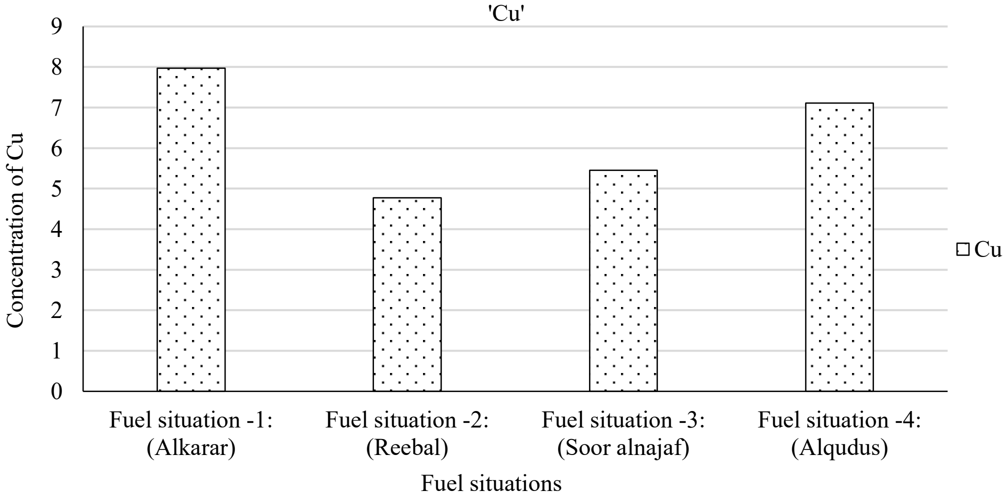

Figure 4. Concentration of Cu in fuel situations.

The results in Figures 3–6 show that heavy metals are an important class of pollutants that have lethal effects on living organisms. They have recently become environmentally harmful, as they have detrimental effects on the health of both humans and living communities in aquatic and terrestrial ecosystems, in addition to their impact on the properties of the ecosystem itself. These harmful effects of heavy metals result from their being highly toxic, non-degradable, and having a long biological half-life [29–31]. They also have the potential to bioaccumulate in various parts of the body. The entry of these elements into the body in quantities exceeding the recommended limits leads to a state of poisoning resulting from the combination of these elements with biological molecules in the body, such as proteins and enzymes, forming stable toxic compounds that destroy the structure of these biological molecules and impede their function [32–35].

High winds also increase the extent of pollution resulting from human activity at the fuel station, due to its being an open area. Therefore, heavy elements spread more quickly than at other stations, increasing the pollution and its quality in the long term [36]. The type and composition of the sediments are indicative of the type and quantity of this pollution and the nature of its source, as a result of the gradual accumulation of these pollutants in the soil. The continuous accumulation of these elements in the sediments explains their presence in higher concentrations than in other areas far from fuel stations.

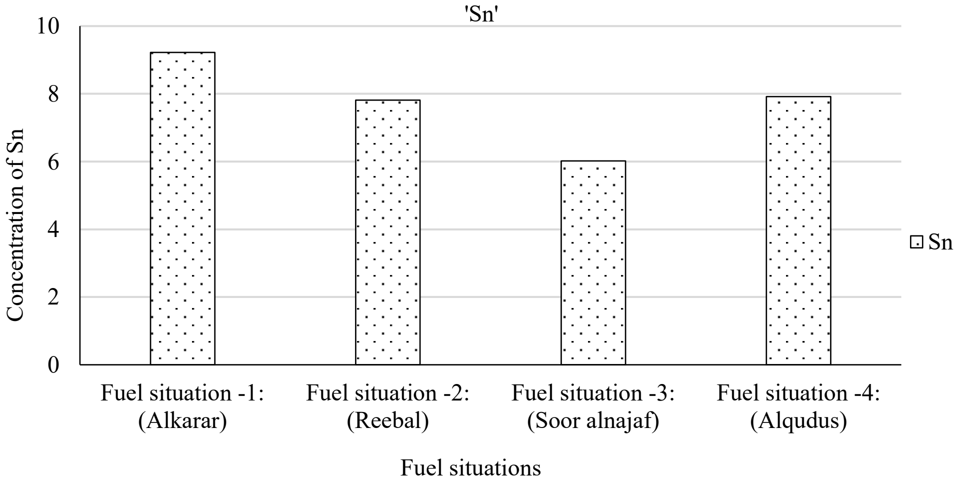

Figure 5. Concentration of Sn in fuel situations.

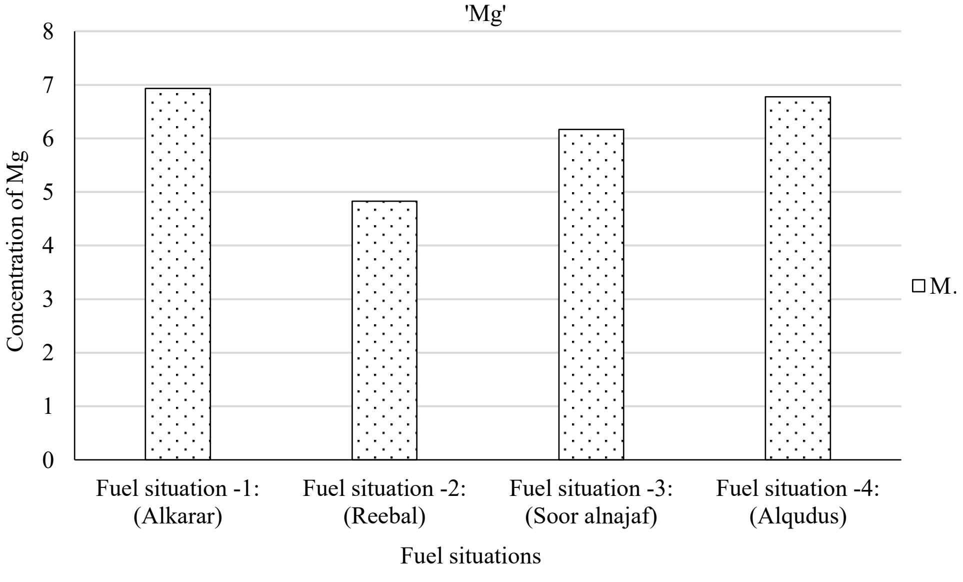

Figure 6. Concentration of Mg in fuel situations.

Studying the Effect of Temperature on Increasing Pollution by Elements and Other Factors

Although the concentrations of heavy metals in the soil and land adjacent to the fuel stations in the current study did not exceed standard specifications, a significant increase in the concentrations of tin and copper was found at Alkarar station. This may be due to the presence of tin in high concentrations, which causes an increase in the concentrations of these elements in the soil. This is due to the fact that it is a government fuel station that is not completely free of other metals. The concentrations of elements, especially tin and copper, in the dust samples taken from fuel stations were mostly high. Even when we compared them with the reference units for lead, we found that the values were very high in both periods [35]. As for magnesium, there was a difference, as it was high in the dust of the stations and low or equal to it in the other samples. Also, according to the pollution level index (CF), tin pollution was very high, while magnesium pollution was found to be moderate. From this, we can conclude that the reason for the high pollution in the dust is due to the presence of toxic elements in the fuel used for transportation, as one of the most important causes of pollution. This is in addition to the presence of a car refining plant and the location of these fuel stations in the city center. It is situated close to the main road and has various facilities, including factories, and is also near several gas stations.

Electrical Conductivity

Electrical conductivity was measured using a HANNA electrical conductivity meter after calibration with standard solutions. The results were expressed in microsiemens/cm. Electrical conductivity represents the total concentration of elements in the studied samples. It represents a measure of the ability of an aqueous solution to conduct electrical current. This ability depends on the presence of ions, their concentration, and temperature. Electrical conductivity is strongly related to the amount of ions and dissolved salts, as well as the amount of ions and heavy elements that precipitate from the soil components [36, 37]. It is an indicator of increased conductivity in the samples. The data is presented in Table 2 and Figures 7 and 8.

Table 2. Results of conductivity and pH of selected locations.

Fuel Situations	**Conductivity (dsm^{-1})**	**pH**
Fuel situation-1: (Alkarar)	9.88	7.92
Fuel situation-2: (Reebal)	6.24	7.54
Fuel situation-3: (Soor Alnajaf)	4.28	7.18
Fuel situation-4: (Alqudus)	8.36	7.86

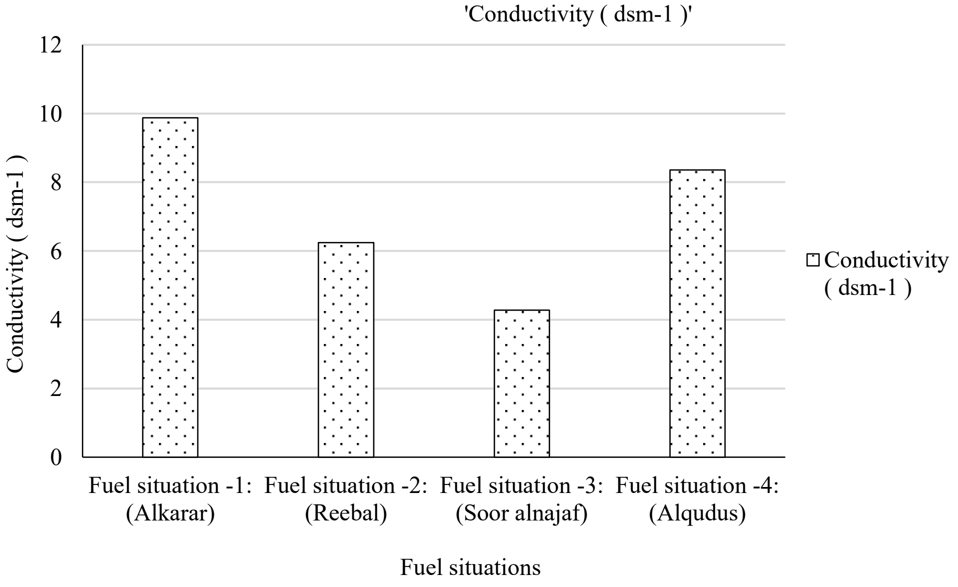

Figure 7. Electrical conductivity of samples (fuel situations).

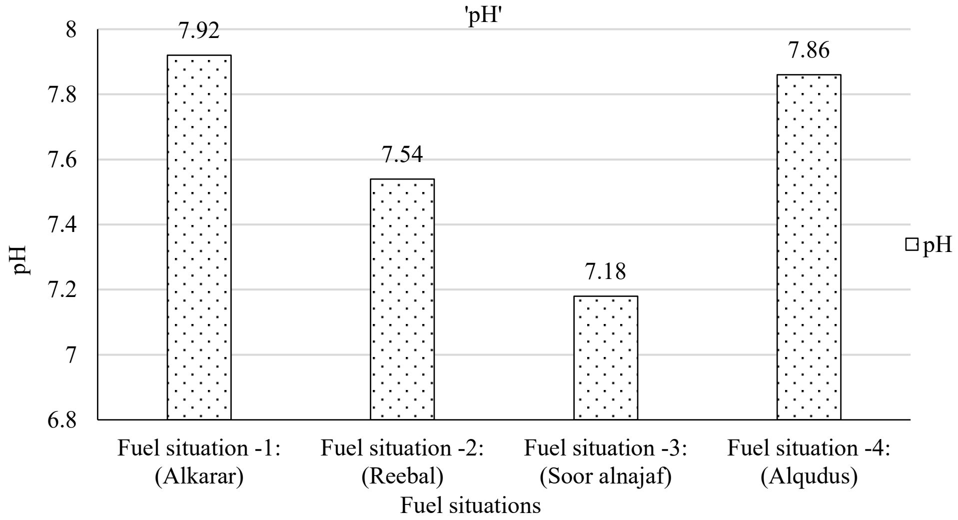

Figure 8. pH of samples (fuel situations).

CONCLUSION

Pollution from fuel station operating activities results in the following liquid waste: car wash water, used oils, spills, or leaks collected from the fuel station's paved floor. These are the main pollutants that can reach the wastewater runoff and potentially extend to groundwater. Monitoring activities include used oils, petroleum, grease, suspended solids, and hydrocarbons suspended in liquid waste. Fuel station monitoring activities should include quality control of normal waste and inspection of the resulting hazardous waste (used oils, solvents, gasoline, and engine fluids) to ensure they are properly treated off-site or disposed of in designated facilities. The way waste and hazardous materials are stored on-site should be monitored to ensure that they do not leak or contaminate soil and groundwater. This applies specifically to underground storage tanks for fuel products.

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