



## Detection of air pollution with copper and chromium in some crowded areas in Baghdad

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### ABSTRACT

Air pollution with heavy metals creates serious environmental and public health threats in rapidly urbanizing cities as a result of their bioaccumulation potential, persistence, and toxicity. This research study the seasonal differences of copper (Cu) and chromium (Cr) present in air in two selected crowded-traffic areas of Baghdad (Al-Bayaa and Al-Shurta Tunnel) and a light-traffic as control site. Samples of particulate matter was collected seasonally using Sniffer low volume sampler equipped with cellulose filters filter, digested with nitric and hydrofluoric acids, and analyzed by flame atomic absorption spectrometry FAAS. Statistical analyses evaluated spatial and temporal patterns.

Results showed marked seasonal differences, with notably higher Cu and Cr levels through the two seasons spring and summer ( $p < 0.05$ ), spatially at high traffic sites. The maximum Cu levels recorded 35  $\mu\text{g}/\text{m}^3$  in Al-Bayaa and 31  $\mu\text{g}/\text{m}^3$  in Al-Shurta Tunnel, while Cr showed maximum at 3.0 in Al-Bayaa and 2.8  $\mu\text{g}/\text{m}^3$  in Al-Shurta Tunnel. In several situations, measured levels were higher than World Health Organization WHO standards values, indicating potential health hazards. Increased concentrations were primarily as a result of heavy traffic activity, vehicle erosion processes including brake and tire degradation, and weather factors such as lower speeds of wind and higher temperatures.

An initial non-cancerous human health hazard evaluation, based on hazard quotients and hazard indices, suggested potential exposure problems. Although limitations associated with areal scope and absence of metal chemical forms, the research supplies important initial data. The results underscore the need for continuous air quality monitoring, effective emission control strategies, and urban planning policies to reduce pollution of heavy metal in heavy populated areas of Baghdad and others similar urban environments.

## 1. Introduction


Air pollution by heavy metal represents one of the most serious environmental challenges facing urban areas at the global level [1]. Fast, population growth, industrialization, and vehicular traffic increased have significantly contributed to the release of toxic metals into

the air [2]. Many heavy metals are cannot degradable by microorganisms and can stay in the environment for long time, causing serious dangerous to health of human and ecosystems [3,4,5].

Among the most commonly detected heavy metals in urban air are Copper and chromium.

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Cu is emitted from vehicle brake wear, some industrial activities and fuel combustion [6,7], while Cr comes from metallurgical processes, fuel combustion, and vehicle component wear [4,5,8]. Long time exposure to airborne heavy metal Cu and Cr has been associated with respiratory diseases, increased cancer risk, and oxidative stress [9].

In the capital of Iraq, Baghdad has experienced rapid urban expansion accompanied by a high increase in the vehicle numbers and heavy traffic [10]. Studies focusing on seasonal different of airborne heavy metals in Baghdad remain limited [10]. Therefore, this study aims to evaluate the levels of Cu and Cr in heavy traffic urban locations through different seasons and to compare the measured concentrations with international air quality limits [1].

## 2. Materials and Methods

### 2.1 Areas of study

Samples of air were collected from two high-traffic sites in Baghdad the first one is Al-Bayaa district and the second Al-Shurta Tunnel. As well as third site was selected as a control area with relatively low traffic. Site selection considered population density, wind direction, and traffic intensity [10].

### 2.2 Collection of air samples

Airborne particulate matter was collected using a low-volume air sampler (Sniffer, Rade Co., USA) operating at a constant flow rate [2,3]. Glass microfiber filters (Whatman, Grade D) with a diameter of 4.7 cm were used for sampling. Prior to sampling, filters were dried at 80°C for 15 minutes and weighed to obtain initial mass.

Air samples were collection through four seasons (autumn, winter, spring, and summer). Each sampling process lasted 60 minutes, and eight samples were collected from each site per season. At end of sampling, filters were sealed, then transported to the laboratory and reweighed to determine mass of particulate [2,3].

### 2.3 Digestion and Analysis of Sample

Filters that collected were cut into small parts and put in beakers that contained polyethylene. For digestion, a mixture of concentrated nitric acid (HNO<sub>3</sub>) and a limit drops added of hydrofluoric acid (HF). Then heated the samples in a bath of water at 60°C for 24 hours. Then filtered and diluted digested solutions to 50 mL using deionized water [2,3],

Levels of Copper Cu and chromium Cr were determined by using flame atomic absorption spectrometry FAAS following protocols of standard analytical. Calibration was performed using certified standard solutions. Blank samples were analyzed to ensure quality control.

### 2.4 Metal Levels Calculation

Concentrations of metals in the air were calculated by using the equation below [2]:

$$\text{Concentration } (\mu\text{g}/\text{m}^3) = (C * V_i) / V_t$$

In which C represents the concentration of metal in solution ppm, V<sub>i</sub> denotes the digested sample of final volume 50 mL, and V<sub>t</sub> defined the total volume of air sample m<sup>3</sup>.

### 2.5 Analysis of Data

Summary statistics including (mean ± standard deviation) for all determined metal levels were analyzed. One-way analysis of variance ANOVA was used to analyze periodic changes in Cu and Cr concentrations at each sampling area. Independent sample t-tests were utilized to assessed local differences among crowded traffic and control areas light traffic. Statistically meaningful was set at p < 0.05. All analyses were conducted by standard statistical procedures widely utilized in environmental investigations.

### 2.6 Quality Assurance and Quality Control (QA/QC)

Quality assurance and quality control protocol were conducted during collection of samples and analysis. Field control samples and laboratory blanks were studied to evaluated

potential pollution. Instrument calibration was performed using certified standard solutions previous to analysis. The standards of detection LOD and standards of quantification LOQ for Cu copper were calculated according to three times the standard deviation of control measurements, while chromium Cr were calculated according to ten times the standard deviation of control measurements. Mean recovery quantities varied between 90–105%, showing adequate evaluative precision. Evaluated inaccuracy was kept in  $\pm 10\%$ .

### 3. Human Health Risk Assessment

To evaluate possible inhalation exposure to Copper Cu and chromium Cr, an

initial non-cancerous health hazard evaluation was conducted. The hazard quotient HQ for each metal was conducted as the ratio of the calculated exposure level to the related reference concentration suggested by Environmental Protection Agency EPA. The hazard index HI was gained through adding HQ values for Copper Cu and chromium Cr metals at each site. HQ or HI values more than unity demonstrate possible health issue. This evaluation gives an early estimation of health risk and is planned to support, instead of replace, comprehensive epidemiological assessments.

## 4. Results and Discussion

**Table 1:** Average concentration of Copper Cu and chromium Cr recorded through study periods in Al-Bayaa, Al-Shurta tunnel, and control areas in Baghdad

Area name	Al-Bayaa				Al-Shurta tunnel			
Variables	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Cu	0.0074	0.00813	20	35	0.00523	0.00405	16	31
Cr	0.0823	0.0991	2.6	3	0.0906	0.0675	2.5	2.8

Area name	Control			
Variables	Autumn	Winter	Spring	Summer
Cu	14.1	14.4	14.5	10
Cr	2	1.8	2.2	2.2

### 4.1 Copper (Cu) Spatial and Seasonal Distribution

The concentrations of Copper Cu showed distinct seasonal variations across all areas. In Al-Bayaa area, Cu levels increased from 0.0074  $\mu\text{g}/\text{m}^3$  in autumn to 35  $\mu\text{g}/\text{m}^3$  in summer season. Alike pattern was noted in Al-Shurta Tunnel, in summer concentrations recorded 31  $\mu\text{g}/\text{m}^3$ . These increased levels through hotter months can be cause as result of raised traffic heaviness, improved vehicle brake erosion, and reduced air spreading [6,7,11] as shown in table 1 and figure 1.

The control site illustrated medium Copper Cu concentrations across the year (10 to 14.5

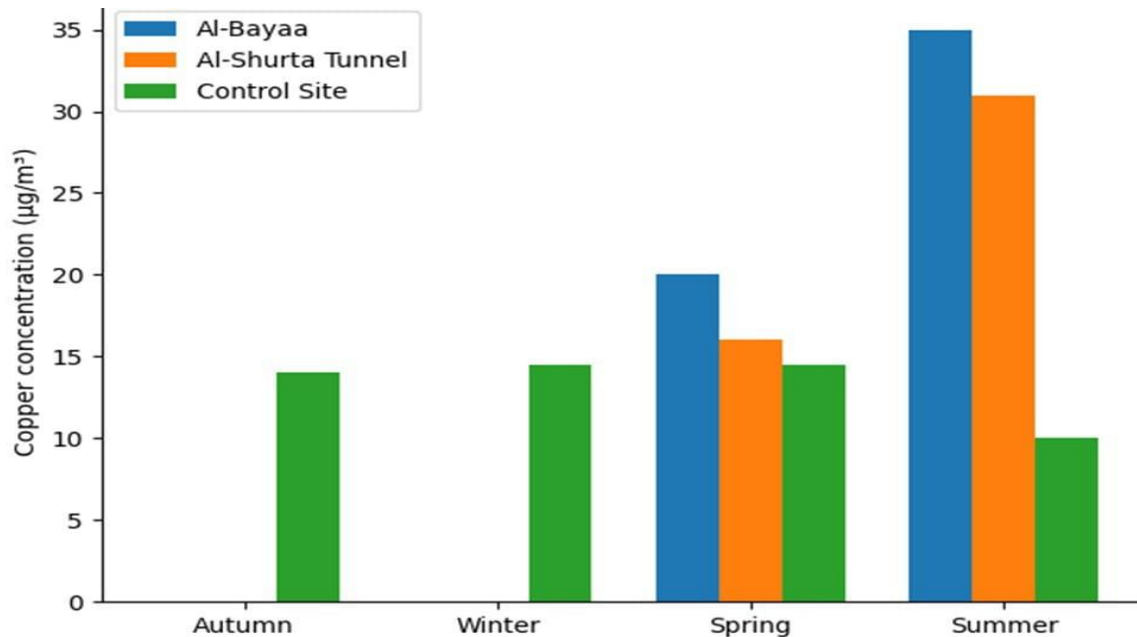
$\mu\text{g}/\text{m}^3$ ), suggesting the effect of local pollution sources, and long transport of airborne particles [20,22].

The detailed statistics of Copper Cu concentrations in air showed clear regional and seasonal diversity across the studied sites. Mean Copper Cu concentrations at the two traffic-ruled area (Al-Bayaa and Al-Shurta Tunnel) were consistently more than those recorded at the control site, signifying the powerful effect of vehicular discharges. One-way ANOVA displayed that seasonal distinctions in Copper Cu concentrations were statistically meaningful at all areas ( $p < 0.05$ ). The maximum mean concentrations were founded during spring and summer seasons,

while the minimum values happened during winter.

The raised Copper Cu levels during hotter seasons can be connected with enhanced road and transport activity flow, heightened brake and tire erosion, and enhanced suspension of road dust under dry conditions. Additionally,

reduced atmospheric dispersion during periods of lower wind speed likely contributed to the accumulation of Cu-rich particulates. Independent t-test analysis confirmed that Copper Cu concentrations at traffic sites were significantly higher than those at the control site ( $p < 0.05$ ), underscoring the dominant role of traffic-related sources.



**Figure 1.** Seasonal difference of atmospheric Copper (Cu) concentration

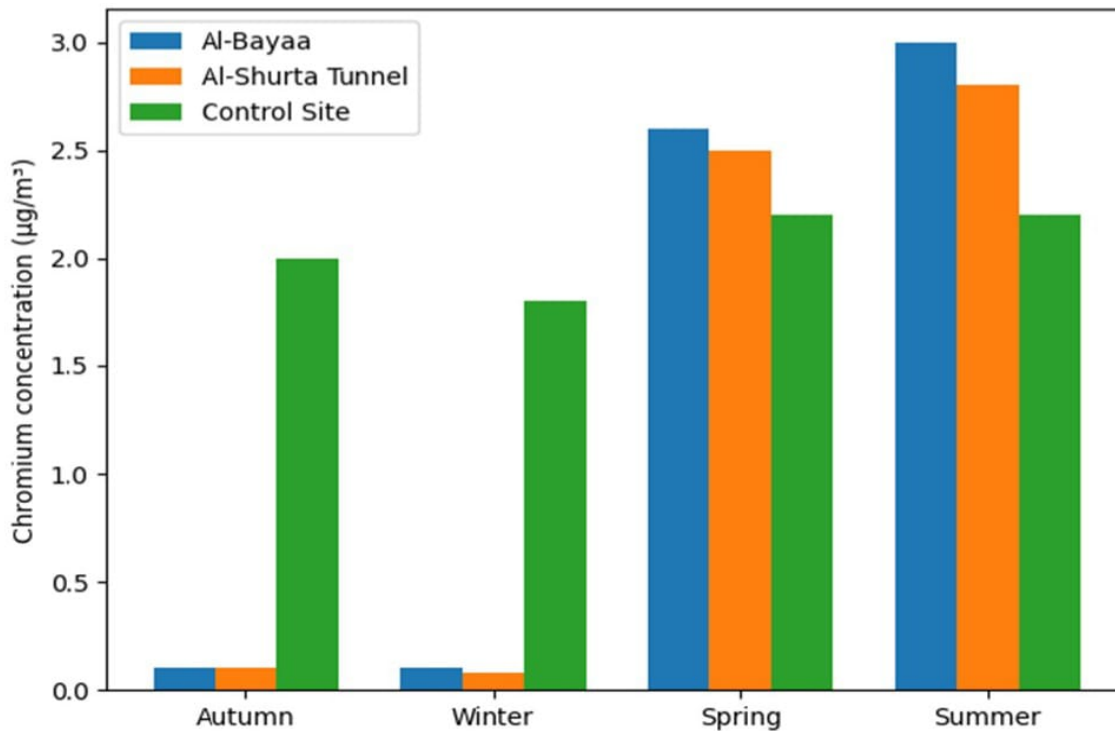
#### 4.2 Chromium (Cr) Spatial and Seasonal Distribution

In general chromium concentrations were lower than Cu but followed a similar seasonal trend. Highest values were founded in summer at Al-Bayaa ( $3.0 \mu\text{g}/\text{m}^3$ ) and Al-Shurta Tunnel ( $2.8 \mu\text{g}/\text{m}^3$ ). The noted elevated through spring and summer may be associated with intensified fuel combustion and higher road dust under dry situations as shown in table 1 and figure 2.

Concentrations of Chromium exhibited models similar to those of Cu, although at lower absolute levels. Statistical analysis of data indicated that significant seasonal variation in Cr concentrations (ANOVA,  $p < 0.05$ ), with maximum values recorded during both spring

and summer. Spatial comparison founded that Cr levels at traffic sites were considerably higher than those at the control site (t-test,  $p < 0.05$ ), reflecting the contribution of fuel combustion, vehicular component erosion, and road dust suspension.

Despite of the present study quantified total chromium only, the noted concentration levels remain ecologically applicable. Previous studies have shown that traffic-related Cr emissions may include both Cr (III) and the more toxic Cr(VI), suggesting potential health consequences even at moderate total Cr concentrations. The absence of chromium speciation is therefore acknowledged as a limitation, and the results should be interpreted with caution [4,5,8].



**Figure 2.** Seasonal difference of atmospheric Chromium (Cr) concentrations

#### **4.3 Comparison with Guidelines and Previous Studies**

Several measured concentrations exceeded WHO limits values for ambient air, specifically during summer [1]. Comparable studies in other Middle Eastern cities have recorded similar seasonal trends [12,13], highlighting the strong effect of the emissions of traffic and climatic conditions on airborne heavy metal levels [18,19,21].

#### **4.4 Effects of Weather Conditions**

Seasonal directions in Cu and Cr concentrations suggest a strong effect of weather conditions. Higher ambient temperatures and decreased precipitation through spring and summer favor particle suspension and limit wet deposition, resulting in raised concentrations of metal in the air. As well as, less temperatures, lead to raised rain, and high speed of winds through winter

improve atmospheric diffusion and removal methods, resulting in lower concentrations. These results are reliable with earlier studies conducted in arid and semi-dry urban habitats.

#### **4.5 Comparison with Guidelines and Health Risk Implications**

Founded concentrations of copper Cu and Chromium Cr at traffic areas sometimes overshoot international standards values for t air, especially during summer season. The initial health hazard evaluation shown that hazard quotient (HQ) values for individual metals were in general below unity, however, accumulated hazard index (HI) values reached or exceeded the threshold at some traffic sites over peak seasons. This suggests a potential non-malignant health threat or problems for population's exposure long time to air pollution related to traffic.

It should be directed out that the evolution of health hazard presented here is moderate and according of limits exposure assumptions.

However, the results point out the significance of ongoing air quality observing, and the application of reduction strategies to decreased heavy metal emissions in thickly populated urban areas.

#### 4.6 Discussion

The statistically valued seasonal differences founded in this research focused the serious effects of crowded and intensity traffic and weather conditions on airborne metal levels. Lower wind speeds and hotter conditions during spring and summer seasons raised particle colloid and decrease atmospheric spreading, leading to increase copper Cu and chromium Cr levels. Instead of this study focused on total chromium, it is accepted that the absence of chemical speciation represents a limitation, as copper Cr (VI) is considerably more toxic than chromium Cr (III). Future studies should combine metal speciation and higher temporal resolution to enhance measure health risks.

Due to sampling sites is limited number may not complete cover the local complexity of urban air pollution in Baghdad. As well as, short term regional difference and chromium speciation were not handled. These causes are conform and enhance direction for future studies including advanced analytical techniques and developed monitoring networks.

#### 5. Conclusion

This study showed noted seasonal and locational differences in airborne copper Cu and chromium Cr levels across different urban areas of Baghdad. Increased concentrations were noted through spring and hotter summer seasons, especially in heavy traffic areas such as Al-Bayaa and Al-Shurta Tunnel. These results refer to vehicular emissions, brake and tire erode [6], and bad weather and climate conditions play an important role in elevating heavy metal levels in air [11].

The recorded levels of Cu and Cr noted more than international standards values, highlighting potential public health problems in areas with densely population. Constant monitoring programs, improved traffic

management, and control of stricter emission policies are recommended to reduce air pollution with heavy metal in Baghdad [14,16,22].

Although providing valuable insights into airborne heavy metal pollution, this study has certain limitations. Sampling was conducted at a few numbers of areas, which may not represent all urban environments in Baghdad [10]. As well as, the research focused on total metal concentrations without differentiating between chemical species of chromium, which may different in toxicity [4,26]. For better analyze health hazards, future studies and research should include a larger number of sampling areas, as well as increase studied periods, and metal speciation analysis [5,27].

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