Air Lead Concentrations Around Al-Haram Area in Makkah Al-Mukarramah Before, During and After the Holy Month of Ramadan

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Air lead concentrations and the flow of motor vehicles at a place near the Grand Mosque in Makkah were measured during the months of Shaban 1409 (March 1989), Ramadan 1409 (April 1989) and Rabi Awal 1410 (October 1989) to investigate the effect of seasonal fluctuation in vehicular traffic flow which increases many-fold in Ramadan due to the arrival of a large number of devotees in Makkah in this auspicious month. The results obtained show that, as the traffic flow increases from an average of 833 cars/30 min in Shaban to a peak of 1470 cars/30 min in Ramadan and then decreases to 752 cars/30 min in Rabi Awal, there is a corresponding increase in air lead concentrations from 0.81 μg/m³ to 2.12 μg/m³ and then a decrease to 0.64 μg/m³ in the respective months. This indicates a positive correlation between lead concentrations in the ambient air and density of motor vehicles, all of which use leaded gasoline in the Kingdom. The air lead levels for Shaban and Rabi Awal are within the maximum permissible levels of 1.5 μg/m³ set by US Environmental Protection Agency. However, the value for Ramadan exceeds the maximum limit.

Lead is a serious metallic toxin which enters the human body through ingestion and inhalation in a contaminated area. Inhaled lead is more important than ingested lead because of significantly higher rate of metabolism of the former. Both natural and man-made sources contribute the contamination of air with lead. Of the man-made sources, burning of leaded gasoline in automobiles has been estimated to contribute about 86% of all lead emitted into the atmosphere. A number of studies have shown a high degree of correlation between the exhausts from automobiles using leaded gasoline and the lead levels in air and street dusts. The present lead content of gasoline in Saudi Arabia (0.4 g/litre, Petromin, personal communication) is considerable

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Submitted: 10.3.91.
Received in final revised form: 17.2.92.
Accepted: 18.2.92.
higher than in many western countries, e.g., 0.15 g/litre in the UK. Makkah is one of the most densely populated cities in the country, with narrow streets and congested housing. Slow dispersal of automobile exhausts from a large number of vehicles in the congested streets can give rise to an increased air lead level. The situation is further worsened during the holy month of Ramadan when there is a huge influx of cars from outside Makkah often creating traffic jams with car engines idling away, particularly during the more auspicious days in the latter half of the month. In view of this, it was thought necessary to check the air lead levels around the Grand Mosque during the month of Ramadan. Two other months (Shaban and Rabi Awal) when traffic flow is usually less were also studied, and compared with the Ramadan result.

Materials and Methods

Air sample collection
Air samples were collected on three different dates during each of the months of Shaban 1409, Ramadan 1409 and Rabi Awal 1410H. Ramadan usually is the month of heavy vehicular traffic in Makkah, particularly in the latter half of the month due to the significance of Lailatul Qadr, the most blessed night, which is believed to fall in this period. Shaban and Rabi Awal are expected to be lean periods as far as visitors to the Holy City are concerned. Air sampling was carried out by a Hi-Volume Sampler (Model 2000, General Metal Works) using 20×25 cm fibreglass filters. Ambient air was drawn through the filter over a 24-h period. Typical total air volumes drawn were in the range of 2036–2862 m³.

Traffic data
In order to study the correlation of air lead concentration with traffic flow rate, the number of automobiles passing through the air sampling point per 30-min intervals was counted three times at 10.00 h, 16.00 h and 21.00 h on each of the air sample collection days. An average of these data was taken to represent the traffic flow rate for the day.

Sample preparation
A 2.5×2.5 cm portion of the filter paper with the collected air particulate was weighed in a sensitive Mettler balance. It was then digested in aqua regia at a uniform temperature of 60 °C and with constant stirring until all particulates were completely dissolved. The resulting solution was evaporated to dryness at 80 °C in an oven. The dried residue was dissolved in 1% HNO₃. The solution was centrifuged and the clear supernatant was assayed for lead by atomic absorption spectrometry.

Analytical technique
Analysis for lead in the sample solutions was carried out with an atomic absorption spectrophotometer (Perkin Elmer, model 603) using the flame method. Atomic absorption spectrometry is a very popular technique for trace element analysis because of its high sensitivity. A description of the technique can be found in Atomic absorption spectrometry in occupational and environmental health practice published by CRC Press. Blank fibreglass solutions prepared from the filters in the same way as the actual samples were run to correct for background lead in the fibreglass. Triplicate readings were taken for each solution and the mean value with a relative standard deviation of less than 10% was accepted. Otherwise, the measurement was repeated.

Results and Discussion
Air-lead levels in the three months under study
Table 1 shows the air lead concentration data along with the measured traffic flow rate. Figure 1 shows the histogram plot of the average values for each of the 3 months. The mean air lead concentrations increased from 0.81 µg/m³ in Shaban to a peak of 1.89 µg/m³ in Ramadan and then decreased to 0.64 µg/m³ in Rabi Awal. These values can be compared with the data from other industrialized nations. A study in the UK showed that the overall annual concentration of lead in air was less than 1.0 µg/m³. In West Germany the concentration near urban schools in the industrial city of Duisburg, where there is a lead smelter, was found

<table>
<thead>
<tr>
<th>Month</th>
<th>Date</th>
<th>Av. Cars/ 30 min</th>
<th>Mean</th>
<th>Air-lead Conc. (µg/m³)</th>
<th>Mean (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1989</td>
<td>5</td>
<td>787</td>
<td>833</td>
<td>0.76</td>
<td>0.81</td>
</tr>
<tr>
<td>(Shaban, 1409)</td>
<td>15</td>
<td>773</td>
<td></td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>938</td>
<td></td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>April 1989</td>
<td>5</td>
<td>1321</td>
<td>1470</td>
<td>1.78</td>
<td>2.12</td>
</tr>
<tr>
<td>(Ramadan, 1409)</td>
<td>15</td>
<td>1976</td>
<td></td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>1112</td>
<td></td>
<td>2.59</td>
<td></td>
</tr>
<tr>
<td>October 1989</td>
<td>5</td>
<td>829</td>
<td>752</td>
<td>0.59</td>
<td>0.64</td>
</tr>
<tr>
<td>(Rabi I, 1410)</td>
<td>15</td>
<td>626</td>
<td></td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>801</td>
<td></td>
<td>0.65</td>
<td></td>
</tr>
</tbody>
</table>

Av = average.
to be 1.6 µg/m³ compared with levels of 0.35 µg/m³ in the more commercial city of Dusseldorf.9 Thus the levels of lead during Shaban and Rabi Awal are similar to those of industrialized countries, and are within the upper limit of 1.5 µg/m³ set by USEPA.10 However, the air lead concentration for Ramadan exceeds the US upper limit and is a cause for concern.

It is interesting to note that the data for the 25th of Ramadan apparently give a higher air lead concentration for a lower traffic flow rate. This is due to the fact that on this particular day, being one of the more probable dates for Lailatul Qadr (the most blessed night in the month of Ramadan), there was a large number of cars arriving in Makkah causing a tremendous congestion on the roads thereby slowing down the flow of traffic. However, as the engines were kept running, the pollution level increased in the atmosphere. This result again points to the automobile exhaust as the main source of air pollution. It also shows that any attempt to correlate air lead concentrations with vehicular traffic will have to take into account not only the flow rate but also the traffic build-up at the place of measurement due to congestion.

Correlation with traffic flow rate
A regression analysis was carried out for all the nine air lead concentration data measured for the 3 months with the corresponding traffic flow rates. The correlation coefficient of 0.52 (p < 0.01) shows a positive correlation between the air lead levels and automobile flow rates. Excluding the data for the 25th of Ramadan (which yield a higher air lead value for a comparatively less traffic flow rate due to reason explained earlier) the correlation coefficient jumps to 0.95 (p < 0.01). The results of the present study tend to confirm the findings of the Meteorology and Environmental Protection Administration (MEPA) of Saudi Arabia which conducted a similar study in Jeddah in 1985.4 The MEPA study in two areas of Jeddah city with traffic flow rates of 216 cars/30 min and 1806 cars/30 min gave the air-lead concentrations as 0.70 µg/m³ and 2.4 µg/m³, respectively, again showing a positive correlation between traffic density and ambient airborne lead. In a study of lead concentration in the dust of Jeddah city, Nasrallah3 showed that proximity to traffic plays a direct role in the increased lead content of streetside dusts. The average dust-lead concentration was found to be 745 µg/g, with the highest value of 1750 µg/g which is considerably higher than that found in many large cities in developed countries, e.g., 1001 µg/g was reported for street dust of the city of Birmingham, UK.11 Since settling of airborne lead is the major source of dust lead, it is not surprising that Jeddah dust has a correspondingly high lead concentration. However, it is also relevant that the rainfall in Jeddah is low compared to for example, Birmingham, so the dust-containing lead does not get washed away. It has also been shown that air pollution affects the trace metal concentrations in biological tissues such as hair12 and blood.13 Differences in hair lead levels in urban and rural Saudi Arabian children14 have also been attributed to contrasting environmental pollution gradients due to vehicular traffic. An interesting result linking the air lead concentration with gasoline lead content was reported15 in which hair lead levels were found to have actually decreased over a period of 5 years concurrent with the decrease of gasoline lead in the same period.

Conclusion
The results obtained in the present study show that the mean air lead concentration in Ramadan exceeds the maximum safe limit set by international air quality standards. Since automobile exhaust from the burning of leaded gasoline has been identified as the major source of urban lead pollution, it is imperative that the lead content of Saudi Arabia's gasoline be further reduced, with the objective of completely eliminating it as soon as practicable according to a well-coordinated programme between industry and government. In the meantime, it is recommended that traffic flow to the Holy City of Makkah should be restricted during Ramadan, particularly during the latter half of the month.

Acknowledgements
The authors would like to thank the Chairman of the Civil Engineering Department, King Abdulaziz University for providing the Air Sampler for the work. Thanks are due to Mr R. Rajput for technical assistance.

References
2Shobokshy MS. Preliminary analysis of the inhalable particulate lead in the ambient atmosphere in the city


4MEPA (Meteorology and Environmental Protection Administration, Kingdom of Saudi Arabia). A report on lead levels in air and in school children’s blood in Jeddah, Saudi Arabia 1985.


