Biological monitoring standards for industrial toluene exposure recommended for South Africa

D. J. Kocks† and C. E. Smith‡
†Department of Occupational and Environmental Health, Box 219, Medical University of Southern Africa, 0204, South Africa; ‡Lancet Laboratories, PO Box 8475, Johannesburg 2000, South Africa

Coal combustion is used in many industrial processes in South Africa. The exposure of workers and the absence of international biological monitoring standards for toluene created a problem. A cross-sectional study on 100 workers indicated that the biological threshold for ortho-cresol creatinine ratio reference value of < 1 mg/g could presently be used as a reference for non-industrial human exposure while the < 2 mg/g rate is for worker exposure in an industrial environment at a coal combustion plant.

Key words: Toluene; Biological monitoring; Occupational health.

INTRODUCTION

South Africa is a developing country and coal combustion is used for many industrial processes. Air pollutants in the form of hydrocarbons or aromatic hydrocarbons such as benzopyrene, benzene and toluene develop as by-products. Workers are exposed to these environmental or occupational health risks because of coal combustion in the engineering, petroleum and steel manufacturing processes. The health risks as a result of long-term exposure include nervous system diseases, heart and liver complications, behavioural manifestations and leukaemia.

Legislation to prevent occupational diseases has been promulgated in South Africa during 1996 and this legislation includes different organic solvents. No standards for biological exposure limit for South Africa have yet been authorized. A biological monitoring standard was needed but no related international information could be obtained to assist with the development of a standard for the industrial process where coal is combusted to coke. A combination of benzene and toluene was chosen for the biological monitoring of workers because it is possible to do an analysis on shift-end urine samples of exposed employees for these chemicals routinely at medical pathology laboratories in South Africa.

The problem of toluene exposure was identified when no universal industrial biological exposure limit expressed as the urine ortho-cresol creatinine ratio could be identified. The recommended reference limit used presently in South Africa of < 1 mg per gram is for non-industrial exposure of communities.

The aim of the study was to indicate that values which exceed the 50 mg per gram reference for urine phenol creatinine ratio could be used for benzene, but that the urine ortho-cresol creatinine ratio reference value of < 1 mg per gram for toluene is not valid as a biological monitoring standard in combination to assess exposure to the coal combustion process. Geographic and ethnic differences in toluene metabolism also indicate the need to develop the specific reference for workers exposed in South Africa.

METHOD

A cross-sectional study of workers was evaluated at a steel manufacturing plant in the Gauteng Province of South Africa during 1996. The data were double punched and stored on a personal computer and analyzed with the aid of a statistical computer programme (SAS).
An atmospheric occupational hygiene survey on the premises during March 1996 indicated that the environmental exposure reference limit for benzene and toluene was constantly exceeded. Eight individuals identified to be most at risk were also evaluated for benzene and toluene exposure conducted by urine analysis by a medical chemical pathology laboratory for creatinine, phenol and ortho-cresol after a completed work-shift. Urine phenol and ortho-cresol analyses were assayed by GC/MS (gas-liquid chromatography/mass spectrometry). Urine creatinine analysis was undertaken by the Coldrimetric Jaffe reaction.

The small sample indicated that the workers were constantly at risk from environmental solvent exposure. The total workforce of 141 was evaluated for benzene exposure and to correlate urine creatinine values. A cross-sectional sample of a hundred workers from the workforce of 141 was evaluated for toluene exposure. Benzene exposure is expressed as urine phenol:creatinine ratio and toluene exposure as urine ortho-cresol value and urine ortho-cresol ratio in Table 1.

RESULTS

Two out of 141 workers (1.42%) exceeded the 50 mg per gram reference level for the phenol:creatinine ratio that indicates that there was exposure to benzene. This indicates that the toluene values obtained would probably also exceed a reference limit value. The sample was too small to indicate statistically significant ethnic and geographic differences and the worker population was then statistically analyzed as one group.

The mean value for ortho-cresol was 2.86 mg/litre (p < 0.05) and was below the reference limit of < 5 mg/litre. The mean value for the ortho-cresol:creatinine ratio was 1.99 mg/gram and exceeded the reference value of < 1 mg/gram used for non-industrial exposure of communities. Twenty-one individual workers were not over-exposed because the values were below the non-industrial exposure reference limit for the ortho-cresol:creatinine ratio of < 1 mg/gram.

DISCUSSION

Coal combustion is a common industrial process in South Africa. Workers are at risk because of exposure to organic solvents in the form of hydrocarbons and aromatic hydrocarbons as air pollutants during the process. Benzene and toluene were used as indicators of exposure at the steel manufacturing plant. Environmental monitoring as occupational hygiene practice for these solvents is expensive and not readily available to industry in South Africa. It was decided to monitor for benzene and toluene because it is possible to do a routine urine analysis for these substances in workers in medical pathology laboratories in the region.

It was found that it would not be possible to minimize the exposure of workers with engineering prevention means in the short term at the steel manufacturing plant investigated. A 6-monthly human biological monitoring system for each worker was needed to comply with South African statutory requirements. Reference exposure limits for toluene created a problem because of non-existing universal international values and the possibility of geographic or ethnic differences.5,6,7,8,9

Two workers out of 141 potential workers exceeded the 50 mg/gram reference level for the urine phenol:creatinine ratio while 78% individual workers or 78.79% exceeded the non-industrial exposure reference limit for the ortho-cresol:creatinine ratio of < 1 mg/gram. The mean value obtained for ortho-cresol was below the reference limit of < 5 mg/litre as an indicator of toluene exposure. All these results indicated a potential environmental or occupational health risk because the workers were exposed to hydrocarbon air pollution exposure during the coal combustion process.

The value for the ortho-cresol:creatinine ratio has to be adapted to be used as a guideline in an industrial environment in South Africa. The statistical mean value of the ratio was 1.99 mg/gram for this study and a value of 2 mg/gram could therefore be recommended.

<table>
<thead>
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<th>Creatinine value</th>
<th>141</th>
<th>14.42</th>
<th>7.78</th>
<th>1.5</th>
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<td>10.10</td>
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<td>83</td>
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<tr>
<td>(expressed as mg/l)</td>
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<td>Phenol:creatinine ratio</td>
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<td>83</td>
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<td>(50-250 mg/g)</td>
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<td>0.42</td>
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<td>1</td>
</tr>
</tbody>
</table>

Table 1. Coke oven plant biological monitoring results of urine of workers for benzene and toluene industrial exposure in South Africa during 1996

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CONCLUSION

Workers exposed to air pollution during coal combustion as an industrial process could be monitored. Benzene and toluene combined can be used for biological monitoring purposes. The urine phenol:creatinine ratio value of < 50 mg/gram, urine ortho-cresol reference limit of < 5 mg/litre and an ortho-cresol:creatinine ratio of < 2 mg/gram could be used as a guideline. The biological threshold for ortho-cresol:creatinine ratio of < 1 mg/g presently used as a reference in South Africa is for non-industrial human exposure while the < 2 mg/g ratio can be used as a guideline for toluene exposure in an industrial environment.

REFERENCES