Health risk assessment and development of intervention programme in cottage industries with high risk of silicosis:
A study among slate pencil workers of Mandsaur

Participating staff

Scientific:  
Dr. RR Tiwari-SRO
Dr. LJ Bhagia- SRO
Dr. YK Sharma- DD

Technical:  
Mr. GC Patel- T O
Mr. PK Majumdar- R A
Mr. VP Chavda- L T
Mr. MD Patel- L T
Mr. JB Vyas- L T
Mr. Bipin Parmar- L A
Mr. KB Borse- L A
Mr. Shaswat Dodia- Project Fellow

Pneumoconiosis resulting from exposure to free silica may be the commonest, best known and most extensively studied of all occupational diseases of lung. The silicosis problem is much more severe in the small and cottage type of industry where not only it is considered as an occupational health problem but also because of the location of these units in the residential areas it poses threat to the community in the vicinity.

Slate pencil workers of Multanpura are a group of unorganized workers. They bring the slate stones from the slate mines and then cut it with the help of rotating saw. This process generates dust. However due to the indigenously developed control device, which includes an exhaust pump at the site of cutting, this dust is sucked up. This sucked dust is then released into the ambient air thereby exposing the community to silica dust via polluted environment (Figure 1). Thus the present study was carried out with the objectives of finding the prevalence of silicosis and other dust related morbidities among slate pencil workers and the community residing in the vicinity, to compare it with the un exposed group and to study the environmental and workplace free silica levels.
565 study subjects were included in the study. After taking the informed consent of these subjects the information regarding demographic characteristics, occupational characteristics and clinical history was recorded on pre-designed proforma. This was followed by clinical examination, pulmonary function testing using Spirovit SP–10 and chest radiography (PA–view) of each subject. However due to incomplete data in some subjects the final analysis included 514 subjects. The workplace environmental monitoring was done at 4 sites using SKC samplers. Silica analysis was carried out with the help of FTIR. The ambient air monitoring was carried out at three sites, which included two sites in the vicinity of slate pencils units and one site at the control village about 5kms away from the village where slate pencil units were present. PM–10 samples were collected using high volume samplers while separate samples were collected for silica analysis.
514 subjects included 194 slate pencil workers as *occupationally exposed group*, 159 subjects from the community residing in the vicinity of these slate pencil units but are not employed in any occupations where exposure to free silica can occur as *para-occupationally exposed group* and 161 subjects from the village Guradia which is 5 kms away from Multanpura as *non-occupationally exposed group*.

The mean age of the subjects were 43.2 $\pm$ 11.4, 39.7 $\pm$ 13.7 and 42.5 $\pm$ 14.8 years for the occupationally exposed, para-occupationally exposed and non-occupationally exposed groups respectively. Among the slate pencil workers 84 (43.3%) were males while 110 (56.7%) were females. Most of the males were involved in cutting process while females were carrying out the work like splitting the stones, packaging and housekeeping. The mean duration of exposure was 17.7 $\pm$ 9.7 years for males and 19.5 $\pm$ 8.8 years for females. Using ILO Classification of Pneumoconioses for classifying chest radiographs it was found that among *occupationally exposed* group 41 (21.1%) subjects had silicosis, 50 (25.8%) had silico-tuberculosis and 20 (10.3%) had tuberculosis while 83 (42.8%) subjects showed normal chest radiographs. Similarly among the *para-occupationally exposed* group 20 (12.6%) subjects had silicosis, 10 (6.3%) had silico-tuberculosis and 13 (8.2%) showed features of tuberculosis while 116 (72.9%) subjects had normal X-ray. Among the *non-occupationally exposed* group 4 (2.5%) subjects showed nodular opacities on chest X-ray, 3 (1.9%) showed features of tuberculosis along with nodular opacities and 19 (11.8%) showed features of tuberculosis while 135 (83.8%) subjects had normal X-ray.

The dust concentration in the work environment is shown in Table 1. The ambient air monitoring showed dust concentration as 284.74 $\pm$ 61.75mg/m$^3$ and 286.18 $\pm$ 64.51mg/m$^3$ respectively while that at control village was found to be 138.07 $\pm$ 33.72 mg/m$^3$. Similarly the silica concentration in the two sites of Multanpura village was 42.71 $\mu$g/m$^3$ and 53.77 $\mu$g/m$^3$ respectively while that for control village was 4.04 $\mu$g/m$^3$. 

Table 1: Dust Concentrations (mg/m³) in the Work Environment of Slate Pencil Industry

<table>
<thead>
<tr>
<th>Factory</th>
<th>Total Dust (mg/m³)</th>
<th>Respirable Dust (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.93 ± 0.92 (6)</td>
<td>1.14 ± 0.05 (6)</td>
</tr>
<tr>
<td>B</td>
<td>1.73 ± 0.99 (4)</td>
<td>1.35 ± 0.37 (4)</td>
</tr>
<tr>
<td>C</td>
<td>1.39 ± 0.40 (4)</td>
<td>1.06 ± 0.45 (4)</td>
</tr>
<tr>
<td>D</td>
<td>1.27 ± 0.67 (5)</td>
<td>0.94 ± 0.29 (4)</td>
</tr>
<tr>
<td>TLV</td>
<td>0.97 mg/m³</td>
<td>0.33 mg/m³</td>
</tr>
</tbody>
</table>

*Figures in parenthesis indicate number of samples*

Table 2: Dust levels in the ambient air of exposed and control village

<table>
<thead>
<tr>
<th>Location</th>
<th>Dust Concentration (µg/m³)</th>
<th>Silica %</th>
<th>Silica concentration (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muchhal Mohalla</td>
<td>284.74 ± 61.75</td>
<td>15.00 ± 7.04</td>
<td>42.71</td>
</tr>
<tr>
<td>Yadgav Mohalla</td>
<td>286.18 ± 64.51</td>
<td>18.79 ± 5.52</td>
<td>53.77</td>
</tr>
<tr>
<td>Control site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guradia village (5 km away)</td>
<td>138.07 ± 33.72</td>
<td>2.91 ± 1.00</td>
<td>4.04</td>
</tr>
<tr>
<td>Ambient standard for silica = 5 µg/m³ (EPA)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The study suggests that the prevalence of silicosis and silico-tuberculosis is still very high and both conditions constitute 46.9% among the slate pencil workers.

Though the workers are suing the indigenously developed control device it is not effective in controlling the dust. Instead it is capturing dust from the workplace and liberating it in the ambient air thereby exposing the community residing in the vicinity.

The prevalence of silicosis and silico-tuberculosis in community residing in the vicinity of these units is 12.6% and 6.3% respectively, which is alarming.

The shifting of these units to some isolated place is recommended.
Child labour:
Occupational health problems, evaluation and control: A study among footwear manufacturing workers of Agra

Participating staff

Scientific:
- Dr. RR Tiwari, SRO
- Dr. SR Tripathi, AD
- Dr. VK Bhatnagar, AD
- Dr. Rekha Kashyap, AD
- Dr. VN Gokani, DD
- Mr. PB Doctor, SRO

Technical:
- Mr. GG Parante, TA
- Mr. RC Patel, RA
- Mr. MR Mishra, LT
- Mrs. HS Trivedi, LT
- Mr. RR Teli, LT
- Mr. AR Shah, LT
- Mrs. Parveen Mansuri, LA
- Mr. PM Khandvi, L Attd.

The Footwear Industry is a significant segment of the Leather Industry in India. India ranks second among the footwear producing countries next to China. The industry is labour intensive and is concentrated in the small and cottage industry sectors. While leather shoes and uppers are concentrated in large-scale units, the sandals and Chappals are produced in the household and cottage sector. India produces more of gents’ footwear while the world’s major production is in ladies footwear. In the case of Chappals and sandals, use of non-leather material is prevalent in the domestic market.

The major production centers India are Chennai, Ranipet, Ambur in Tamil Nadu, Mumbai in Maharashtra, Kanpur and Agra in Uttar Pradesh, Jalandhar in Punjab and Delhi. Children are employed in the manufacture of shoes particularly in the Agra. The different working processes in a footwear-manufacturing unit are shown in Figure 1. Children between 10 and 15 years old are mainly employed in assembling shoes. Some 80 percent of the children work for contractors at home. Children work on soling (fixing upper portions of shoes to leather or rubber soles) with glue. Children in cramped poorly lit rooms suffer from continuous skin contact with industrial adhesives and breathing vapors from glues.
Figure 1. The work processes in a footwear-manufacturing unit

The children working in the footwear industry are exposed to physical factors like poor illumination, noise and poor ventilation, and chemicals like benzene that is used as a solvent in glues. Thus most children suffer from respiratory problems, lung diseases and skin infections through constant exposure to glue and fumes. Thus the present study was carried out with the objectives of finding the prevalence of different morbidities among these child labourers and to compare it with the unexposed group.

In the present study, the exposed group included 139 child labourers working in the different processes of footwear manufacturing. The comparison group included 160 school children studying in the government schools located in the neighbouring areas. Informed consent of all the subjects was obtained after explaining the detailed purpose and procedure of the study. By using interview technique for collection of information the data regarding demographic, occupational, personal and clinical characteristics were recorded in a pre–designed and pre–tested proforma. This was followed by complete clinical examination of all the subjects. In each study subject neurobehavioral test battery was applied.
which consists of digit symbol test, finder dexterity, tweezer dexterity, vocabulary test, picture completion and maze completion test. Urine samples from a sub-sample of 25 children was taken to measure the t,t muconic acid.

The exposed group included 56 (40.3%) males and 83 (59.7%) while the comparison group included 81 (50.6%) males and 79(49.4%) females. Majority of the child labourers and school children belong to 10–14 years age group. The mean age of child labourers was 10.8 ± 1.5 years and the mean age of comparison group was 11.0 ± 1.5 years. The difference was found to be statistically non–significant (t=1.1; df=1;p>0.05). The mean duration of exposure was 20.5 ± 16.2 months while the mean working hours per day was 3.9 ± 1.9 hours. It was found that the male children were working in the processes like cutting leather, putting the leather piece on cast (fitter) and application of adhesives while females were working mainly in the manual knitting of the upper portions of chappals. The mean income earned by these children was found to be 53.4 ± 7.1rupees per week. 94 (67.6%) of the children were compelled by the parents to work in the shoe manufacturing while 42 (32.2%) have taken it on their own choice.

The mean height of the child labourers was 131.0 ± 9.8 cms while that of school children was 136.9 ± 9.4 cms. The difference was statistically significant (t=5.5; df=1;p<0.05) Similarly, the mean weight of child labourers i.e. 25.9 ± 5.6 kgs was significantly lesser than the mean weight of school children i.e. 28.6 ± 5.6. (t=4.2; df=1;p<0.05). When these anthropometric parameters were analyzed after adjusting for age it was revealed that both height and weight of the child labourers was lower than that of school children. This difference was more remarkable in the earlier age groups. However, with increasing age a catch phenomenon was observed for height as well as weight.

In all 98 (70.5%) of the child labourers were symptomatic while only 104 (65%) school children had symptoms. The common complaints in child labourers included eyestrain and lacrimation from eyes in 43.9% followed
by respiratory symptoms such as cough and frequent common cold in 33.1% subjects and neurological complaints such as headache, tremor, tingling numbness, etc. in 26.6%. In the comparison group the common symptoms were respiratory symptoms in 41.9%, followed by neurological symptoms in 20.6% and musculoskeletal symptoms such as back pains and leg pains in 16.3% subjects.

The vocabulary test score were almost similar in the two groups. The scores for digit symbol, finger dexterity and tweezer dexterity were significantly lower in the child labourers as compared to school children. The school children took longer time for picture completion and maze learning tests as compared to child labourers. The difference was found to be statistically significant.

The chemical analysis of the different fluid used in the footwear manufacturing revealed the presence of organic solvents. These samples were extracted with methanol. The details are given in Table 1. The analysis of urine samples for tr-t-muconic acid is under progress. Table 1: Chemical analysis of the fluids used in shoe manufacturing

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>White fluid</td>
<td>Benzene, Toluene, Trichloropropane</td>
</tr>
<tr>
<td>Toe hardener</td>
<td>Hexane, benzene, propane, dimethyl heptane</td>
</tr>
<tr>
<td>Adhesive for rubber sole</td>
<td>Heptane, cyclohexane, xylene, cyclopentane</td>
</tr>
<tr>
<td>Adhesive for PVC soles</td>
<td>o,p-xylene, cyclohexane, ethyl benzene</td>
</tr>
<tr>
<td></td>
<td>1,3,5-trimethyl benzene, dimethyl hexane</td>
</tr>
<tr>
<td>Fevicol hardener</td>
<td>Trichloroethylene</td>
</tr>
</tbody>
</table>

The chemical analysis of the fluids used for the footwear manufacture revealed the presence of a mixture of organic solvents, which are known to affect the neurobehavioural functions. The mean height and weight of the child labourers were significantly lower than that of school children. This can be attributed mainly to the lower socio-economic status. The neurobehavioural test revealed better performance levels of school children than child labourers. This may be the effect of exposure to hazardous chemicals.
Occupational health survey among child labourers in stone quarries

Participating Staff

Principal Investigator: Dr. H. N. Saiyed, Director

Scientific Technical
Dr. H. G. Sadhu, DD Mr. P. Meshram, RA, RMRCT, Jabalpur
Dr. A. Saha, SRO Mr. Santosh, LA, RMRCT, Jabalpur

An occupational health survey was conducted under ILO – INDUS project involving 147 working children of stone quarries and 146 control subjects. This study was undertaken with the objective of exploring the health status of the child workers and to compare them with control subjects. An effort was also made to understand the occupational health problems, if any of the child workers.

Mean age of the workers was comparable with the control subjects. The control subjects included 84 boys and 62 girls whereas the working children group included 81 boys and 66 girls (Table 1). Almost 19% of the control subjects were of 14 and above years age as compared to 15% in working children (Table 2).

Table 1: Distribution of subjects according to category, age and sex

<table>
<thead>
<tr>
<th>Category</th>
<th>Sex</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>Mean ± SD</td>
<td>n</td>
<td>Mean ± SD</td>
<td>n</td>
</tr>
<tr>
<td>Controls</td>
<td>84</td>
<td>11.6 ± 2.1</td>
<td>62</td>
<td>11.0 ± 2.1</td>
<td>146</td>
</tr>
<tr>
<td>Workers</td>
<td>81</td>
<td>11.8 ± 1.7</td>
<td>66</td>
<td>10.8 ± 1.9</td>
<td>147</td>
</tr>
<tr>
<td>Total</td>
<td>165</td>
<td>11.7 ± 1.9</td>
<td>128</td>
<td>10.9 ± 2.0</td>
<td>293</td>
</tr>
</tbody>
</table>

n = Number of subjects in the subgroup

Table 2: Category and age group – wise distribution of the study subjects

<table>
<thead>
<tr>
<th>Category</th>
<th>Age group</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 and below</td>
<td>11 – 13</td>
<td>14 and above</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Controls</td>
<td>60</td>
<td>41.1</td>
<td>58</td>
<td>39.7</td>
<td>28</td>
</tr>
<tr>
<td>Workers</td>
<td>61</td>
<td>41.5</td>
<td>64</td>
<td>43.5</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>41.3</td>
<td>122</td>
<td>41.6</td>
<td>50</td>
</tr>
</tbody>
</table>

n = Number of subjects in the subgroup
Some of the other characteristics of the study subjects are as follows:

- About 9% of the control children were illiterate as compared to 60% of the working children.
- 6.8% of the child labours were having habit of mud chewing as compared to 3.4% of controls.
- The average income of workers was Rs. 27±26.2. The girls earned relatively more. Almost 95% of child workers were compelled by their parents to take this job.
- 10.2% child workers were smokers as compared to 0.7% of controls.

Table 3 shows different types of work carried out by the child workers. Majority of the children were engaged in stone breaking. The average daily work hours were 4.6±2.1 hours. The average work duration was 26.3±14.5 months.

Table 3: Sex and work type – wise distribution of the study subjects

<table>
<thead>
<tr>
<th>Sex</th>
<th>LOADING &amp; STONE BREAKING</th>
<th>STONE BREAKING</th>
<th>_LOADING</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.5</td>
<td>76</td>
<td>93.8</td>
</tr>
<tr>
<td>Girls</td>
<td>0</td>
<td>0.0</td>
<td>57</td>
<td>86.4</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>1.4</td>
<td>133</td>
<td>90.5</td>
</tr>
</tbody>
</table>

n = Number of subjects in the subgroup

The main complaints of the working children were cough, breathlessness, backache, muscle cramp, joint pain and injury at work. About 32% boys and 24.2% girls complained of frequent injury at work (Table 4).
Table 4: Distribution of health complaints of the study subjects

<table>
<thead>
<tr>
<th>Complaints</th>
<th>Controls</th>
<th>Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough</td>
<td>2 (1.4)</td>
<td>10 (6.8)</td>
</tr>
<tr>
<td>Breathlessness</td>
<td>1 (0.7)</td>
<td>3 (2.0)</td>
</tr>
<tr>
<td>Backache</td>
<td>--</td>
<td>9 (6.1)</td>
</tr>
<tr>
<td>Muscle cramp</td>
<td>--</td>
<td>4 (2.7)</td>
</tr>
<tr>
<td>Joint pain</td>
<td>2 (1.4)</td>
<td>17 (11.6)</td>
</tr>
<tr>
<td>Injury at work</td>
<td>--</td>
<td>42 (28.6)</td>
</tr>
</tbody>
</table>

On examination it was found that height and weight of the working children was comparable with the control subjects but skin fold thickness was significantly lower in working children (Table 5). Otherwise no abnormality was observed among the study subjects during clinical examination.

Table 5: Skin fold thickness of the subjects according to category & sex

<table>
<thead>
<tr>
<th>Category</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean ± SD</td>
<td>n</td>
</tr>
<tr>
<td>Controls</td>
<td>84</td>
<td>8.0 ± 1.7</td>
<td>62</td>
</tr>
<tr>
<td>Workers</td>
<td>80</td>
<td>6.7 ± 1.3</td>
<td>66</td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>7.3 ± 1.6</td>
<td>128</td>
</tr>
</tbody>
</table>

*n = Number of subjects in the subgroup

To conclude, the child labourers and control were comparable with regard to age, sex, socioeconomic status, height and weight. The skin fold thickness among the child workers was significantly lower than the controls (p < 0.05). About 9% of the control children were illiterate as compared to 60% of the working children. 10.2% child workers were smokers as compared to 0.7% of controls. The main complaints of the working children were cough, breathlessness, backache, muscle cramp, joint pain and injury at work. About 32% boys and 24.2% girls complained of frequent injury at work. The overall work conditions including ventilation, illumination, etc. were found to be satisfactory. However, dustiness due to mining, breaking and loading of stones were potential environmental hazards. The free silica could not be detected in the basalt stone while in dolomite stone it was found to be less than 1%.
A pilot project on Hazardous Substances Emergency Events Surveillance (HSEES) in Gujarat
- Indo-US joint programme

Participating Staff

Scientific
Dr. H N Saiyed
Dr. Aruna Dewan

Technical
Mr. Shamik Joshi

ATSDR, USA
Dr. Vikas Kapil
Perri Ruckart Zeitz

Govt. of Gujarat, Dept of Industrial Safety and Health, Ministry of Labor

Regional Coordinators:
Ahmedabad region: Mr. B.P. Parmar
Vadodara region: Mr. J.J. Vaghela
Surat region: Mr. V.B. Patel
Rajkot region: Mr. S.A. Solanki

HSEES is a web-based surveillance system developed by ATSDR, USA and is currently used in 15 states of USA for collection of data related to release of hazardous substances and their impact on public health. Gujarat is one of most industrialized states of India with a large number of chemical industries. In collaboration with ATSDR, a pilot HSEES project has been started in Gujarat for surveillance of chemical accidents. The objectives of this pilot project are:

1. To collect and analyze data on chemical accidents and their public health impact.
2. To use this information for prevention of such events in future.

Gujarat state has been geographically divided into four regions and regional coordinators collect information on all types of chemical accidents viz. industrial, transportation, household and others in a standardized format which includes date, time, type of event, chemicals involved, persons injured, type of injuries and factors responsible for the accident.
A central coordinating team evaluates the data, which is uploaded into the web-based system. From November 2004 to April 2006, 164 chemical accidents were recorded of which 41% were industrial accidents, 21% happened during transportation of chemicals, 16% in residential areas and 22% in others category. 57.9% of the events had victims and there were 312 injuries and 127 deaths. (Figure 1). Chemicals involved included petrochemicals, mixtures of industrial chemicals, irritant gases, asphyxiants and corrosives. Primary and secondary factors for the accidents have been identified.

From the data collected and analysed so far it has found that:

- Chemical accidents in Gujarat are associated with high morbidity and mortality. Compared to HSEES data reported from US where 9% of the events had victims, 57.9% of events from Gujarat had victims
- Untrained and contract workers were more likely to be involved in accidents leading to injury and death.
- Personal protective devices and safety precautions were not used when accidents happened inside the industry.
- Some unusual events are being used as case studies to create awareness among different stakeholders for prevention of such accidents in future.
The surveillance system has been found useful to develop a database on chemical accidents. Compared to internationally published data (Kaye 1998), chemical accidents in Gujarat had a much higher percentage of victims. Some unusual events with high mortality such as mass OP poisoning and sudden deaths due to exposure to sewage gases have been identified through the surveillance system. These case studies are being used to create awareness among different stakeholders for prevention of such accidents in future and research studies have also been initiated. (Kaye W. Hazardous substances emergency events surveillance 1993–1996. North American Congress of Clinical Toxicology: Orlando, Florida. 1998.)

Figure 1: Location wise classification of events

- Industrial: 41%
- Transportation: 21%
- Residential: 16%
- Others: 22%
Mass Organophosphate (Ethion) poisoning with high mortality

Participating Staff

Scientific:  
Dr A. Dewan, D.D. (SG)  
Shri A. B. Patel, S.R.O.  
Ms Ramavati Pat, S.R.F.  
Dr U. K. Jani, Assoc. Prof.*  
Dr V. C. Singel, Assoc. Prof. *  
Dr M. D. Panchal, Resid. *

Technical:  
Mrs K S Shah, T.A  
Ms G B Jinger, T.A.  
Mrs S K Patel, L.T.  
Mr P I Patel, L A

*B J Medical College, Civil Hospital. Ahmedabad

OP pesticides continue to be the most common type of pesticides involved in acute poisoning in countries like India and Sri Lanka. A large number of them including ethion are registered for use in India. Despite structural differences, the mechanism by which they elicit their toxicity is identical and is associated with the inhibition of the nervous tissue acetylcholinesterase. Morbidity and mortality by OPs remains especially high in rural settings where facilities for intensive care are either absent or very limited. World Health Organization (WHO) has estimated that each year more than 2,00,000 people in the world die from pesticide poisoning; most of them occur in Asia and at least 50% of them are of OP–poisoning. Episodes of mass poisoning due to OP pesticides have been reported from developing countries like Pakistan and India.

An episode of mass organophosphate (OP)–poisoning characterized by abdominal pain, vomiting, diarrhoea, excessive secretions and respiratory distress was investigated. 15 persons developed signs and symptoms of OP poisoning and 10 persons died within 24 hours. One person died after eight and a half months. Information was gathered from villagers and doctors at the primary health center and district hospital. Five surviving persons were brought to New Civil hospital Ahmedabad. Serial estimations of Plasma and RBC cholinesterase were carried out in these
five patients by Poison Information Center (Fig.1 and 2). The incident occurred in a remote village nearly 235 km from Ahmedabad in north Gujarat involved 9 adults and 6 children who had consumed a meal during a social ceremony. They were first shifted to a community health center about 30 km away where three persons died. Others were taken to the district level hospital at Palanpur and by the time they were further transported to a tertiary care hospital at Ahmedabad, 5 more were dead. Of the 7 survivors, one was found to be dead on admission and another victim succumbed within few hours. Remaining 5 persons were hospitalized for variable durations. Three recovered within a week but two developed complications. One person had lung infection but recovered fully but the other had cerebral anoxia following cardio respiratory arrest leading to permanent brain damage. Both remained hospitalized for 7 to 8 weeks. The person who had brain damage died after eight and a half months. Plasma and RBC cholinesterase levels in five cases correlated with clinical presentation at the time of admission and recovery of cholinesterase levels was slow.

Analysis of blood samples by GC–MS showed the presence of ethion in Patient–3 with the ethion concentration 1.3 mg/L twenty–four hours after the exposure. Plasma cholinesterase was very low on day one in four of the five cases (Figure–1). In Patient–1, plasma cholinesterase was within the normal range and the RBC cholinesterase was also slightly inhibited (it returned to normal range within 4 days post exposure). Patient–2 and 3 did not require ventilatory support even though plasma cholinesterase levels were almost 90% inhibited on day one; their RBC cholinesterase levels on day one were not as low as the two critically ill patients (Patients–4 and 5). However, recovery of RBC cholinesterase in these two patients was also very slow and even on the day of discharge, the levels were almost 50% inhibited while they were clinically normal. In Patient–4 and 5, plasma cholinesterase values were more than 90% inhibited on day one whereas RBC cholinesterase remained zero for 4–8 days after which there was a very gradual rise in the levels (Fig. 1 & 2).
Fig.-1: Serial Plasma Cholinesterase levels in Ethion-poisoning cases.

Fig.-2: Serial RBC acetylcholinesterase levels in Ethion-poisoning cases.
This report highlights the problem of accidental pesticide poisoning in developing countries resulting in high morbidity and mortality as facilities for immediate treatment of acutely poisoned persons are not available within reasonable distance. The episode also shows that children were more sensitive as all six of them died within 24 hours. Such incidents should sensitize clinical toxicologists, health authorities as well as the policy makers to the problem of pesticide poisoning, an issue which overrides all other kinds of poisoning in third world countries. This study, to our knowledge, is the first of its kind and there are no data in the literature regarding deaths in humans after exposure to ethion.
Health status assessment of the workers engaged in diamond processing industry in Surat district

Participating Staff

Scientific
Dr. H. N Saiyed, Director
Dr. A. Dewan, D.D.(SG)
Dr. V. N .Gokani, D.D.
Mr. B. C. Lakkad, D.D.
Dr. Rajesh Beniwal, R.O.

Technical
Mr. A. M. Suthar, TO
Mr. M M Patel, RA
Mr U M Desai, TA
Mr. M H Vakhria, TA
Mr H H Patel, TA
Mr M D Patel, TA
Mrs P. Mansoori, LA
Mr. B I Leuva, LA

Diamond manufacturing has been considered a safe work process. Except anecdotal reports of occupational lung disease due to hard metal, largely there is a paucity of identified toxicants in the work environment of diamond manufacturing. The Govt. of Gujarat provided the financial and administrative support to conduct the study for health Status assessment of the workers engaged in diamond processing industry in Surat district.

The diamond manufacturing units usually are swanky low–rises with closed windows, very limited air circulation and lots of cameras, artificial lighting and air–conditioning. The diamond industry at Surat employs about half a million people directly and probably many times indirectly. Diamond is a stone whenever it enters a manufacturing unit. The excess stone needs to be cut off to deliver the planned diamond. The shavings are important as smaller diamonds can be manufactured out of them. Nowadays, the traditional process of diamond manufacture is subdivided into smaller individual processes to achieve assembly line production. The modern diamond industry uses advanced technologies in the work processes. The major work–processes identified in the industry are laser operations, planning operations, marking operations, and grinding operations.
Laser operators are exposed to fullerenes containing soot and ozone. Grinders are exposed to soot but only carbon nano-tubes and diamond crystals. Planners use lasers to scan diamonds and generate 3-D images. Diamonds are covered with opaque fluid containing titanium dioxide for the process. The planners also use solvents to clean diamonds after the planning process. The burns created on diamonds' surfaces during this process produce very little soot, because, these burn marks are superficial and have to act as indicators for other workers. However they can be exposed to atmospheric fullerenes, if sitting in the same room as laser operators. Markers have exposure to ozone and fullerenes on an average to much lesser extent than planners and laser operators as not all markers sit near planners or laser operators and share common air-space. Grinders do not have exposure to ozone or fullerenes as they sit in different area in same buildings or different building. Except planners no other work group uses solvents.

A sample size of 900 to 1000 was judged appropriate for the pilot study. Diamond manufacturing units were informed about the plans to conduct a health survey and only units volunteering to participate were chosen for the study. Written informed consent was obtained from each worker participating in the study and other practices adopted were in accordance with the Indian Council of Medical Research guidelines. As samples were to be preserved for future use, ethical approval was obtained from the ethics committee of the institute. The project plan was also put up to the scientific advisory committee of the institute and approval obtained.

Subsequent, to benzene exposure, anemia is usually the first effect to be noted, followed by leucopenia, then, thrombocytopenia and finally pancytopenia. The blood counts of the workers in the present study reveal that 189 workers have reduced red cell counts, 5 workers have reduced white cell counts and 250 workers had reduced platelet counts. Increased red cell counts were observed in 24 workers, 72 workers had higher white cell counts and 10 workers had higher platelet counts. Thus the increased and decreased blood counts are a reflection of complex and multivariate nature of the exposure of the working population. On
the first day of the survey, it was observed that the younger workers were having noticeably higher percentage of hypertensive among them. Subsequently, with more enrollments it became evident that proportionately more of younger people were being enrolled in the study. Out of nine hundred forty-eight workers up to the age of thirty years, six hundred sixty-six (70%) were up to the age of twenty-four. The explanation for it can be either “healthy worker effect” commonly encountered in occupational settings or it can be to a very limited extent due to the fact that more young workers have been employed in recent years due to expansion of industry.

The workers employed in diamond processing industry have blood counts not typical of benzene poisoning. The presence of both lower and higher counts in the workers is difficult to explain on the basis of exposure to benzene. The results of tt–MA shall be enabling in generating a final comment on benzene poisoning.

However, an overview of other risk factors in work environment of diamond manufacturing is also important at this point so as to find an explanation for the observations. The soot generated by lasers has an important or only constituent, which is nano–particles called fullerenes. Diamond industries, use purest form of carbon and probably produce fullerenes, which are left floating in air. Continuous discharging lasers produce large quantities of ozone, which, may build up in limited air circulation buildings.

This study postulates that myocardium appears to be the target organ for the effects of nanoparticles. The proportion of hypertensive (JNC VIII) workers in the group up to age twenty–four years (23.9%) is very high comparing to the prevalence reported (1.5%) in a cross–sectional study of Indians of the age–group seventeen to twenty–three. In a study of ten industrial populations in India the prevalence of hypertension (stage1 & stage2) was found out to be 12.2% in the age group 20–29. The prevalence of hypertension (stage1 & stage2) in diamond workers is 23.9% up to the age of 24 and 25.5% up to the age of 30.(Table 1)
Table 1: Prevalence of hypertension on the basis of age and occupation

<table>
<thead>
<tr>
<th>JNC VII criterion</th>
<th>MARKER</th>
<th>PLANNER</th>
<th>LASER OP.</th>
<th>GRINDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>Count% (Mean Age)</td>
<td>Count% (Mean Age)</td>
<td>Count% (Mean Age)</td>
<td>Count% (Mean Age)</td>
</tr>
<tr>
<td>Normal (Up to 24 yrs)</td>
<td>15.1 (21.4) (2.4)</td>
<td>22.6 (21.1) (2.3)</td>
<td>18.47 (21.0) (3.1)</td>
<td>15.64 (21.0) (4.1)</td>
</tr>
<tr>
<td>Normal (Up to 30 yrs)</td>
<td>14.8 (23.3) (4.0)</td>
<td>21.8 (22.0) (3.0)</td>
<td>17.6 (22.8) (4.0)</td>
<td>16.6 (23.6) (7.0)</td>
</tr>
<tr>
<td>Pre-hypertensive</td>
<td>60.2 (21.8) (3.5)</td>
<td>57.6 (20.9) (2.4)</td>
<td>59.78 (24.4) (2.8)</td>
<td>54.42 (21.2) (4.7)</td>
</tr>
<tr>
<td>Pre-hypertensive</td>
<td>58.2 (23.8) (4.0)</td>
<td>55.5 (22.0) (3.0)</td>
<td>59.6 (23.3) (4.0)</td>
<td>53.9 (23.3) (6.0)</td>
</tr>
<tr>
<td>Stage 1 (Up to 24 yrs)</td>
<td>23.3 (21.3) (3.1)</td>
<td>17.2 (20.6) (2.7)</td>
<td>18.47 (21.7) (3.1)</td>
<td>23.12 (21.6) (4.6)</td>
</tr>
<tr>
<td>Stage 1 (Up to 30 yrs)</td>
<td>23.0 (23.7) (4.0)</td>
<td>19.4 (22.5) (3.0)</td>
<td>19.9 (23.4) (4.0)</td>
<td>24.1 (23.8) (6.0)</td>
</tr>
<tr>
<td>Stage 2 (Up to 24 yrs)</td>
<td>1.3 (20.0) (3.0)</td>
<td>2.5 (21.7) (2.6)</td>
<td>3.26 (20.0) (3.1)</td>
<td>6.8 (23.0) (6.0)</td>
</tr>
<tr>
<td>Stage 2 (Up to 30 yrs)</td>
<td>4.1 (26.8) (6.0)</td>
<td>3.3 (24.1) (3.0)</td>
<td>2.9 (21.3) (3.0)</td>
<td>5.4 (24.1) (6.0)</td>
</tr>
</tbody>
</table>

The body mass–index of workers across the occupational groups is comparable and less than 3% of workers have body mass–index over 30. Occupational groups are almost comparable on other measures. (Table 2)

It has been reported that fullerenes have least effect on thrombosis and mixed carbon nano–tubes have the highest thrombotic potential. Data for platelet counts is not differing significantly on the basis of profession in the present study. However, it appears that mixed exposure of carbon nanotubes, diamond crystals & hard metals have pre–dominant effects on leukocytes.

Pro–inflammatory effects contrast with reduced blood counts in the same industrial population. Thus, maybe different work practices (using different type of solvents) may be the reason for the observed differences. The overall work environment for diamond workers appears to be angiotensive with supervening effects of chemicals (solvents), nanoparticles and ozone. The magnitude of exposure to these risk factors is variable but effects may not be variable owing to the fact that for nanoparticles the particle surface area is much more important than absolute mass being released.
Table 2. Comparison of anthropometrical and haematological data across different occupational groups

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Marker (n=122)</th>
<th>Planner (n=449)</th>
<th>Laser (n=136)</th>
<th>Grinder (n=241)</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD) Range</td>
<td>Mean (SD) Range</td>
<td>Mean (SD) Range</td>
<td>Mean (SD) Range</td>
<td>p-value</td>
</tr>
<tr>
<td>AGE (Yrs.)</td>
<td>23.9 (3.2) 17-30</td>
<td>22.2 (2.9) 17-30</td>
<td>23.2 (3.1) 18-30</td>
<td>23.6 (3.4) 23-30</td>
<td>&lt;&lt;0.001</td>
</tr>
<tr>
<td>HEIGHT (cm.)</td>
<td>170.3 (6.5) 155-183</td>
<td>168.7 (7.5) 142-188</td>
<td>169.3 (7.9) 147-183</td>
<td>168.1 (7.5) 168-188</td>
<td>0.515</td>
</tr>
<tr>
<td>WEIGHT (kg.)</td>
<td>61.4 (10.3) 43-96</td>
<td>57.6 (9.7) 37-105</td>
<td>59.3 (10.2) 39-103</td>
<td>59.2 (8.8) 58-86</td>
<td>0.001</td>
</tr>
<tr>
<td>BMI (KG/sqM) (Age&lt;24)</td>
<td>20.3 (3.0) 15.02-31.4</td>
<td>20.0 (3.4) 13.89-38.77</td>
<td>20.3 (3.2) 14.93-34.42</td>
<td>20.7 (3.3) 13.58-31.64</td>
<td>0.167</td>
</tr>
<tr>
<td>BMI (KG/sqM) (Age&lt;30)</td>
<td>21.16 (3.3) 15.01-34.2</td>
<td>20.3 (3.4) 13.89-38.77</td>
<td>20.7 (3.4) 14.83-34.41</td>
<td>20.9 (3.2) 13.58-31.64</td>
<td>0.012</td>
</tr>
<tr>
<td>BMI over 25 (Age&lt;24)</td>
<td>n=8 %=10.9 n=41 %=11.6</td>
<td>n=9 %=9.8 n=19 %=12.9</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI over 30 (Age&lt;24)</td>
<td>n=1 %=1.4 n=8 %=2.3 n=1 %=1.1 n=3 %=2.0</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI over 25 (Age&lt;30)</td>
<td>n=19 %=15.6</td>
<td>57 %=12.7</td>
<td>20 %=14.7</td>
<td>32 %=13.3</td>
<td>NA</td>
</tr>
<tr>
<td>BMI over30 (Age&lt;30)</td>
<td>n=3 %=2.5</td>
<td>8 %=1.8</td>
<td>2 %=1.5</td>
<td>5 %=2.1</td>
<td>NA</td>
</tr>
<tr>
<td>Standardized work duration</td>
<td>4 (2) 0.2-8.0</td>
<td>2 (2) 0.06-11.2</td>
<td>4 (2) 0.32-8.9</td>
<td>6 (2) 5.0-12.4</td>
<td>&lt;&lt;0.001</td>
</tr>
<tr>
<td>HB (mg %)</td>
<td>14.4 (1.0) 10.4-16.6</td>
<td>14.3 (1.1) 8.3-17.1</td>
<td>14.1 (1.4) 7.3-16.5</td>
<td>14.2 (1.3) 14.5-17.5</td>
<td>0.126</td>
</tr>
<tr>
<td>R.B.C (M/cu mm)</td>
<td>5.0 (0.5) 3.2-7.4</td>
<td>5.0 (0.6) 2.9-7.2</td>
<td>5.0 (0.5) 3.5-6.6</td>
<td>5.0 (0.5) 4.97-6.69</td>
<td>0.772</td>
</tr>
<tr>
<td>W.B.C (/cu mm)</td>
<td>7362 (1479) 4200-12300</td>
<td>7584 (1716) 3900-14900</td>
<td>7513 (1950) 3400-17700</td>
<td>7981 (1773) 7900-17500</td>
<td>0.004</td>
</tr>
<tr>
<td>Platelet Count (/cu mm)</td>
<td>298803 (58734) 14600-494000</td>
<td>292410 (70795) 680000-733000</td>
<td>290228 (93664) 291000-715000</td>
<td>294954 (73361) 293000-656000</td>
<td>0.779</td>
</tr>
<tr>
<td>Reticulocyte (%)</td>
<td>0.7 (0.2) 0.5-1.8</td>
<td>0.7 (0.3) 0.1-3</td>
<td>0.7 (0.2) 0.2-2</td>
<td>0.7 (0.3) 0.7-3</td>
<td>0.094</td>
</tr>
<tr>
<td>Health poor compared to last year</td>
<td>n=4 %=3.3 n=9 %=2.0 n=6 %=4.4 n=8 %=3.3</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self reported Sub-optimal general health</td>
<td>n=5 %=4.1</td>
<td>n=10 %=2.2 n=7 %=5.1 n=20 %=8.3</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All the workers in the diamond industry at Surat have same ethnic background, sedentary office type job, and have the same food (small meals & lunch at factory premises) and same socio-economic status.

The workers have both increased and decreased blood counts in the same occupational setting. The proportion of hypertensive workers up to age 24 is alarmingly high. The reasons for these observations can only be ascertained with the results for cytogenetics analysis, tt-MA and results of advanced tests are available from Indian Institute of Immunohaematology.
Health risk assessment of rural and urban population due to indoor/ambient air pollution – Ahmedabad city

Participating staff

Project-in-Charge
Dr. H.N. Saiyed, Director

Scientific
Environmental monitoring
Dr. Rekha Kashyap, A.D.
Dr. S.N. Sinha, R.O.

Technical
Mr. S.H. Shah, T.O.
Mr. N.M. Desai, R.A.
Mr. P.G. Shah, T.A.
Mr. G.M. Patel, R.A.
Mr. J.A. Shah, L.T.
Mr. K.R. Dabhi, L.T.
Mr. R.P. Patel, L.T.
Mr. K.M. Vyas, L.A.
Mr. M.M. Mansuri, L.A.
Mr. K.B. Borse, L. Attendant

Biological monitoring
Blood (Benzene)
Dr. V.K. Bhatnagar, A.D.

Urine (trans, trans muconic acid)
Dr. (Ms) V.N. Gokani, D.D.
Mr. P.K. Kulkarni, D.D.
Mr. P.B. Doctor

Medical Survey
Dr. Asim Saha, S.R.O.

Hematalogical
Dr. A.B. Karnik, D.D.

Lung Function Test
Dr. N. Mohan Rao, D.D.

Benzene is an important industrial chemical and it is an intermediate in the synthesis of numerous chemicals. It is an ubiquitous component in the environment that has been linked to adverse health effects particularly leukemia, aplastic anemia, bone-marrow, disorders in human and other cancers, even at low dose. It is also toxic to the hematopoietic system and causes acute myelogenous leukemia in population with
occupational exposure. Since benzene is hematotoxic and has been classified as a Group I carcinogen by the International Agency for Research on Cancer (IARC), monitoring and control of benzene exposure is important. Petrol contains Volatile Organic Compounds (VOCs). Petrol vapour evaporates during the filling process of vehicles at petrol pumps and lead to the benzene exposure. This pilot study was undertaken at the selected petrol pumps of the Ahmedabad city to know the benzene exposure. The study was conducted with the following objectives.

Air monitoring of benzene, toluene and xylene with the use of personal sampler and analysis by GC–MS. Estimation of benzene in blood samples using GC Head space with PID detector. Estimation of trans, trans–Muconic acid (t,t–MA) by reversed phase high performance liquid chromatography (RP–HPLC) in the post shift urine samples of exposed population. Medical examination with standard questionnaire along with haematological investigations and lung function test.

To assess the benzene exposure to high-risk population, the petrol fillers were identified and the study was executed at different petrol pumps of Ahmedabad city. The personal sampler (Air check sampler model 224–52 SKC Inc.USA) fitted with activated charcoal sorbent tube with flow rate of 0.5 L min −1 was used for monitoring of benzene exposure of the individual petrol filler. A total 29 samples were analyzed by GC–MS/MS to know the concentration of benzene evaporation during the filling of petrol. Two minor urinary benzene metabolites, trans,trans–muconic acid (t,t–MA) and S–phenylmercapturic acid (S–PMA) were suggested as biomarkers of benzene exposure. In the present study, the RPHPLC method with Photo Diode Array (PDA) detector was developed as a proposed practical method for the determination of urinary benzene metabolite t,t–MA using solid phase extraction (SPE) for sample preparation with a short analysis time of 12 minutes. This method was used to analyze the post shift urinary t,t–MA level of biomass fuel users and Petrol fillers.
### Table 1: Air monitoring findings (Mean ± SEM, Median)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Benzene µg/m³ N=29</th>
<th>Toluene µg/m³ N=29</th>
<th>Xylene µg/m³ N=29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SEM</td>
<td>81.26±17.89</td>
<td>20.31±5.86</td>
<td>93.75±47.80</td>
</tr>
<tr>
<td>Median</td>
<td>42.93</td>
<td>7.91</td>
<td>26.29</td>
</tr>
<tr>
<td>Range</td>
<td>0.22 – 334.81</td>
<td>1.53 – 139.58</td>
<td>4.65 – 1389.33</td>
</tr>
</tbody>
</table>

### Table 2: Urinary tt MA level among Biomass Fuel Users and Petrofillers (Mean ± SEM, Median)

<table>
<thead>
<tr>
<th>Smoking habits</th>
<th>Biomass fuel users</th>
<th>Petrofillers</th>
</tr>
</thead>
<tbody>
<tr>
<td>March (NIOH) N=55</td>
<td>September (NIOH) N=31</td>
<td>January (NIOH) N=16</td>
</tr>
<tr>
<td>tt–MA mg/g creatinine Post shift (Mean ± SEM, Median)</td>
<td>tt–MA mg/g creatinine Post shift (Mean ± SEM, Median)</td>
<td>tt–MA mg/g creatinine Post shift (Mean ± SEM, Median)</td>
</tr>
<tr>
<td>Smoker</td>
<td>0.14±0.04 0.17 (0.07–0.19)</td>
<td>0.27±0.09 0.30 (0.00–0.51)</td>
</tr>
<tr>
<td>Non-smoker</td>
<td>0.08±0.01 0.05 (0.008–0.33)</td>
<td>0.19±0.04 0.17 (0.00–0.36)</td>
</tr>
<tr>
<td>Chewer</td>
<td>–</td>
<td>0.17±0.03 0.15 (0.00–0.46)</td>
</tr>
<tr>
<td>Total</td>
<td>0.08± 0.01 0.05 (0.008–0.33)</td>
<td>0.19± 0.03 0.18 (0.00–0.51)</td>
</tr>
</tbody>
</table>

*Figures in parenthesis indicate the range;  
*Comparison with September data (p<0.005)
The main findings of the study were as follows:-

None of the blood sample showed the presence of benzene. A questionnaire survey (interviewer administered) along with medical examination of 37 petrol filters was undertaken to assess the morbidity pattern of such workers. Mean age of the workers was 33.78 + 8.70 years and majority of the workers (75.7%) were in the age group of 21 – 40 years. Almost 90% of the workers were married and 18 (48.6%) workers had up to primary level education only. So far as habit is concerned 12 (32.3%), 16 (44.4%) and 7 (19.4%) workers had the habit of smoking, tobacco chewing and consuming alcohol respectively. Mean family income was 3213 rupees and mean average number of family members was 5.5 ± 4.0. Burning / watering of eye (10.8%), cough (5.4%) headache (13.5%), fatigue (8.1%), irritation of throat (7.7%) and irritation of skin (5.4%) were the complaints of the workers, which they suffered during work. Icterus and pallor was observed in 6 workers each (16.2%). Only one worker was hypertensive.
Assessment of air pollutants due to adulteration of petroleum fuels with different composition at source level

Participating Staff

Scientific
Dr. S. N. Sinha, RO
Dr. Rekha Kasayp, AD
Dr. H. N. Saiyed, Director

Technical
Mr. S. H. Shah, T.O
Mr. P. G. Shah, T.A
Mr. G. M. Patel, R.A
Mr. J. A. Shah, Technician
Mr. K. R. Dabhi, Technician
Mr. R. P. Patel, Technician
Mr. K. M. Vyas, Lab. Asst.
Mr. M. M. Mansuri, Lab. Asst.
Mr. K. B. Borse, Lab. Attendant

In India ambient air pollution is one of the major contributors of the diseases. The ambient air pollutants (AAP) such as SO2, NOx, particulate matter (PM), volatile organic compounds (VOC’s) and poly-nuclear aromatic hydrocarbons (PAH’s) emitted through the automobile exhausts and industrial activity. Exposure of AAP is an important cause of morbidity and mortality in India. Adulteration of gasoline and diesel is common in South Asia as elsewhere in the word. Some adulteration increases emissions of harmful pollutants from vehicles, worsening urban air pollution and caused bad impact on health. The Center for Science and Environment (CSE) prepared a report on gasoline and diesel adulteration in Delhi, providing a good overview of the scope of the problem and some technical data on the subject. Fuel adulteration can increase the emission of hydrocarbons, CO, NOX and Particulate matter. Air toxin emissions such as benzene depend mostly on fuel composition and catalyst performance. PAHs in the exhaust are due primarily to the presence of PAH’s in the fuel itself and in the case of gasoline, in part due to PAH formation by fuel combustion in the engine. Earlier study showed that the addition of Kerosene in gasoline results in higher level of HC, CO and PM emissions even from catalyst-equipped cars.

In India the data related to the air pollutants in ambient environment is available but the data related to the adulteration of petroleum fuels with
different composition of kerosene is not sufficient to come on any occlusions. Therefore the present study is aimed for estimation of different type of air pollutants emitted at source level from different types of vehicles due to adulteration of petroleum fuels with kerosene and others solvents.

The mean concentrations of benzene was 278, 83, 62 and 58 ppb for 100% P, 75% P + 25%K, 50%P+50%K and 75%K+25P% respectively while the mean concentrations of toluene was 1510, 411, 382 and 170 ppb for 100% P, 75% P + 25%K, 50%P+50%K and 75%K+25P% respectively. Similarly the mean concentrations of xylene was 84, 31, 27 and 22 ppb for 100% P, 75% P + 25%K, 50%P+50%K and 75%K+25P% while the mean concentrations of ethyl benzene was 39, 17, 15, 15 ppb for 100% P, 75% P + 25%K, 50%P+50%K and 75%K+25P% respectively. The initial trend showed (Fig.1) that the increasing the percentage of kerosene in petrol decreasing the common VOC's like benzene, toluene, xylene and ethyl benzene.

![VOCs concentration in different composition of petrol with kerosene](image)

Fig.1 VOCs concentration in different composition of petrol with kerosene

The mean concentration of SPM was 1315, 1515, 1660 and 2036 µg/m3 for 100%P, 75%+25%K, 50%P+50%K and 25%P+75K% respectively. The initial trend showed that the increasing of percentage of kerosene in petrol increasing the concentration of SPM (Fig.2). While the
concentration of NOx was 4.24, 3.4, 5.26 and 0.76 µg/m³ for 100% P, 75%P+25%K, 50%P+50%K and 25%P+75K% respectively (Fig. 3).

The initial trend showed that the % on kerosene increasing in petrol the concentration of SPM increases while the concentration of benzene, toluene, xylene and ethyle benzene decreasing. For NOx but reverse trend was observed for volatile organic compounds. The concentration of NOx increases along the percentage of kerosene increasing except 50% P + 50% K.
Environmental impact assessment study near UCIL, Bhopal due to allegedly improper disposal of toxic waste – a pilot study

Participating Staff

Scientific:  
- Dr. H. N. Saiyed, Director  
- Dr. V. K. Bhatnagar, AD  
- Dr. N. G. Sathwara, AD  
- Dr. S.N. Sinha, R.O.  
- Mr. B. C. Lakkad, DD  
- Dr. Sunil Kumar, DD (SG)  
- Mr. P.K. Kulkarni, DD  
- Dr. D.J. Parikh, E.M.S.  
- Dr. V K. Shivgotra, RO.

Technical:  
- Mr. M. R. Variya, TA  
- Mr. Yogesh Shah, TA  
- Mr. M.M. Patel, R.A.  
- Mr. R.A. Rathod, R.A.  
- Mr. J.B. Vyas, T.A.  
- Ms. Nivedita Shukla, J.R.F.  
- Mr. S.N. Yadav, L.T.  
- Mr. G.P. Kamble, Lab. Attd.

As per the directives of MOHFW, New Delhi, NIOH carried a preliminary study on “Environmental Impact Assessment Study Near UCIL, Bhopal due to Allegedly Improper Disposal of Toxic Waste”. The team took a site visit around the UCIL, and Solar Evaporation Ponds, Bhopal, where toxic wastes from the UCIL have been dumped. After collecting the necessary information from the concerned officers of MPPCB, CPCB, Bhopal Gas Rehabilitation Department, MP Govt. and other stakeholders, the team initiated the collection of biological sample (blood) and environmental samples – (water and soil).

From the above locations and also from UCIL factory premises, the soil (n=25) and water (n=29) samples have been collected. The blood samples (N=101) from general population were collected for the analysis of pesticide residues (DDT and HCH) and metal (mercury) analysis. Subjects were informed regarding the objective of the study and their consent obtained. The subjects were interviewed to get their personal and demographic information. The samples were transported at 4°C in icebox and they were stored at the same temperature till the analysis.

Samples of blood, soil and water were analyzed for the residues of persistent pesticides (DDT and HCH) following extraction and cleanup by
conventional procedures and finally by GC-ECD. Analysis of mercury level in blood, soil and water samples were done by acid digestion and finally by Flow Injection Analysis – Mercury Hydride System (100) Lamp – EDL System–2 attached with AAS. Analysis of volatile organic chemicals (benzene, toluene xylene and chlorobenzene) in water samples was done by extraction in hexane and final analysis by GCMS.

Serum level of DDT had a mean of 25.73 ng/mL, which ranged from 5.57 – 85.32 ng/mL. The HCH content in serum samples had a mean of 3.71 ng/mL and ranged from 0.26 to 15.29 ng/mL. The levels of mercury in human blood samples were detected in 25 out of 101 blood samples. The mean value of mercury in blood samples was 0.55 and had a range of 0.2 to 1.2 µg/L These levels of DDT, HCH and mercury in the blood of people living at distances from UCIL are comparable with the levels of these compounds reported from other parts of the country. These values are within the normal range (2–20 µg/L) reported by Agency for Toxic Substances and Disease Registry, USA and the blood mercury levels of 1.75 ± 0.22 µg/l reported by Industrial Toxicological Research Centre, Lucknow in subjects not occupationally exposed to mercury.

Levels of DDT and HCH residues in soil samples (n=25) had a mean value of 7.84 (Range: 0.31 – 58.62) and 6.11 (Range: nd – 37.09) ng/gm, respectively. This mean value of HCH was from 19 detectable soil samples excluding Sample No 17 showing 1,317 ng/gm, an abnormally high value, confirmed by GC–MS, and this sample was collected from outside wall of the UCIL.

The mercury content in soil samples (n=23) ranged from 4.5 to 2077 µg/kg, collected from various locations within and outside the UCIL. Among these samples, first four samples were taken from the inside of the premises of the plant; the mean value was 737.17 µg/kg, which ranged from 157.7 to 2077 µg/kg. While remaining 19 samples collected from other locations had a mean of 276.15 µg/kg and the range was from 4.5 to 799 µg/kg.
Out of 29 water samples collected, only 17 water samples were available for the analysis of DDT and HCH. The levels of DDT and HCH in water samples in detectable water samples (n=17) were 0.65 and 0.098 ng/mL respectively and ranged from 0.2 – 1.42 and 0.01 – 0.25 ng/mL. The mean value of mercury in detectable water samples (5 out of 29) collected from Bhopal was 0.08 µg/L. The water samples collected from the premises of the UCIL plant and nearby sites showed the mercury in the water was below detection limit in (0.01µg/l) in 24 samples and in the rest of the 5 water samples (N=5) the mercury was in the range of 0.063–0.218µg/l. First two samples taken from the premises of the UCIL plant shows non-detectable level of mercury in water. These values are within permissible level of 1 µg/l in the drinking water prescribed by Ministry of Environment and Forests (MOEF) Govt. of India.

The result showed that levels of VOCs i.e. benzene, toluene, xylene and chlorobenzene in water samples were not detected and were below the detection limit of the instrument i.e. 2 ppm.

The serum levels of DDT, HCH and mercury in the blood of people living at distances from UCIL are comparable with the levels of these compounds reported from other parts of the country. The levels of DDT and HCH in soil and water samples inside UCIL and at different locations are also comparable except for one sample just outside the boundary wall of UCIL which showed high values of HCH in soil. The levels of mercury in water and soil sample outside the UCIL compound and at different locations are comparable with the other reports. However, one of the samples collected from the premises of UCIL showed high value of mercury (2077 µg/kg). The VOCs like xylene, benzene, toluene and chlorobenzene in water samples collected from various locations including UCIL were below the detectable level of 2 ppm. There is a need for study involving other contaminants in environmental and biological media.
Assessment of health risk among spray painters:
Levels of serotonin in controls and spray painters

Participating Staff

Scientific : Technical :
Dr. S.S.A. Zaidi, A D Mrs S.J. Gandhi, TO 
Dr. R.R. Tiwari, SRO Mr. U. M. Desai, TA
Mr. K. A. Patel, LT 
Mr. J. K. Dabhi, TA 
Mr. R.C. Kushwah, F Attd.

Spray painters are heavily exposed to a mixture of organic solvents, pigments and some heavy metals and some of them are potentially toxic to cause biochemical and neurochemical alterations, some of them such as serotonin might have diagnostic value in assessing solvents toxicity. The aim of this study was to evaluate the role of serotonin in solvent induced toxicity in spray painters exposed to a mixture of solvents over a period of long time and the results were compared with control group. Figure 1 shows standard calibration for the estimation of serotonin by Radioimmunoassay (DLD diagnostic kit, Germany).

Fig. 1. Calibration curve of serotonin
Level of serotonin in serum of control group was found to be 192.20 ± 121.70 ng/ml; Mean ± SD, range 86.91–515.32, N=10; Normal reference range 40–400 ng/ml). Only one subject was found to have elevated level of serotonin (515.32ng/ml). Plasma (platelet poor plasma, PPP) serotonin levels in these subjects were significantly (< 0.01) low (12.7±7.38 ng/ml) as compared to serum level. The level was significantly enriched (24.89 ± 17.11 ng/ml) when plasma was made rich (platelet rich plasma, PRP) in platelet counts (Table 1). Urine serotonin level in spray painters was registered quite high 200.91 ± 197.74 ng/ml as compared to control subjects (102.75 ± 49.08 ng/ml, N=12 in each group) but it was statistically insignificant due to the large variation of serotonin level among spray painter’s group. It ranged 45.68–731.07 and 40.85–215.64 ng/ml in spray painter and control group respectively (Table 2). This study indicates that serum seems to be more appropriate biological sample for the relatively easy estimation of serotonin as compared to the other biological media. Higher level of serotonin detected in spray painters over control group might indicate the effect of solvents exposure, physical activity and other confounding factors such as stress, working condition.

Table 1: Levels of serotonin in different biological media in adult young males

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Biological samples</th>
<th>Serotonin (ng/ml)</th>
<th>Normal value ng/ml</th>
<th>Platelet Count x 1000 (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Serum</td>
<td>192.20 ± 124.75 (100.4–577.5)</td>
<td>40–400</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Platelet rich plasma (PRP)</td>
<td>24.89 ± 17.11 (8.51–60.15)</td>
<td></td>
<td>371–1233</td>
</tr>
<tr>
<td>3</td>
<td>Platelet poor plasma (PPP)</td>
<td>±7.38 (6.45–32.8)</td>
<td>&lt;10</td>
<td>0–13</td>
</tr>
<tr>
<td>4</td>
<td>Urine</td>
<td>304.77 ± 137.08 (90.13–573.6)</td>
<td>50–250 µg/day</td>
<td>---</td>
</tr>
</tbody>
</table>
Table 2: Levels of serotonin in urine in Spray painters and healthy control subjects

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Serotonin in urine (ng/ml)</th>
<th>Normal value (µg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical parameter</td>
<td>Spray painters</td>
<td>Controls</td>
</tr>
<tr>
<td>Mean ± S D Range</td>
<td>200.91 ± 197.74 (45.68 – 731.07) (N=12)</td>
<td>102.75 ± 49.08 (40.85– 215.64) (N=12)</td>
</tr>
</tbody>
</table>

The higher level of serotonin in exposed workers might reflect the effect of various factors including behavioral and neurological changes. The higher level of serotonin in serum as compared to the plasma rich in platelets reflects the rupture of platelets resulting in higher serotonin level in serum. This was much further lowered in plasma free platelets.

This study indicates that serum seems to be more appropriate biological sample for the estimation of serotonin as compared to the other biological media. Higher level of serotonin detected in spray painters over control group might indicate the effect of solvents exposure, physical activity and other confounding factors.
Environmental cum medical surveillance study of children residing near the Rampura Agucha mine, Hindustan Zinc Limited, Bhilwara district, Rajasthan

Participating Staff

<table>
<thead>
<tr>
<th>Scientific</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. H. N. Saiyed, -Director,</td>
<td>Shri R. A. Rathod, RA</td>
</tr>
<tr>
<td>Dr. N. G. Sathawara – AD</td>
<td>Shri M. R. Mishra, LT</td>
</tr>
<tr>
<td>Dr. Ranjana Choudhari, RO</td>
<td>Shri R. C. Patel, LT</td>
</tr>
<tr>
<td>Dr. S. R. Tripathi, AD</td>
<td>Shri G. G. Parante, LT</td>
</tr>
<tr>
<td>Dr. Vijay Shivgotra, RO</td>
<td>Shri Idrish Shaikh, L A</td>
</tr>
<tr>
<td>Dr. D. J. Parikh, EMS</td>
<td>Ms. Shruti Patel, Sr. T A</td>
</tr>
</tbody>
</table>

V. S. General Hospital, Ahmedabad

Dr. Vinod Bhadukiya, Pediatrician
Dr. Kosha Gajera, Pediatrician

Ms. Shagufta Shaikh, Project Fellow
Mrs. Nandita Ravi, Project Fellow
Shri Hiraj Patel, L. Attd.
Shri B. V. Vaghela, L. Attd.

The Ministry of Environment and Forests (MoEF), Govt. of India had directed the management of M/S. Rampura Agucha Mine (Hindustan Zinc Limited), P. O. Agucha, Dist. Bhilwara, Rajasthan to carry out study of blood level of population in the vicinity of mine, particularly children. The management requested NIOH to undertake analysis of lead in blood samples of children residing near this mine. Hindustan Zinc Limited (HZL) is the only integrated Zinc manufacturer in India and owns captive zinc mines that supply complete requirement of zinc concentrate for its smelters. HZL operates mechanized open cast (Rampura Agucha Mine) as well as underground mines (Rajpura Dariba and Zawar Mines) in the state of Rajasthan with state of the art technology.

This study was conducted with the following objectives:

1. Community environmental assessment to quantify the lead exposure in air and water in and around the mining area.
2. Medical survey including medical examination of children residing near the mine with supporting parameters like anthropometrics measurements and IQ (Intelligent Quotient) Test.
3. Biological monitoring of assessment of lead in blood of children residing near the mine.
4. To recommend suitable preventive measures to minimize the dust exposure.
This study was divided into two parts i.e. (1). Environmental study and (2) Epidemiological study. Environmental survey included collection of air and water samples from different locations within 2.5 km radius (exposed) and from the location 10 km away from the mine (control). Air and water samples were collected from the exposed villages such as Agucha, Bherukheda-1, Bherukheda-2, Rampura, Parasurampura and Control village – Rupaheli.

A total four hundred fifty two (Exposed–298 and Comparision–154) school children in the age group of 08–14 years studying from 5 to 9 standard were selected randomly. The schools were selected from exposed (Agucha, Bherukheda-1, Bherukheda-2, Rampura, Parasurampura) and control (Rupaheli) villages.

The study consisted of detailed medical examination along with lead estimation in blood samples of randomly selected subjects. A standardized questionnaire was prepared to collect the records of students who were randomly selected for medical examination. Details of personal and general information along with other specific medical examination related to lead exposure was recorded in the pre–designed proforma.

Blood lead level is used as a biological indicator (biomarker) of exposure in the study, whereas clinical findings consisting of symptoms (of lead toxicity) and medical examination were used indicator of effect. The data of anthropometric measurements like height; weight, upper segment and lower segment were also recorded.

An Indian adaptation of Weschler Intelligence Scale (WISC) was administered to assess Intelligence Quotient (IQ). This test is divided in two parts (A) Verbal Test (B) Performance Test. A total of 255 school children (115 boys and 140 girls) were examined. This study group was divided into two groups namely exposed and control (comparison) which were again subdivided according to sex. The scores of psychological tests were converted into scaled scores. Verbal IQ and performance IQ were then evaluated.
The results of analysis of air and water samples showed that most of the observations were below the permissible levels prescribed by Central Pollution Control Board (CPCB), New Delhi. The values of lead in air with respect to various villages near Rampura Agucha mines varies from 0.026 µg/m3 to 1.04 µg/m3 which is in general less than the prescribed levels by CPCB (2006). The lead levels in water samples ranged from 6.3 to 13.3 µg/l and also within prescribed level. Overall, values reported above are well within prescribed limit of 50 µg/liter in potable water samples and 1.5 µg/m3 in ambient air samples.

Blood lead levels in exposed and control group of children studying in various schools, residing in villages near the Rampura Agucha Mines are given in Table-1. It indicates that the mean blood lead levels of exposed children are 7.7 µg/dL with the range of 1.4 to 14.0 µg/dl for boys and 8.56 µg/dL with the range of 1.1 to 14.4 µg/dl for girls and mean lead levels of control group of children are 6.12 µg/dL with the range of 1.10 to 14.0 µg/dL while for girls mean value is 4.63 µg/dL with the range of 0.84 to 14.0 µg/dL.

<table>
<thead>
<tr>
<th>Group</th>
<th>Comparison (control)</th>
<th>Exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>No.</td>
<td>78</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>159</td>
<td>139</td>
</tr>
<tr>
<td>Mean ± S.D.</td>
<td>6.12 ± 2.68</td>
<td>4.63 ± 3.51</td>
</tr>
<tr>
<td></td>
<td>7.70 ± 3.50</td>
<td>8.56 ± 3.49</td>
</tr>
<tr>
<td>Range</td>
<td>1.10–14.00</td>
<td>0.84–14.00</td>
</tr>
<tr>
<td></td>
<td>1.40–14.0</td>
<td>1.1–14.4</td>
</tr>
</tbody>
</table>

Although CNS symptoms are observed in 68 exposed group subjects (22.8%) and 21(13.6%) control group subjects, no clinical signs of lead encephalopathy or peripheral neuropathy are found on medical examination and the CNS symptoms obtained on history cannot be attributed to the lead exposure considering the low blood lead levels (<15 µg/dL).

Gastrointestinal Tract, psychological and renal symptoms are present in 1(0.3%), 1(0.3%) and 3(1%) respectively of exposed group children statistically non–significant. This relative absence of signs and symptoms pertaining to lead toxicity among exposed group can be
explained on the basis of low blood lead levels in exposed group (maximum blood lead level in exposed group found only 14.4 µg /dL). At this level of lead exposure clinical signs and symptoms of lead toxicity are not observed.

Growth and development assessment:
Environmental exposure to lead may delay growth and pubertal developments particularly in girls. In both exposed and control groups, most of the growth parameters like height, weight are showing an increasing trend of values with increasing age, which can be explained as a normal trend. Physical growth parameters of exposed group are comparable with that of control group for both girls and boys.

Psychological test performance:
The result of the children of exposed and control group shows no significant difference on their performance in verbal and performance test in between the groups and sex. Also the total scaled score of I.Q. did not show any significant differences in their performance in both the sex and groups. The scaled score of the verbal sub- test did not show any significant difference on their scores between the two groups viz. exposed and control. Similarly, in the performance sub- test also. Thus, cognition is not found impaired. This indicates that low levels of lead did not affect appreciably IQ levels in both the groups of children.

The environmental monitoring study suggests that lead levels in air and water samples near the mining areas are within the CPCB (2006) prescribed standards. Lead levels in all children residing near the mining (Exposed Group) and away from the mining (Control Group) areas are less than 15 µg /dL. Comparing the two areas it is found that the mean blood lead levels are higher in exposed group than control group. However, the blood lead levels observed near mining area are comparable or less than reported from the other parts of the country. Medical examination of all children did not show any case of lead toxicity/poisoning. Central Nervous System (CNS) related symptoms as reported by the subjects during medical examination
are observed higher in exposed group compared to control group. The higher percentage of CNS symptoms obtained on history cannot be attributed to the lead exposure considering the low blood lead levels of the subjects (<15 µg/dL). The values of physical growth parameters of exposed group are comparable with that of control group for both girls and boys hence it is evident that physical growth is unaffected due to the observed level of lead exposure. IQ tests did not reveal any effect on cognitive performance in both the groups. Overall, findings of this study suggest that even though the lead exposure do exist in mining areas but at present its health risk is not seen/observed in children residing near the mines however intervention strategies are required to control lead exposure in order to safeguard the children.

Recommendations:
1). Periodic medical examination including biological monitoring of the children residing near the mine should be carried out. 2). Periodic assessment of community environment (air, water & soil) for lead should be carried out. 3). Health education and awareness programme related to heavy metals exposure and health effects should be organized for the villagers residing near the mine. 4). Engineering control at the source of the dust exposure should be made more powerful so that emission levels of dust will remain controlled.
Role of environmental chemicals in human reproduction

Participating Staff

Scientific :
Dr. Sunil Kumar, DD (SG)
Ms. Minal Mankad, Sr. Research Fellow

Collaborators:
Dr. N.G. Sathawara, Asst. Director, NIOH, Ahmedabad
Dr. S.S.A. Zaidi, Asst. Director, NIOH, Ahmedabad
Dr. H.U. Doshi, Dept. of Obs & Gyn, BJ Medical College, Ahmedabad
Dr. B. R. Leuva, Dept. of Obs & Gyn, BJ Medical College, Ahmedabad
Dr V. Mishra, High Risk Pregnancy Unit, IKD, Ahmedabad

The environment including physical, chemical, seasonal and lifestyle influences male and female fertility profoundly. The decreasing trend in fertility rates in many industrialized countries is now so dramatic that it deserves much more scientific attention. It is speculated that changing lifestyle and increasing environmental exposures, e.g. to endocrine disrupters and persistent chemicals, are behind the trends in occurrence of male reproductive health problems. Thus the present study was carried out to study the role of toxic exposures—both occupational and environmental on male reproduction. A total of 212 subjects were enrolled randomly in this study. A brief history about smoking, tobacco chewing and alcohol habits was recorded on pre-tested proforma. Information regarding occupational exposure to agents such as metals, pesticides, heat and solvents that could possibly affect spermatogenesis was also recorded. Reproductive history was noted for all the men and their partners, which included duration of active married life, abortions, neonatal deaths, etc.

Semen samples were obtained by masturbation in a sterile container and evaluated for physical parameters and microscopic examination such as total sperm count, motility, morphology, viability, number of pus cells and hypoosmotic swelling test (HOS test). Biomarkers for the function of the accessory sex glands such as zinc for prostatic function, fructose for seminal vesicles, alpha – glucosidase for epididymal dysfunction were
also measured. Analysis of reproductive hormone levels (LH, FSH and testosterone) was carried out in serum as well as seminal plasma. Seminal plasma samples were digested using microwave digestion and Pb, Cd and Cu were measured in serum and seminal plasma using atomic absorption spectrophotometer.

Attempt was made to correlate exposure to toxic substances with semen quality and hormone levels. Levels of metals in blood/serum and seminal plasma were also correlated with semen quality parameters such as sperm count, fast progressive motility, sperm morphology and with biomarkers of accessory sex glands. The results indicated that no statistically significant change was observed in semen parameters among subjects indulging in any of these habits i.e., chewing tobacco and arecanut, smoking, using alcohol. However, among oligozoospermic men, marginally lower sperm count was observed among smokers in comparison to non-smokers, chewers in comparison to non-chewers and alcohol consumers compared to non-alcohol consumers.

While categorizing the subjects into “Exposed to toxic substances” and “Unexposed” according to their status of exposure to toxic metals, pesticides, solvents, heat, etc. based on their occupational history, it was observed that 42% of the subjects had either present or previous exposures to harmful substances. There was a significant effect of exposure to toxic agents on sperm count (p<0.05) after adjusting further effects of possible confounders such as age and seminal plasma zinc. This indicates that persons working in occupations involving hazardous exposure are more at risk of having poor semen quality. In addition, exposure to toxic substances resulted in significant elevation in serum FSH levels, which indicate a probable damage to Sertoli cell function. Further marginally higher LH and lower level of testosterone was also noted in this group of subjects.

Considerable levels of lead and cadmium were observed in seminal plasma indicating that these metals accumulate in the reproductive
organs. The levels of metals in blood/serum and seminal plasma were in the following order: Zn>Cu>Pb>Cd (Table-1). Lower sperm counts were observed among subjects with higher seminal plasma lead levels. Similarly, lead was observed to have a significant negative effect on normal sperm morphology. Further, a significant negative correlation was also observed between seminal plasma lead and mean percentage of sperms having normal double–stranded DNA.

**Table-1: Metal Levels in Blood/Serum and semen Samples**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Biological Medium</th>
<th>Mean ± S.E.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Blood (µg/dl)</td>
<td>24.8 ± 2.1</td>
<td>0–91.2</td>
</tr>
<tr>
<td></td>
<td>Seminal Plasma (µg/dl)</td>
<td>18 ± 1.3</td>
<td>1.5–89.4</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Blood (µg/L)</td>
<td>14.6 ± 3.4</td>
<td>0.2 – 71.6</td>
</tr>
<tr>
<td></td>
<td>Seminal Plasma (µg/L)</td>
<td>8.8 ± 3.0</td>
<td>0.02 – 40.6</td>
</tr>
<tr>
<td>Zinc</td>
<td>Serum (µg /L)</td>
<td>957 ± 42.0</td>
<td>466–1722</td>
</tr>
<tr>
<td></td>
<td>Seminal Plasma (mg/L)</td>
<td>95.5 ± 5.6</td>
<td>8.95–327.6</td>
</tr>
<tr>
<td>Copper</td>
<td>Serum (µg/L)</td>
<td>950 ± 38.0</td>
<td>260–1620</td>
</tr>
<tr>
<td></td>
<td>Seminal Plasma (µg/L)</td>
<td>90.0 ± 60.0</td>
<td>30.0–240.0</td>
</tr>
</tbody>
</table>

Mean zinc level in both serum and seminal plasma was lower among azoospermics compared to subjects with normal count. In addition, positive correlation was observed between zinc and all the sperm parameters, indicating a positive role of zinc in reproductive function. Higher percentage of immature spermatozoa with concomitant decrease in seminal plasma zinc among subjects having higher seminal plasma lead levels suggests that lead may exert its effect by lowering zinc levels and indirectly affecting the antioxidant defense mechanism leading to DNA damage. A negative non–significant correlation was observed between seminal plasma lead and seminal plasma zinc levels (Fig–1).
Mean sperm count, fast progressive motility, and normal morphology values were lower among subjects whose seminal plasma cadmium levels were above 10 µg/L. However, the difference between the subjects having Cd level < 10 µg/L and ≥ 10µg/L was statistically non significant (Table – 2).

Table–2: Comparison of sperm count, motility and morphology based on seminal plasma cadmium level. (Mean ± S.E.)

<table>
<thead>
<tr>
<th>Cadmium level (µg/L)</th>
<th>Rapid Progressive Motility (%)</th>
<th>Count (millions / mL)</th>
<th>Morphology (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>27.4 ± 4.2</td>
<td>53.1 ± 21.0</td>
<td>14.2 ± 1.8</td>
</tr>
<tr>
<td>≥10</td>
<td>21.1 ± 2.3</td>
<td>30.3 ± 10.3</td>
<td>15.4 ± 2.4</td>
</tr>
</tbody>
</table>

The present study clearly suggests that exposure to toxicants through occupation and environment as well as lifestyle factors (tobacco smoking, chewing and alcohol consumption) might play an important role in deterioration of semen quality. Hence, action is needed to reduce the workplace exposure and eliminate unwanted toxicants in the environment.
Chlorpyrifos toxicokinetics in acute poisoning cases

Participating Staff

Scientific:
Ms. Ramavati Pal, SRF
Dr. Aruna Dewan, DD (SG)
Dr. S N Sinha, RO

Among the organo phosphates, chlorpyrifos (o, o-diethyl o- (3,5,6-trichloro-2-pyridinyl) phosphorothioate) is a broad-spectrum insecticide, used to kill a wide variety of insects and hence responsible for the increase in accidental poisoning and suicidal ingestion with this chemical.

At Poison Information Center on an average two confirmed chlorpyrifos poisoning cases report every month. Twenty cases of acute poisoning due to chlorpyrifos were reported from August 2005 till date from different hospitals of Ahmedabad. The Gas Chromatography-Mass Spectrometer (MS/MS) method was used for the quantitative analysis of chlorpyrifos from blood samples of these cases and 24 serial samples of five patients collected on different days were analyzed. The RBC Cholinesterase and Plasma cholinesterase as well as paraoxonase levels of these patients have also been estimated.

Among these five patients two had severe poisoning and the remaining three were of moderate poisoning. Both severe poisoning cases were on ventilator. One (BB) was for 3 days and another (VB) was for 20 days. The average hospital stay for chlorpyrifos acute poisoning patients was 15 days. There were two important observations. One was related to chlorpyrifos concentration in blood, which decreased rapidly within the first few days (Fig.1). The chlorpyrifos concentration in the blood samples of AB was 3.76 ppm on the 1st day of poisoning and it decreased to 0.50 ppm on the 6th day and for DB was 3.3 ppm on 3rd day to 0.3 ppm on 14th day. This shows 70–90% of decrease in chlorpyrifos concentration within 6–9 days. The blood sample of VB was analyzed from 11th
day onwards so there was already a low concentration of chlorpyrifos and it decreased further very slowly. The second observation is that as the chlorpyrifos concentration falls, the RChE level also decreases simultaneously (Fig.2). This may be due to the transformation of this compound into its toxic metabolite oxon as it is reported in earlier studies. But as the method for oxon has not been standardized, it’s difficult to correlate clinical picture with its toxicokinetics. The method for analysis of oxon and TCP are under standardization.

![Concentration Vs Days](image1)

**Fig.1 shows that the levels of chlorpyrifos decreases rapidly within the first few days. (Note: AB, BB, KB, VB and DB are patients).**

![RChE activity Vs Days](image2)

**Fig.2 shows the typical pattern of RBC cholinesterase in chlorpyrifos poisoning as the levels of it decreases initially for about a week and then followed by the recovery. The decrease in activity is due to toxic oxon formation. (Note: AB, BB, KB, VB and DB are patients).**
Fig. 3 shows when the maximum concentration of chlorpyrifos, the RChE level is normal or near by but as soon as it chlorpyrifos gets converted into oxon, the RChE level goes down and recovered again when patient recovers.

Three important observations made out of this study, which are as follows.

1. Chlorpyrifos poisoning is not severe according to our clinical observation and cholinesterase levels. As per our observation chlorpyrifos poisoning is moderate as complete recovery was found in all cases.

2. Initially both RChE and PChE levels fall down within 6–9 days and chlorpyrifos concentration also decreases simultaneously (Figure 1,2,3). The PChE is more inhibited compared to RChE.

3. The decrease in chlorpyrifos concentration may be due to formation of its active metabolite oxon as reported data.
Environmental-cum-epidemiological study of chronic renal failure in Canacona taluka of Goa: Collaborative study

Participating Staff

Scientific Ochratoxin
Dr. H.N. Saiyed, Director Mrs. Anuradha Derasari, T.A.
Dr. A. Dewan, DD (SG) Mrs. H. S. Trivedi, L.T.
Pankaj B. Doctor, SRO Mr. R. R. Teli, L.T.
Dr. V.N. Gokani, D.D Mrs. P. R. Mansuri, L.Asstt.
Dr. V.N. Gokani, D.D Mr. B.V. Patel, L.Asstt.

Technical

Metals
Dr. N.G. Sathawara, A.D Mr. R.A. Rathod – R.A.
Mr. R.A. Rathod – R.A.
Mr. J.B. Vyas, T.A.
Mr. Shashwat Dodia, Proj. Fellow

Participating organization
NIOH, Ahmedabad
Department of Health, Govt. of Goa
Dept. of PSM, Govt. Medical College, Goa

The high prevalence of kidney diseases in Canacona Taluka of Goa has been a matter of concern for the local people as well as administrators for over 20 years. Several representations have been received from time to time by the Directorate of Health Services, Goa, from the residence of Canacona suggesting that the cases of kidney diseases are higher. Department of Health Services Goa and Dept. of PSM, Govt. Medical College, Goa have initiated a descriptive epidemiological study of the chronic renal failure cases in Canacona Taluka in the past two years. In February 2005, a joint team of NIOH scientists and Health officials from Goa examined the epidemiological data from Canacona. After discussion and literature review, it has been felt that clinically the disease seems to be similar to Balkan Endemic Nephropathy (BEN). The present paradigm is that BEN is an environmentally acquired disease. Two most plausible environmental agents supposedly involved in etiology of Balkans endemic nephropathy are mycotoxin produced by fungi in mouldy cereals and food commodities and aromatic compounds present in the drinking water.
Mycotoxins are natural products produced by fungi that evoke a toxic response when introduced in low concentration to higher vertebrates by natural route. Ochratoxin A (OTA) mainly produced by species of *Aspergillus ochraceus* and *Penicillium verrucosum* is a mutagenic, oncogenic and nephrotoxic. OTA is responsible for chronic nephropathy in pigs and also may be the cause of endemic Balkan Nephropathy and some interstitial nephropathies seen in North Africa and France.

Ochratoxin A has been associated with two human diseases: Balkan Endemic nephropathy (BEN) and urothelial Tumors (UT). Although a direct link between BEN/UT and OTA remains to be established, epidemiological data correlates a moderate increase in serum OTA levels with a significantly higher incidence of nephropathy and urothelial tumors in humans. Studies carried out in several countries including Tunisia, Egypt and France have also indicated a link between dietary intake of OTA and the development of renal and urothelial tumors. A recent study by Gilbert et al (2001) has shown that the correlation between urinary OTA concentration and dietary intake appears to be stronger than the corresponding relationship between plasma OTA level and intake. Human may take up OTA by the consumption of foods made from contaminated cereals, and other products like coffee, beer, wine, foods of animal origin etc. The estimated tolerance dosages in humans were estimated at 0.2–to 4.2–ng/kg–body weight. Tolerable dietary intake (TDI) is 5–ng/kg body weights per day. European union set the maximum permissible limit for OTA in raw cereal grains and cereal products at 5 and 3 µg/kg, respectively and in dried vine fruits at 10 µg/kg (EC, 2002). The study has been carried out with the following objectives:

1. To study the presence of metals like lead, cadmium, arsenic and mercury from drinking water, fish, soil and blood samples.
2. To isolate the ochratoxin producing fungi from the indoor environment of residential premises and commonly consumed dried fish.
3. To estimate the level of ochratoxin A in urine samples by Reversed Phase HPLC
4. To analyze organic compounds from drinking water samples
Ninety blood samples, 14 soil samples, 38 water samples and 21 dry fish samples were collected from different area of Canacona taluka of Goa. Blood and fish samples were preserved at 4°C until analysis. 50 biological samples (urine) was collected to assess the levels of OTA from suspected cases of Chronic Renal Failure (CRA) and 30 urine samples of matched control subjects was also collected. Mean number of total micro flora (cfu/gm) from the different environmental samples is shown in Table-1.

Table-1: Mean No. of total micro flora from different environmental samples

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Samples</th>
<th>No. of cfu/gm of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Environmental dust (15)</td>
<td>1.2 X 10^4</td>
</tr>
<tr>
<td>2</td>
<td>Scrapped dust (10)</td>
<td>2.93 x 10^3</td>
</tr>
<tr>
<td>3</td>
<td>Dry coconut leaves (5)</td>
<td>1.6 x 10^5</td>
</tr>
<tr>
<td>4</td>
<td>Dry fish (5)</td>
<td>0.8 x 10^2</td>
</tr>
</tbody>
</table>

(Figures in parenthesis indicate No. of samples)

The presence of Ochratoxins A (OTA) in urine samples of suspected cases of chronic renal failure is given in Table-2.

Table-2 : Number of cases for presence of OTA in urine samples

<table>
<thead>
<tr>
<th>Sex</th>
<th>Nos.</th>
<th>No. of positive cases</th>
<th>Nos. below detection limit (0.001 ng/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>22</td>
<td>13 (59%)</td>
<td>9 (41%)</td>
</tr>
<tr>
<td>Female</td>
<td>28</td>
<td>17 (61%)</td>
<td>11 (39%)</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>30 (60%)*</td>
<td>20 (40%)</td>
</tr>
</tbody>
</table>

*Out of 30, level of OTA was found higher in 25 cases and the reported value in healthy person i.e. 0.065 ng/ml.

Table-3 : Levels of OTA in the urine samples of exposed and control subjects

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No.</th>
<th>Concentration of OTA in urine (ng/ml) (Mean±SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected cases of CRF</td>
<td>50</td>
<td>0.14±0.03</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>0.06±0.02</td>
</tr>
</tbody>
</table>
Table–3 shows the levels of OTA in the urine samples of suspected cases of CRF and control subjects. The analysis of lead, cadmium and mercury was carried out using atomic absorption spectrophotometer Mercury in water and soil samples has been analysed and the results are given in Table–4 and 5.

**Table–4 : Levels of Pb, Cd, Hg from water and dry fish samples**  (Mean ± SD)

<table>
<thead>
<tr>
<th>Samples</th>
<th>No. of samples</th>
<th>Pb</th>
<th>Cd</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>36</td>
<td>8.20 ± 8.16 (2-35)</td>
<td>4.05 ± 1.70 (0.7-7.0)</td>
<td>0.07 ± 0.06 (0.01-0.37)</td>
</tr>
<tr>
<td>Dry fish</td>
<td>21</td>
<td>4.85 ± 2.85 (1.6-10.2)</td>
<td>0.46 ± 0.35 (0.07-1.3)</td>
<td>0.04 ± 0.05 (0.01-0.12)</td>
</tr>
</tbody>
</table>

**Table–5 : Levels of lead and cadmium from blood samples***

<table>
<thead>
<tr>
<th></th>
<th>Pb (µg/dl)</th>
<th>Cd (µg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>10.86</td>
<td>0.51</td>
</tr>
<tr>
<td>S.D.</td>
<td>6.26</td>
<td>0.33</td>
</tr>
<tr>
<td>Range</td>
<td>3-34</td>
<td>0.18-0.16</td>
</tr>
</tbody>
</table>

* No. of samples – 90

**References:**


Biomechanics of sitting: 
Influence of seat features and modes of sitting  
(CSIR sponsored project)

Participating Staff

Scientific:
Dr P K Nag, DD (SG)  
Dr Anjali Nag, AD  
Ms Hir Vyas, JRF  
Ms Swati Pal, SRF  
Mr Kalpesh Gosai, SRF  
Mr Sanjay Kotadiya, SRF

Whether or not our bodies are designed to sit is debatable, what isn’t debatable is that sitting is integral of our lives. How we sit and what we sit on are the two potential risks for back pain, due to the sustained load imposed on the spinal and paraspinal structures. Evidences are inconclusive what quantification and scaling available to the researchers to evaluate postural dynamics in relation to sitting modes and seated features. The present contribution focuses on recognizing the dimensional compatibility and stabilometric evaluation of postural orientation to optimize sitting and seat features for future ergo-design application.

There are two different aspects of the study — chair sitting and floor sitting modes, which are two completely varied modes used in distinct occupational setups. The longitudinal investigation covered 30 men, who volunteered in chair sitting study and 10 women, who served as volunteers in the floor sitting study. A test rig system (Figure 1) was designed to undertake biomechanical analysis of the sitters with varied adjustment of chair-desk, and assessment of postural load in sitting and influence of seat features. In chair sitting (men), the study included observation on (a) sequence of dynamic motion, (b) segmental force distribution in sitting, and effects of back contours, (c) geometric parameters of the seat (adjustability to arm and wrist rest, seat height,
depth, cushion angle, slope of the seat pan; stability and suspension). In floor sitting, the study covered (a) determining the force exertion and base of support area, (b) evaluating the stabilometric dimensions derived from measuring the ground reaction force (c) identifying the distribution of the CoP (center of pressure) patterns.

Segmental force distribution
Primarily, there is a lacuna in the data as regard to segmental force distribution of a seated person in a chair-desk complex. The orthogonal force components (Fx, Fy and Fz direction) were determined from the force platform signals, with respect to body segments and seat features (Figure 2). Numerical analysis yielded that the seat pan and the footrest
take up about 70% of the total body force, and the backrest takes about 12% of the total force. The study included multiple parameters related to seat dimensions and geometry (seat height, depth, slope of the seat pan, adjustability to arm and wrist rest) and the relative force distributions indicate the importance of the design of the component parts. To examine the seat dynamics, other factors such as the suspension and synchro mechanism are to be considered in relation to segmental force distribution.

![Diagram of force distribution](image)

*Figure 2. Segmental force distribution, as measured from piezoelectric force platform*

**Floor sitting modes**
Women adopt unique floor sitting modes to perform domestic chores and other informal occupational activities. The postural stability of a sitting mode might determine the extent of time that a woman can maintain a posture uninterrupted, and in turn indicate its relative comfort. The study attempted to apply stabilometry to characterize the body pressure distribution and categorize the floor sitting modes of women. The stabilometric dimensions derived from measuring the ground reaction force reflected the displacement of CoP of a person within a plane parallel to the support surface, and the characteristics of low amplitude body
oscillation and postural control. Eight modes of floor sitting (Figure 3) had variations with respect to (a) pelvic support (present or absent), (b) leg position (bent, extended or crossed) and (c) body orientation (straight/sideways). The floor sitting modes had variations as regard to the positioning of the body segments and the surface area occupied as the base of support. The base of support was largest in the squatting posture (Pos 1, 354 ± 80 sq.cm) and lowest in Pos 4 (200 ± 56 sq cm) where only feet were in contact with surface. In chair sitting, however, the contact area (92 sq. cm) was similar, as the volunteers sat on the marked seat pan. The floor sitting modes had unique variations in CoP displacement due to the base area of support, and therefore, the net force distribution and its direction of exertion were also marginally influenced by the sitting modes. The resultant force expressed as a fraction of the total body weight yielded highest in Pos 4 (50.0 ± 5.6 kgf); incidentally, this level of force was about 3% higher than the force exerted during standing. On the other hand, Pos 5, 7 and 8 having extended legs had force distribution of about 8% less than recorded in Pos 4, indicating relative stability of the posture. These aspects of the findings are further being investigated from the recording of the muscle load of different body parts.

![Figure 3. Floor sitting modes](image)

**CoP pattern categorization**

The personal characteristics and the sitting variations effect the afferent and efferent feedbacks, and the interactions manifest in low amplitude body oscillations, as reflected in the CoP displacement pattern. The postural control mechanism that exhibits passive acceleration appears to be a promising approach in characterizing sitting behavior and categorizing CoP spread pattern. The theory of wavelet transformation (WT) was applied for systematic analysis of time–frequency/scale evaluation of transient CoP signals. The WT allowed identifying body
oscillation characteristics, as shown in Figure 4. The sample illustration indicates two peaks with relative energy content at given scales to frequency. Generally, this stabilometric dimension indicates the direction, area and the speed of body displacement.

Based on analysis of nearly 700 CoP displacement characteristics in medio–lateral and antero–posterior direction, the trace graphs (based on distance and angle between the CoP point and the barycentre) were categorized for CoP spread pattern, as shown in Figure 5. Eleven distinctive CoP patterns were characterized, as the combined influence of sitting modes and personal characteristics. It was noted that most women volunteers were similar in body mass index and habituated in floor sitting modes. The CoP butterfly pattern (4) was prevalent (25%). The three most prevalent patterns (4,6,3) represent 60%, however, the CoP pattern (1,2 and 8) were less prevalent (3.6%).

The postural control is critical for optimal motor functions and stability. The question remains whether the stabilometry can be adequately be applied in postural evaluation and control, with reference to distinct sitting modes of chair and floor sitting. Perhaps, this is the first reported evidence of characterization of body displacement in sitting postures. The preliminary study reiterates that the stabilometric approach has a high promise in understanding the floor sitting postures and further
multi-dimensional scaling of the involved components might suggest a better combination of sitting modes and features for postural stability and comfort in use.

Figure 5. Center of pressure (COP) characterized into eleven distinctive patterns among women in floor sitting modes
Ergonomics of human-computer-interaction compatibility assessment

Participating Staff

Scientific:
Dr. P. K. Nag, DD (SG)
Dr. Anjali Nag, AD
Ms. Swati Pal, SRF

A massive use of computer technology revolutionized the world of work, and consequently, the workplace has fundamentally changed the way men and women do work. As a result, video display terminal operators are subject to a potential risk of developing various musculoskeletal disorders, which result from sustained sitting, constrained work posture, equipment, workstations, office environment, or job design, or from a combination of these. The project has the primary objectives to elucidate the multiple approaches of examining the work stresses of computer operators. The study focuses on the aspects of human–computer interaction (HCI) compatibility/incompatibility and ergonomics work design measures for a more comfortable and safe work.

The study included both field and longitudinal laboratory investigations. A cross-sectional field survey among the professional computer operators from the telecommunication sector (N=315) explored the aspects of work in relation to human–computer interaction. According to their type of activity, the operators were divided among 5 workgroups, including call center and help line (work group 1), data entry (work group 2), across counter customer services (work group 3), programming, draft and letter writing (work group 4) and fault repairing (work group 5). Excessive use of VDT is associated with their continuing epidemic of potential health effects of cumulative musculo–skeletal injuries, biomechanical strains and other related problems. In order to address the physical compatibility aspects of HCI, a new laboratory set up (Figure 1) include 3D motion analysis and electromyographic systems, and
stabilometric measurement system using force platforms. A simulated seat system with a fixed base support was fabricated to make multiple adjustment of the chair–desk–keyboard complex for VDT work to explore the musculo–skeletal and biomechanical stresses of computer operators. The reflecting markers were used for joint motion analysis. The electromyographies of 8 muscles were recorded simultaneously through the electrodes placed on the forearms, shoulder and back.

An interviewer–administered checklist, comprising of 21 modules of checkpoints was adopted for work analysis of the computer operators. The relative loadings of the work stressors (Figure 2) indicated that the response patterns of the computer workgroups differed widely to different work stressors. The detailed component analysis showed that for wrkgrp1, component 1 is broadly associated with training and recognition, job feedback, monitor, task variety, organizational issues and lighting and that explained about 21.1% of the total variance. For the wrkgrp2, the stronger component (component 1) is associated with workplace design, job autonomy, feedback, lighting, monitor; job related exercises and that explained 16.4% of the total variance. For wrkgrp3, the component 1 explained 17.5% of the total variance and covered the items, such as keyboard and pointing devices, skill requirement, job related exercises, climate. For wrkgrp4, the first component consists of skill requirement, noise, mental load, corrective eyewear, monitor, job feedback and explained 23.6% of the total variance and for wrkgrp5, component 1 explained 18.7% of the variance and covered mental load, climate, job specialization, noise and annoyance.
Figure 2. Relative loading of the HCI stress variables in different workgroups, recorded as agreement/disagreement (Likert scale).
The lighting and illumination, monitor and job feedback checkpoints were responded similarly for wrkgrp1 and 2, and fell under component 1. The checkpoints on physical work were responded similarly by wrkgrp1, 2, 3 and 4, and fell under component 2. The mental load was a predominant work stressor in the wrkgrp 4 and 5, and grouped under component 1.

The laboratory study focused on multiple adjustment of the chair–desk–keyboard complex, effect of different types of input devices, influence of wrist rest to determine overall muscular loading and postural characteristic of sitting, using 3D motion analyzer and other instrumental set up. Comparison of RMS ratio for different keyboards indicated that KB4 demanded relatively less muscular load in comparison to other three keyboards (Figure 3).

Figure 3. RMS amplitude of different muscle groups with changes in types of keyboard characteristics. Muscles of right and left side: Flexor digitorum superficialis (FDS), Extensor digitorum (ED), Upper trapezius (UT), Erector spinae (ES), at L5–S1 region.
Tukey's HSD test also showed that the muscle load at 1st, 20th, 40th and 60th sec is significantly less (p<0.05) for KB4 than the other three keyboards for Rt FDS, Rt and Lt ED, Rt and Lt UT and Rt ES. Apart from the relative amplitude of the muscle activity, the signal content represented by defining intensities in time and frequency (continuous wavelets transformation) was passed through wavelet transformation to characterize the activity pattern and to better understand the underlying processes of muscle loading in keying work. The theory of wavelet transformation (WT) was applied for analysis of time–frequency/scale evaluation of transient signals. The mathematical functions in WT allow cutting up signals into different frequency components, and each component with a resolution matched to its scale, representing a signal in terms of a finite length or fast decaying oscillating waveform. The extensive computation yielded the time–frequency domains of EMG of different muscles, which were taken to analyze the oscillations of the EMG signal as part of the muscle activation at a given point in time. The sample analysis (Figure 4) of the flexor digitorum superficialis allowed emphasizing that the scale to frequency content of the muscle signal varied over time with the keying tasks.

Figure 4. Amplitudes of wavelet transform of flexor digitorum superficialis of right side in keying task.
Our previous study included assessment of several seat dimensions and examined its relative influence in the muscle load of upper and lower back, as well as some arm muscles during computer work. The computer input devices and types of work (text processing, graphics manipulation and data entry) have bearing on the loading of the upper and lower back muscles. The median frequencies of the upper trapezius fibers stayed at higher level with the increasing keyboard height from 24 to 30 inches with reference to chair height of 18 inch. The trend of the data is indicative that the kind of computer work may determine the workstation design requirements. The decrease in the median frequency in case of graphics application at 21 inch chair height indicated the distinctive fatiguing trend of the muscle, in comparison to other computer tasks.
Design improvisation of personal cooling garment system (PCGS)

Participating Staff

Scientific                Technical
Dr. P.K. Nag, DD (SG)    Dr. S.P. Astekar, LT

Heat protective garments (e.g., ice vest, air-cooled vests, wettable covers) have been developed to conserve a comfortable microclimate. Industrial protective clothing, like fuel handler suits, chemical warfare suits, pressure suits, suits worn in a radioactive environment and immersion (anti-exposure) suits impede body heat exchanges. Cognizant of the problems of industrial workers and other vulnerable groups, such as cardiac insufficient persons accidentally exposed to high heat, a personal cooling system (PCG) was designed and fabricated for accelerated body cooling. The current development is the design improvisation of the previous design of the water-cooled garment, developed in the laboratory.

Salient Design Features of the Improved Cooling Garment

1. The PCG system is a microclimate auxiliary cooling system that comprises a jacket-like enclosure, creating an interior space around a person’s upper part of the body.

2. The coolant is re-circulated in three-layered vest of fabric lined with interwoven latex tubing and inter-spaced coating of rubberized solution.

3. The PCG is a modular design of coolant re-circulating units. At present, there are three different sizes of coolant unit (sizes can be varied, depending on the size and shape of the body area and to the extent of cooling required).
4. One circular unit (Sink) consists of 5-meter tube length of 2 mm internal diameter, and nine such units are interconnected for upper body part cooling. One unit holds 20 ml of coolant; therefore, 9 units hold about 180 ml of coolant. The total tubing length is around 50 meter including interconnection to coolant reservoir. (Figure 1)

5. Other rectangular units (one unit of 28-meter tube length, having 225 ml coolant capacity, and two units of 14-meter length) were made for test measurement.

6. The original design could achieve liquid flow rate at about 2.5 to 5 liter/hour. The present system has limitation on the flow rate due to the portable power supply and pump used. However, the selection of the ice cooled coolant at 5 to 10°C is re-circulated through the circular tubing (Sink) partially improved the efficiency of the system. A small sized portable water pump is immersed into the liquid coolant kept in double-layered reservoir bottle of a size of 1 litre capacity. The low temperature of the coolant creates a microclimate temperature condition and thereby promotes heat transfer between the wearer's body and circulating fluid.

7. There were limitations on the test measurement; however, in the present analysis, it was possible to include high speed recording of the thermal profile across the sections of the garment system. Also, the thermal scanning of the sink (Figure 1: lower 2 figures) indicated that the effective cooling area i.e. 24 °C was obtained in sink 1 and sink 3 as they were nearer to the inlet temperature as compared to sink 2 and sink 4.

8. The laboratory test measures included the heat exchanges through the garment layer, evaporation required by the body ($E_{req}$), evaporation through skin ($E_{sk}$) as well as the physiological data (e.g. metabolic rate, mean skin and core temperature, rate of sweating) and the ambient environmental conditions.
9. The gradient of temperature between the ambient and garment environment was higher at higher ambient heats, indicating the garment was more effective at higher ambient heat. For example, at 40°C ambient temperature, the gradient was about 10°C at 0.3 m/sec air velocity as shown in the Figure 2. Whereas, in lower ambient condition (<30°C ambient temperature at 0.3 m/sec air velocity), the gradient of microclimate and ambient conditions was about 3°C.

10. Worker tolerance time was greatly increased because of wearing the PCGS. With wearing the PCG, the young volunteers sustained comfortable heat balance over 2 hours exposure in extremely hot environment at about 40°C or above. Significant advantages occur when the work area temperature is over 45°C.
11. The covered upper body part area is about 0.30 sq m (20% of the total body surface area). Similar local ensemble for upper and lower limbs will be added benefit to attain better thermal comfort. This suggests that even localized cooling of any part of the body has some influence on other segmental areas.

12. PCG system is portable and easy to set up and use. Different size and shapes of the tubing units can be interconnected easily for localized cooling of the body area. It has therapeutic application in inducing controlled cooling or warming, as required of the heat exchange of the person.

13. PCG is lightweight (about 0.75 kg), electrically or battery operated system. The reservoir bottle and pump accessories had an additional weight of about 1 kg. PCG system is useful to provide auxiliary body cooling to maintain comfortable microclimate, skin and body core temperatures. PCG system is found to be comfortable and less fatiguing. It improves tolerance to heat stress and enhances work performance.
14. Caution is needed to avoid compression of the tubing and interruption of the water flow in the clothing ensemble. If the jacket is not frequently used, the affluent coolant needs to be pushed out of the tubing for hygienic reasons. The effective use time of the garment is limited by the amount of coolant available in the reservoir and by the build-up of inlet water temperature.

15. Research is on going for better design and improvisation of the PCG structure in climatic chamber studies; the present PCG system holds high promise for wider use in industry and other workplaces.
Electromyographic and biomechanical analysis of VDU operators in relation to postural stress and musculoskeletal discomfort

(ICMR SRF Programme)

Participating staff

Scientific:

Ms. E. Poddar, SRF
Dr. P.K. Nag, DD(SG)

The work of the above stated project focuses on the problem issues of the VDU operators, who commonly suffer from the work related musculoskeletal discomforts due to prolonged computer use. The reasons for high prevalence for such problems seem to be multifactorial and one important factor is assumed to be static muscle load, which may be caused by work posture, work task, workstation designs.

Longitudinal studies aimed at quantifying the muscle load in VDU work and find out the less stressful workstation set up for users comfort and safety. In particular, this study was designed to evaluate (a) how postural load of VDU operators was influenced by different workstation set up and (b) to identify less stressful workstation set-ups. A mixed model design was used to test for main effects of the workstation set up on the activity of forearm, shoulder and lower back muscles. The workstation designed for the experiment (Figure 1) had combinations of chair height, Keyboard height and Monitor height, as shown in Table 1.

Fig. 1 Photograph of VDU operator during experiment
Table 1. Different workstation set up included in the laboratory experiment

<table>
<thead>
<tr>
<th>Workstation set up (C)</th>
<th>Chair height (inch)</th>
<th>Keyboard height (inch)</th>
<th>Monitor height (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 1 (C15:K24:M27)</td>
<td>15</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Condition 2 (C15:K27:M27)</td>
<td>15</td>
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<td>Condition 5 (C15:K30:M30)</td>
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<td>Condition 6 (C15:K24:M33)</td>
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<td>Condition 9 (C18:K24:M27)</td>
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<td>Condition 14 (C18:K24:M33)</td>
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<td>Condition 15 (C18:K27:M33)</td>
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<td>Condition 17 (C21:K27:M27)</td>
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<td>Condition 18 (C21:K27:M30)</td>
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<td>Condition 19 (C21:K30:M30)</td>
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<td>Condition 20 (C21:K27:M33)</td>
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<td>Condition 21 (C21:K30:M33)</td>
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When seat height was constant at 18 inch, word processing operators showed lesser loading in FDS, ED and BR for the keyboard height of 30 inch, 27 inch and 27 inch respectively. In case of data entry and graphics operators the loading was not changed apparently according to the keyboard height. Fatigue trend was found in FDS in graphics and word
processing operators in FDS when keyboard height was 30 inch (seat height 18") (Figure 3).

![Fig 2. Changes of MDF in RES, LES, UT and LT in different seat height](image)

**Fig. 2. Changes of MDF in RES, LES, UT and LT in different seat height**

![Fig 3. Changes of MDF in FDS, ED, FCR and BR in different keyboard height (when seat height was constant at 18")](image)

**Fig 3. Changes of MDF in FDS, ED, FCR and BR in different keyboard height (when seat height was constant at 18")**

**Influence of work tasks on the muscle load during VDU work**

Word processing showed highest intercept RMS values in FDS, ED, FCR, UT, LT, LES and RES muscles compare to graphics and data entry operators. Word processing operators showed highest load in ED, FCR, and RES muscles when chair height was 15inch. Where as when chair
height was 15 inch, they showed higher loading in FDS, BR, UT, LT and LES. On the other hand, graphics operators showed relatively higher loading in their fore arm, shoulder and lower back muscles when chair height kept in 15 inch excepting FDS. Data entry operators displayed higher loading in shoulder and lower back muscles when chair height was lowest (15 inch). Their hand muscles were loaded relatively higher level when chair height was 18 inch.

Influence of workstation set up on the muscle load during VDU work

**Back muscles and seat height**

It is observed that when the operators were involved in word processing task, the mean RMS (ratio) of right erector spinae (RES) was higher when seat height was 21 inch. On the other hand, the mean RMS (ratio) value of left erector spinae (LES) was higher when seat height was 18 inch among same group of operators. Among the operators who were performing graphics application the mean of RMS (ratio) was lesser when seat height was 21 in RES and higher in LES. The mean amplitude of RMS (ratio) of data entry operators was lesser when seat height was kept at 21 inch in RES and at seat height 15 inch in LES.

**Forearm muscles and keyboard height**

Increased loading in case of word processing operators in FDS when keyboard heights were kept at 30” and chair height was kept at 15”. In case of ED the same phenomena has been observed. Loading of FDS was also higher among them compare to the others. The loading of FCR was lesser in word processing operators when keyboard height was 27” (seat height 15”). Other type of operators showed almost same loading of the entire arm muscles in all the heights. When seat height was constant at 18 inch, word processing operators showed lesser loading in FDS, ED and BR for the keyboard height of 30 inch, 27 inch and 27 inch respectively. In case of data entry and graphics operators the loading was not changed apparently according to the keyboard height. Fatigue trend was found in FDS in graphics and word processing operators in FDS when keyboard height was 30 inch (seat height 18”). It was found that in case of word
processing operators the keying operation was different than data entry operators. It also reveals that the muscle load is greatest in word processing than graphics and data entry job. Granstrom et al. (1985) stated that the amplitudes of the EMG curve are related to the muscle load. According to them, the distribution of amplitudes during a work cycle is often used to describe the variations in workload. We can also suggest that word processing \((F (20,413) = 3.13)\) and graphics application \((F (20,520) = 2.52)\) give greater load in FCR compare to data entry operation \((F (20,625) = 2.52)\).

**Load shifting**
The load of erector spinae remains continuous during VDU operation. That may be because of maintaining upright sitting posture. It was found that during graphics application the load of right erector spinae was lesser but the load on left erector spinae remained higher. That may be the reason of load shifting. During word processing at seat height 21 inch the load of right erector spinae was higher but the load of left erector spinae was lower also supports the hypothesis that there was load shifting from right to left erector spinae.

**Back muscles and seat height**
As the chair height varied the back muscle loading was also different. Word processing and graphics operators showed decreasing in frequency level during higher chair height (21") in RES and UT. From the result we can say that the seating heights increased the fatiguing trend of the back muscles. This trend was not found in LES and LT in case of word processing operators may be because of load sharing of RES and UT. It can be suggested that lower seat height between 15 and 18 inch would be less stressful for the operators.

**Forearm muscles and keyboard height**
Low frequency component was visible in forearm muscles (FDS, ED, FCR and BR) in case of the VDU operators when keyboard height was higher compared to sitting height. It means that if keyboard height remains higher compared to sitting height there may be relatively greater chance of
fatiguing of fore arm muscles earlier. On the other hand, the same keyboard height (30 inch) seems to be much less stress full for the fore arm muscles of operators when it was set in comparison of higher seat height (18 inch). We can suggest from this part of the study that higher keyboard height gives lesser forearm muscle load when sitting height would be higher and vice versa.

In conclusion, the computer work is potentially stressful job for the operators who are professionally involved for long duration. The project comes out with some significant findings for ergonomically designed and scientifically tested comfortable workstation elements. The study emphasizes that with the variation in task the muscle load changes and the physics of the workstation elements must be changed for different job tasks. Muscle loading is substantially high in this apparently sedentary job for longer working duration. The type of job essentially determines the relative less of muscular stress; apparently in the highest to lowest order of severity — graphics – data entry – word processing. The workstation characteristics, as elaborated in the report, are the first rank stressors, in comparison to the types of jobs. During data entry operation high frequency muscle contraction in the forearm, shoulder and lower back muscles reflected. Higher seat height is preferable for graphics application work. Over all the sitting height between 15 inch and 18 inch would be less stressful.
Experimental studies on chronic arsenic (As) exposure
Part I : Endocrine and reproductive dysfunction

Participating Staff

Scientific :
Dr. H.N. Saiyed, Director
Dr. (Mrs) K.G. Patel, D.D.
Dr. Sunil Kumuar, D.D. (Sr)
Dr. N.G. Sathwara, A.D
Mr. D.N. Gandhi, S.R.O.
Mr. Ashok Kumar, A.D.

Technical :
Mrs. K.R. Aggarwal, R.A
Mr. S.N. Yadav, T.A.
Mr. G.M. Panchal, L.T.
Mrs. B.A. Shah, L.A.
Mr. M.M. Madia, L.A.
Mr. B.A. Parmar, L.A

This research proposal aims at assessing the risk of inorganic arsenic exposure through intrauterine exposure with reference to endocrine and reproductive dysfunction in rats. Time pregnant rats were procured from the National Institute of Nutrition, Hyderabad. 1 to 2 days pregnant albino rats (about 10 weeks old) were treated orally with 0, 1.5, 3.0 and 4.5 mg of Arsenic /Kg/day from Day-8 to up to parturition.

The observations on weight gain of dams, gestation period, number of pups per litter, male female sex ratio, the live birth index, viability index and weaning index were recorded. Data revealed that there were not major changes in weight gain of dams, gestation period, and number of pups per litter as well as male female sex ratio. It was observed that live-birth index was between 100% in treated and non-treated groups. However, viability index and weaning index was lower i.e. about 82 and 86% respectively in 4.5 mg/kg treated group compared to 97% in control.

No abnormality was observed in physical development landmarks parameters such as fur formation, eye opening, pinna detachment, incisor eruption observed in offsprings. No considerable alteration in the weight of the male sex organs like testis, epididymis, vas deference, seminal vesicles, prostate glands and other vital organs (adrenal, liver & kidney) were observed in any treated groups. Serum testosterone, LH and FSH levels will be measured. The testicular and associated tissues have been processed for histopathology. Blood and testicular samples for the determination of arsenic residue have been stored properly.
Experimental studies on chronic arsenic (As) exposure
Part II: Neurobehavioral dysfunction

Participating Staff

Scientific: Technical Staff:
Mr. D. N. Gandhi, SRO Mr. G.M. Panchal, LT
Mr. S. Yadav, TA Mr. S. Yadav, TA
Mr. N.V. Parmar, LA

The possible neurobehavioral adverse effects of the heavy metal Arsenic (As) on male and female offspring rats exposed *in utero* and during lactation were investigated. Dams were treated orally with 0, 1.5, 3.0 and 4.5 mg of Arsenic /Kg from Day–8 to up to parturition. Maternal and behavioral outcome data and for ages at development of physical development as well as behavioral landmarks (Reflex development, Motor & coordination and Spontaneous motor behaviors) were assessed. Behavioral endpoints of the male and female offspring were examined (D–0 to D–30) at weaning as well as at post-natal exposure (Up to 50Days) to same doses of Arsenic (0.0, 1.5, 3.0 & 4.5 mg/Kg orally) at weaning to adulthood. In this study we examined neurobehavioral-screening battery consists of a functional observational battery (FOB), which is a series of tests to assess sensory, neuromuscular, and autonomic function, and an automated measure of motor activity. These tests are primarily intended to provide dose–response and time–course data, as well as profiles of neurological effects, which can then be used to make decisions concerning a compound’s neurotoxic potential and lead to subsequent studies for risk assessment.

In the present study, behavioral endpoints of the male and female offspring were examined at (D–0 to D–30). No change or abnormality was observed during maternal and behavioral outcome for ages at development of physical development as well as behavioral landmarks such as Reflex development, Motor and coordination and Spontaneous motor behaviors at given all doses. At post-natal exposure (up to 50
days) to same doses of Arsenic at weaning to adulthood. In this study we examined neurobehavioral-screening battery consists of a functional observational battery (FOB), which is a series of tests to assess sensory, neuromuscular, and autonomic function, and an automated measure of motor activity.

- Sensorimotor functions/measures such as approach response (Ranked), touch response (Ranked), click response & tail–pinch response (Ranked)
- Neuromuscular function/measures such as gait abnormality (Ranked), air righting reflex (Ranked), Landing foot splay (mm), posture (Ranked), forelimb grip strength (kg)
- Autonomic function/measures such as salivation (Ranked), lacrimation (Ranked), palpebral closure (Ranked), pupil response (Quantal), urination (Count) and defecation (Count)
- CNS activity and Excitability Function/measures such as handling reactivity (Ranked), Ease of removal (Ranked), arousal (Ranked); rearing (Count); convulsions and tremors (Quantal); vocalization (Quantal);
- Stereotype behaviors (Repetitive observation).

Observed behavioral endpoints indicate that Arsenic has not affected significantly with all three doses of arsenic indicating that arsenic might not cause observable changes in the function of the sympathetic and para-sympathetic nervous system.
Lead exposure and control programme in small and medium scale lead based industries  
(ICMR EMS Project)

**Participating Staff**

**Scientific**
- Dr. D.J Parikh, EMS
- Dr. H.G. Sadhu, A.D.
- Dr. N.G. Sathawara, A.D
- Mr. B.C. Lakkad, D.D
- Dr. Rajesh Beniwal, R.O

**Technical Staff**
- Mrs. R.S. Kapadia, T.O.
- Mr. M.M. Patel, R.A.
- Mr. B.U. Leuva, L.A.
- Mr. R.A. Rathod, R.A.
- Mr. H.D. Patel, L.A.
- Mr. Idrish Sheikh, L.A.

**Project Staff**
- Mr. Umesh Mishra, JRF
- Ms. Shruti Patel, Sr.T.A.
- Mrs. Nandita Iyer, Proj.Fellow
- Ms. Shagufta Sheikh, Proj.Fellow

Present study was carried out in small and medium scale battery manufacturing units, lead starate manufacturing unit, lead oxide manufacturing unit and lead recycling unit in Ahmedabad and nearby places. In the medium size units, the workers have to do a specific type of job, where as in small ones, they have to perform all types of jobs for a longer duration as the job demands. The study included assessment and evaluation of lead exposure and its health risk, in organized medium scale battery unit and unorganized small-scale lead based units.

**Organized Sector:**
During medical examination of 145 workers, sign and symptoms like pain in abdomen, metallic taste, muscular tremor, increased frequency of micturition, vomiting and constipation, etc. were observed more in workers working in Production Department (118) compared to Administrative Department (27) of this battery manufacturing unit. This may be due to absorption of lead fumes/dust inhaled or ingested by the workers working in Production Department.

The mean lead levels in 27 employees working in Administration Department (Office, Canteen, Security, etc.) were $33.2 \pm 13.2 \mu g/dl$ while the mean pb levels of 117 workers engaged in Production Section (like lead alloy, grid casting, lead oxide manufacturing, paste making, pasting of plates, curing of plates, formation of plates, dry charging of plates, and battery assembly) were observed as $44.9\pm17.6 \mu g/dl$. These results indicate that higher lead levels are being observed in number of workers (especially from production section) in this unit compared to $40 \mu g/dl$ prescribed by American Conference of Governmental Industrial Hygienists (ACGIH). The results of hematological examination of
battery workers revealed that the mean hemoglobin content among workers of Production Department was found slightly less than of the Administrative Department. This indicates that the hem synthesis might decrease with high level of lead exposure in the workers. Overall, this survey definitely indicates high concentration of lead in blood in the battery-manufacturing unit.

Unorganized Sector:
Medical examination of 45 workers was carried out in four type of lead based small-scale unit e.g. battery manufacturing unit, lead stearate plant, lead oxide plant and battery recycling unit. Workers were mainly non-smokers but most of the workers working in Production Department were having the habit of tobacco chewing. Considerable numbers of workers were having higher systolic blood pressure (130mm Hg) and diastolic blood pressure (90mm Hg).

The signs and symptoms like pain in abdomen, muscular tremor, constipation etc. were observed more in workers working in production department compared to administration department of these small scale units. However, in comparison to high lead levels, the lead poisoning/toxicity signs and symptoms are not seen in clinical examination.

The mean lead levels in 13 workers of Administrative Department [like office, security, driver etc] were 50.8±31.2µg/dl, while it was 94.3±22.3 µg/dl in 31 workers working in production department (carrying out various activity for the production of lead oxide manufacturing of battery, production of lead stearate and production of lead ingots during battery recycling). This result indicates very high lead levels in many workers of both the departments in all four units compared to 40 µg/dl prescribed by ACGIH.

Hematological examination of these workers revealed that hemoglobin content in workers of production section was found less than the workers working in the administrative section.

This pilot study revealed some positive sign and symptoms of lead toxicity among the workers. As considerable number of workers have very high concentration of blood lead levels in these units. This may be attributed to the fact that poor infrastructure at the work places like restriction of air movement due to poor ventilation, poor house keeping and absence of suitable exhaust system to remove the lead fumes/dust to expel there by polluting the premises leading to health hazards. While the exposure is comparatively less in medium scale battery manufacturing units due to better hygienic and engineering control. Educational awareness among workers and owners, preventive and intervention strategies are required to minimize the lead exposure in small and medium scale units.