Occupational Health Hazards Due to Exposure in Chemical Industries, Mines & Environment

Vinay K. Khanna, Ph.D.
CSIR - Indian Institute of Toxicology Research
M.G. Marg, Lucknow – 226 001, India
Motto – Safety to Environment and Health and Service to Industry

- Environmental Toxicology
- Food, Drug and Chemical Toxicology
- Nanomaterial Therapeutics & Toxicology
- Regulatory Toxicology
- Systems Toxicology and Health Risk Assessment
The institute aims to accomplish its goals through the following objectives:

✓ Mode of action of toxic chemicals/pollutants

✓ Safety evaluation of chemicals used in industry, agriculture and everyday life

✓ Remedial/preventive measures to safeguard health and environment from pollutants

✓ Occupational health hazards due to exposure in chemicals industries, mines, agricultural fields and environment

✓ Simple/rapid diagnostic tests for diseases caused by industrial and environmental chemicals

✓ Collect, store and disseminate information on toxic chemicals

✓ Human resource development for dealing with industrial and environmental problems

✓ Provide a platform to public and entrepreneurs to address queries and concerns regarding safety/toxicity of chemicals, additives and products
Epidemiological Studies on Health Hazards in Industries, Mines, and Environment

- Health Survey of Saw Mill Workers, Lucknow
- Health Survey of Metalware Workers, Moradabad
- Health Study of Workers Engaged in Local Thermal Power Station, Lucknow
- Health Survey of Cotton Mill Workers, Kanpur
- Health Study of Welders
- Health Examination of Tannery Workers
- Bio-Monitoring for Fluorosis, Gusainganj, Lucknow

Continued ……
Monitoring of air-borne concentration of asbestos fibre content in the occupational environment of U.P. Asbestos Ltd., Mohanlalganj, Lucknow

Occupational Exposure to Phosphine in Indian Workers (Collaboration with SGPGIMS, Lucknow)

Health Survey of Pesticide Sprayers, Malihabad

Magnitude and Usage Pattern of Artificial Synthetic dyes in Foodstuff
Building blocks – Living/Non-living things

Natural/ Synthetic Food, Fabric Medicines Computer Fuel, Industries Byproduct used chemical process

Improve the quality of life

Innovation

Process

Magnitude of Hazards Dose/ Duration/ Age

Produced

Used

Disposed

CSIR - IITR
Environmental Chemicals

- Metals
- Monomers
- Pesticides
- Solvents
- Radioactive materials
- Natural and animal toxins
- E-Waste
Occupational Exposure – Routes

Inhalation
Nearly all airborne materials can be inhaled

Dermal Absorption
Through contact of substance / chemicals on the skin

Ingestion
Unintentional (As most workers do not swallow materials deliberately) / Intentional

Injection
Associated with blood borne pathogens through sharp objects / needles
Risk and Hazard – Major Difference

Risk

Chance or probability that an individual could be harmed or experience adverse health effect on exposure

Hazard

Source of potential damage, harm or adverse health effect on something or some one in a certain work condition

Risk assessment / Modeling to avoid hazards
Chemical Exposure and Visibility of Effects

Environment

Exposure
Single/ Combination/ Mixture

Health Effects
Transient/ Persistent

Visibility of Effects
Immediate/ Latent/ After Long Time

Chemical Industries

Mines
Health Hazards – Influencing Factors

**Vulnerability**
- Age/Gender
- Race
- Life style
- Genetic factors
- Medical history

**Work place/Exposure Conditions**
- Physical properties
- Multiplicity of exposure
- Duration of exposure
- Magnitude of exposure
- Timing of exposure
# Occupational Exposure to Chemicals and Associated Health Effects

## Cardiovascular Disease

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Industries</th>
<th>Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead, Cadmium</td>
<td>Battery mfg. and recycling</td>
<td>Hypertension</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>Degreasing, Dry cleaning</td>
<td>Atherosclerosis</td>
</tr>
<tr>
<td>Fluorocarbon, Trichloroethylene</td>
<td>Refrigeration, Solvent workers</td>
<td>Arrhythmias</td>
</tr>
</tbody>
</table>

## Respiratory Diseases

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Industries</th>
<th>Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvents, Ammonia</td>
<td>Chemical industries</td>
<td>Irritation, Inflammation</td>
</tr>
<tr>
<td>Inorganic dust</td>
<td>Mining, Coal, Construction, Sandblasting, Plating, Metal refining</td>
<td>Pneumoconiosis, Cancer</td>
</tr>
<tr>
<td>Chromium</td>
<td>Plating, Metal refining</td>
<td>Cancer</td>
</tr>
</tbody>
</table>
### Occupational Exposure to Chemicals and Associated Health Effects

#### Liver Diseases

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Sources</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon tetrachloride</td>
<td>Cleaning fluids, Dry cleaners</td>
<td>Acute liver toxicity</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>Plastics and Vinyl chloride mfg.</td>
<td>Liver cancer</td>
</tr>
</tbody>
</table>

#### Skin Diseases

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Sources</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic epoxides</td>
<td>Plastic industries varnish</td>
<td>Allergic/contact dermatitis</td>
</tr>
<tr>
<td>Cutting oils, Grease</td>
<td>Machine-tool operators</td>
<td>Acne</td>
</tr>
<tr>
<td>Arsenic, tar Pesticides</td>
<td>Petroleum refinery, Agricultural workers, Manufacturing and packaging industries</td>
<td>Skin Cancer</td>
</tr>
</tbody>
</table>
### Renal Diseases

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Industries</th>
<th>Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury, Cadmium, Pesticide</td>
<td>Battery, chemical industries</td>
<td>Acute/Chronic Renal failure</td>
</tr>
<tr>
<td></td>
<td>Pesticide handlers</td>
<td></td>
</tr>
</tbody>
</table>

### Blood Diseases

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Industries</th>
<th>Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Battery mfg., Lead smelting</td>
<td>Anemia</td>
</tr>
<tr>
<td>Benzene</td>
<td>Solvent &amp; soap mfg.</td>
<td>Aplastic anemia</td>
</tr>
</tbody>
</table>
## Occupational Exposure to Chemicals and Associated Health Effects

<table>
<thead>
<tr>
<th>Nervous System Disorders</th>
<th>Mercury</th>
<th>Pesticides</th>
<th>Lead</th>
<th>Cadmium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
<td>Thermal power plants, Ore processing</td>
<td>Agriculture, Manufacturing and packaging industries</td>
<td>Battery workers, Paint industries, Glass industries</td>
<td>Battery workers, Paint industries, Glass industries</td>
</tr>
<tr>
<td><strong>Health Effects</strong></td>
<td>Headache, Dizziness, Memory loss, Insomnia, Anxiety</td>
<td>Neurobehavioral abnormalities, Impaired motor functions, Cognitive deficits</td>
<td>Wrist drop, Muscular weakness, Seizures, Tremors, Low IQ (children)</td>
<td>Impaired motor functions, Learning disabilities</td>
</tr>
</tbody>
</table>
## Nervous System Disorders

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Activities</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Production of alloys, refining of lead and copper, pesticides, semiconductors, electroplating</td>
<td>Impaired verbal comprehension and long term memory, Slurred language, Auditory damage, PNS, Low IQ in children</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mining, welding, Ferro-alloy industries, alkaline batteries, Mn-based pesticides</td>
<td>Abnormal gait, Hallucination, Manganism, Parkinsonism, Heightened aggressive behavior</td>
</tr>
</tbody>
</table>
Mercury poisoning - Kodaikanal

One of the popular tourist attraction of Tamil Nadu; Shola forests of Western Ghats famous for carpets of green grasslands

1983 – Chesebrough Pond’s relocated Thermometer factory from Watertown, NY (later acquired by HUL in 1986)

Residential locality; Eco-sensitive area

2001 – Residents and environmental groups uncovered a dump site – 7.4 ton stockpile of crushed mercury containing glass, spilled on the ground in scrap yard

Also dumped mercury containing waste in the part of the Shola forests in company premises
Mercury poisoning in Kodaikanal - Environmental Contamination

Department of Atomic Energy –

Kodaikanal lake contaminated with mercury (Dispersal of elemental mercury to atmosphere and water through effluents from the factory)

## Mercury levels

<table>
<thead>
<tr>
<th></th>
<th>Kodaikanal lake</th>
<th>Berijam lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moss and Lichens</td>
<td>7.9 – 8.3 ug/kg</td>
<td>0.2 ug/kg</td>
</tr>
<tr>
<td>Fish</td>
<td>120 – 290 mg/kg</td>
<td>-</td>
</tr>
</tbody>
</table>

Just 1g mercury disposed may contaminate the lake (25 acre) and its inhabitant – unfit for human consumption
Mercury poisoning in Kodaikanal – Health effects

Over 1,100 workers in the factory; Unaware of the risks and dangers while handling mercury

No safety equipments, No proper facilities to cleanup after working, No face masks that could reduce the intake of mercury from air

Contract workers handling the mercury with bare hands during the clean up; Family members also exposed through them

Initially – Headache, Skin rashes, Spinal problems

Environmental mercury – Kidney, Liver, Eyes, Brain, Reproductive system and Birth defects
Mercury poisoning in Kodaikanal – Health effects

Preliminary Health check up – 2 Occupational and Community Health Specialists from Bangalore

30 Workers and ex-workers
- Gum and dental problems
- Mood swings and nervous disorders
- Skin allergies

Medical health check up sponsored by company –
Ruled out associated health problems with mercury exposure

18 ex-workers, 09 children of former workers died due to illness

Miscarriages, congenital abnormalities, physical and mental disorders reported in many workers – Associated with mercury exposure
Mercury poisoning in Kodaikanal – Ultimate Fate

2001 – Factory closed 18 years after operation

2003 – TNPCB ordered to send back the dumped mercury waste (289 ton) to US for recycling and disposal

2004 – The SC Monitoring Committee ordered the company to clean the contaminated site and surrounding area.

TNPCB permitted to dispose of equipments in the contaminated area
Endosulfan disaster - Kasargod

An organochlorine pesticide used in agriculture and allied sectors

US EPA – Highly hazardous category, Considered as POP, Banned in many countries

1976 – 2000 - The Plantation Corporation of Kerala (PCK), sprayed endosulfan aerially on cashew plantations over an area of 12000 acres in 9 villages of Kasargod district three times a year to eradicate tea mosquitoes

Over 50,000 villagers of the Kasargod district exposed; Over 3,000 people living near downstream and downwind were affected by debilitating diseases

NHRC mandated the NIOH, Ahmedabad to investigate the issue – Aerial exposure associated with health problems
Endosulfan Disaster – Health Impacts

Physical and behavioral disorders
Cardiovascular diseases
Sensory loss
Neurological ailments
Congenital Anomalies
Dermatological and Musculoskeletal disorders

Environmental studies – Presence of endosulfan in soil, water, sediments, cashew leaves

Biological studies – Concentration of endosulfan, levels of hormones – growth, thyroid and reproduction

Epidemiological studies – Assess the disease burden, incidences of selected diseases

CSIR - IITR
CSE, New Delhi; NIOH, Ahmedabad, KAU, Thiruvananthapuram
Endosulfan – Problem of Disposal

Remaining endosulfan stored in HDPE drums

HIL has come up with new technology to neutralize stored endosulfan (1,600 litres) in Kasargod – Operation Bloosom Spring (following the norms of FAO)

To come up with a clear and effective plan to dispose remaining stock of endosulfan in Kasargod
A Study by NIOH, Ahmedabad

Effects of Endosulfan

- Absorbed through skin
- Gets into humans mostly through water and food
- Affects central nervous system, kidneys, liver and reproductive system

Results of medical survey

<table>
<thead>
<tr>
<th>Disease</th>
<th>Sprayed area</th>
<th>Non-sprayed area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital anomalies</td>
<td>95</td>
<td>70</td>
</tr>
<tr>
<td>Mental retardation</td>
<td>97</td>
<td>83</td>
</tr>
<tr>
<td>Cancers</td>
<td>58</td>
<td>34</td>
</tr>
<tr>
<td>Infertility</td>
<td>104</td>
<td>75</td>
</tr>
<tr>
<td>Repeated abortions</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Growth retardation</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>Movement disability</td>
<td>67</td>
<td>04</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Psychiatric problems</td>
<td>46</td>
<td>33</td>
</tr>
<tr>
<td>Other problems</td>
<td>54</td>
<td>0</td>
</tr>
</tbody>
</table>

A study by the National Institute of Occupational Health has linked the pesticide to higher prevalence of neurobehavioural disorders, congenital malformations in female children and abnormalities in male reproductive systems in Padder village of Kasaragod district.

(Source: State Health Department)

An Example - Pesticides Exposure

Single, Short term
High level exposure
Accidental / Suicide

Long term
High level exposure
Pesticide Formulation and Manufacturers

Long term
Low level exposure
Individual / General population through contamination

Similar / different problems at different places
A crucial economy sector that includes utilization of metallic and non-metallic minerals

Indian mining sector – Daily employment – 5,60,000; 87% (4,90,000) in public sector and 13% (70,000) in private sectors


Regularly exposed to dust of potential pollutants and toxicants – chromium, lead, mercury, cadmium, manganese, aluminum, fluoride, arsenic etc.

Occupational health assessment of chromite toxicity among Indian miners – AP Das and S Singh, Indian J. Occupational Environ. Med. 15, 6-13, 2011 (Data compiled by OSHA, Odisha SPCB and Odisha VHA used to assess the risk of diseases among Sukinda chromite miners)
Pathways from exposure to disease – Modifying factors and opportunities for intervention

CSIR - IITR

Additive or Synergistic Co-exposure

Genetic Susceptibility

Age, Gender, Nutrition, Behavior

Modifying Factors

Exposure Concentration

Exposure Duration

Exposure Frequency

Dose

Biomonitoring

Screening Wellness programs

Surveillance

Occupational health standards

Personal protective equipments

Engineering and administrative controls

Healthy Worker

Subclinical Disease

Repair

Adverse Health Effects

Progression

Casarett and Doull’s Toxicology, 2001
Recommendations

✓ Periodical monitoring and determination of chromium concentrations in work area

✓ Characterization and quantification of toxic Cr (VI) in mine environment be studied

✓ Regular health checkup of workers (estimation of Cr (VI) in body fluids and tissues)

✓ Create awareness among the workers to protect them by training and educational programmes
Medical Surveillance

Know the hazard
- How worker is exposed?
- How worker is affected?

Characterize the hazard
- Exposure levels
- Exposure duration

Know the worker
- Susceptibilities

Obtain information on medical examinations
- Directed towards specific organ system

Analyze Medical Data
- Disease, recovery, rehabilitation
  Effectiveness or failure of control measures
How Prepared We Are?

- Planning
- Prevention
- Preparedness
- Response
- Recovery
Acknowledgements

Rajendra K. Shukla
Pranay Srivastava

References –
and http://nim.nih.gov
Thank You