It is a matter of serious concern that despite taking measures to control benzene and aromatic content in petrol through successive stages of emissions standards which had initially borne results in terms of reducing ambient benzene concentration, the levels are rising again in many Indian cities. Benzene — a volatile compound of petrol — is a toxic air pollutant and a known human carcinogen. This can be extremely harmful even at trace amount. Benzene being a part of volatile organic compounds also contributes towards formation of yet another harmful gas – ozone.

1.1 Ambient levels of benzene

Scary collage of data is emerging from the air quality monitoring of the Central Pollution Control Board (CPCB). In prominent cities of Bangalore, Chennai, Delhi, Kanpur, Pune, and Kolkata significantly high levels have been reported. The National Ambient Air Quality Standards have adopted the annual average standard of 5 microgramme per cum for benzene. In contrast, the daily average levels reach alarming heights of more than 100 microgramme per cum in Bangalore, close to 55 microgramme per cum, 35 microgramme per cum in Delhi and 50 microgramme per cum in Kolkata (See Graph 1: Benzene levels in key cities). This shows very high daily exposure.

In Delhi CPCB and Delhi Pollution Control Committee (DPCC) monitor the ambient benzene levels. The available data shows that the ambient concentration of benzene has increased quite notably in two heavy traffic locations – Civil Lines and Airport (see Graph 2: High benzene levels in heavy traffic locations of Delhi)

Independent studies carried out by the scientists of Jawaharlal Nehru University during
two different time periods — year 2001-2002 and winter months of 2007 show increase in benzene levels in the city. The annual average benzene concentration for the earlier period was around 86.47 +/- 53.24 micro-gm per cubic metre. But subsequently the average benzene concentration has shot up to 187.49 +/- 22.50 micro-gm per cubic metre. The study has attributed this to rising level of vehicular population in the city. This emerging data demands immediate action to reduce the benzene levels. (Graph 3: Benzene levels in winter months of 2001-02 and 2007)

1.2 Local concentration of benzene in and around refueling stations in Delhi

A very important source of benzene emissions is evaporation of petrol from petrol tanks, refueling and vehicles. Petrol is a very volatile substance. It quickly evaporates during loading and dispensation. This contributes towards high ambient concentration in petrol pumps. This makes the refueling stations high risk areas.

Available data shows very high concentration of benzene, toluene and xylene these are the prominent group of volatile organic compounds – (benzene being the most harmful of
BENZENE LEVELS

them) in and around petrol pumps in Delhi. This is responsible for very high occupational exposure to petrol pump workers and dealers. This also puts those visiting petrol pumps at risk.

Some recent data is available from a study conducted by Meena Sehgal and others of The Energy and Resources Institute (TERI) and published in International Journal of Environmental Studies in 2011. This study has monitored benzene at 40 petroleum-filling stations in Delhi and within the breathing zone of the dispensing crew during 2009–2010. This shows extremely high concentration of benzene, toluene and xylene especially during dry season. The maximum concentration was phenomenally high — 6406, 5890, and 9512 microgram per metre cube, respectively, during winter months. The study covered fuel stations belonging to Indian Oil, Hindustan Petroleum and Bharat Petroleum located in South Extension, Lodhi Road, Defence Colony, Vikas Marg, Connaught Place and Chanakyapuri. (See Graph 4: Maximum VOC levels (benzene, toluene, zylene) recorded in petrol pumps in 2009-10)

The same study has tried to assess the difference in emissions with and without the petrol vapour recovery system that traps petrol vapour in refueling stations. The results for the same locations with and without vapour recovery systems in the dry season shows that operation of vapour recovery systems can reduce emission of benzene, toluene, and xylene, as much as by 49 percent. But this also means that the vapour recovery system with much higher efficiency levels are needed to reduce the local impacts more drastically. (Graph 5: VOC levels at different refilling stations with and without vapour recovery system during winter season)
2. SERIOUS HEALTH CONCERNS

Benzene is a potent carcinogen and is blamed for leukaemia. The WHO estimates a 4 in 1 million risk of leukaemia on exposure to benzene to a concentration of \(1 \, \text{g/m}^3\). According to US EPA acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupational settings.

Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus have been observed in animal tests. Increased incidence of leukemia (cancer of the tissues that form white blood cells) have been observed in humans occupationally exposed to benzene.

3. SOURCES OF BENZENE

The prominent sources are vehicles and fuels that will require strong action.

3.1 Fuel source

- Benzene and aromatic content of petrol are the principle sources of benzene. Benzene and aromatic compounds occur naturally in petroleum and become more concentrated when petroleum is refined to produce high octane gasoline. Refinery strategies are needed to reduce their content without affecting the octane rating of the fuel. While benzene requires direct control total aromatics also need reduction as these can also contribute towards formation of benzene.

In Bharat Stage IV petrol benzene content is one percent, total aromatics is 35 percent and olefins 18 percent. At Euro V and VI levels benzene and aromatic content will not change but olefins will be reduced further to 13 percent. The global best practice shows that benzene content – as in the US — is further reduced to 0.62 percent and the aromatics to 25 percent in polluted areas.


Graph 5: VOC levels at different refilling stations with and without vapour recovery system during winter season

Table 1: Reduction in benzene in petrol

<table>
<thead>
<tr>
<th>Date of introduction</th>
<th>Benzene content in petrol</th>
<th>Areas covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1996</td>
<td>No spec</td>
<td>Entire country</td>
</tr>
<tr>
<td>April 1996</td>
<td>5%</td>
<td>Entire country</td>
</tr>
<tr>
<td>April 2000</td>
<td>3%</td>
<td>Metro cities</td>
</tr>
<tr>
<td>November 2000</td>
<td>1%</td>
<td>NCT and Mumbai</td>
</tr>
<tr>
<td>2005</td>
<td>1%</td>
<td>All metro cities</td>
</tr>
</tbody>
</table>

- Evaporative losses from refueling stations: There is need for clear strategies for controlling evaporative emissions from transportation used (tank trucks: loading, transit, etc); storage in service stations: bulk fuel drop losses and underground tank breathing losses; motor vehicle tanks: and refueling losses. All these stages require strategic control. As mentioned earlier petrol is volatile and evaporates quickly and adds to the emissions. Globally, therefore the petrol vapour is recovered as saleable liquid petrol, at a rate of 1 litre of petrol from 1000 litres of vapour, and this is sold back to the motorist.

3.2 Vehicular source

Both exhaust emissions as well as evaporative emissions from vehicles can contribute to the ambient levels. In Delhi high vehicular volume has been blamed for rising benzene levels.

- Exhaust emissions from vehicles:
  - Cars: Advanced three-way catalytic converters have been introduced in petrol cars. These are expected to scavenge the harmful toxic emissions. The lambda testing in Delhi is also expected to ensure proper functioning of cat converters.
  - Two- and three-wheelers: The transition from old two-stroke engines to four stroke engines in two-wheelers has helped to lower the exhaust emissions significantly (Graph 6: Exhaust benzene emissions from two-wheelers). However, there is still a sizeable on-road fleet of two-stroke engines and also those without catalytic converters that are needed to clean up the exhaust toxics. Improving the fuel quality further in reducing in-use emissions.

- In newer two- and three-wheelers further tightening of emissions standards will help to further lower the overall volatile organic compounds and hydrocarbons.

- It is also important to ensure that all three-wheeler models – petrol as well as gaseous fuel models — are fitted with catalytic converters.

- Evaporative emissions from vehicles: Benzene emissions can increase from evaporative losses from vehicles themselves.
  - Cars: One strategy that has already been adopted for cars is to have evaporative standards to minimize evaporative emissions.
  - Two-wheelers: Evaporative emissions standards have not been adopted for two-wheelers yet. This has already been done in countries like Thailand. In India estimates of evaporative emissions from two-wheelers are not available in public.
Global assessments have shown that motorcycles equipped with carburettor emit about 1.2-1.3 kg hydrocarbons/year/vehicle. The fuel injection system can reduce this quite significantly.

- Need on-board vapour recovery: In addition to evaporative standards it has now been further mandated in the US and Europe to equip the vehicles with on-board recovery of petrol vapour and to put it back in the tank. This is urgently needed in India as well to control evaporative losses from the vehicles.

3.3 Fuel adulteration
Can be a serious source of benzene. This must be checked with zero tolerance.

5. EVAPORATIVE LOSSES LEAD TO SERIOUS ECONOMIC LOSSES

Concerted effort should be made to raise awareness amongst both petrol pump dealers as well as the vehicle users that evaporative losses mean direct economic losses. In fact, 1000 cum of vapour is equivalent to losing about a litre of petrol. This therefore, makes eminent sense to capture the vapour and put it back in the tank to save fuel. This is also important for energy security.

6. WHAT OTHER COUNTRIES ARE DOING TO REDUCE EVAPORATIVE LOSSES IN REFUELING STATIONS?

The vapour recovery and controls for evaporative losses have progressed quite a lot globally. The strategies are targeted at capturing petrol vapours in refueling stations and vehicles and also improvement in fuel quality.

6.1 Europe
- Stage I Petrol Vapour Recovery: The Directive 1994/63/EC in Europe was designed to prevent emissions of volatile organic compounds during the storage of petrol at terminals and distribution to service stations. This first stage Directive contained measures that terminals should have floating roofs and reflective coatings so as to reduce evaporative losses from storage tanks. In addition when petrol is loaded onto tankers and transported to service stations vapour is recovered and returned to the...
tanker or terminal. Similar measures are deployed for underground tanks.

- **Stage II Petrol Vapour Recovery**: Stage II petrol vapour recovery further evolved that involves over and above the state I system the provision of recovering petrol vapour displaced from the fuel tank of a motor vehicle during refuelling at a service station and transferring that petrol vapour to an underground storage tank at the service station or back to the petrol dispenser for resale. This directly returns petrol vapour to the fuel pump instead of only to the underground storage tank, as is the case with conventional vacuum-assisted systems. The system is fitted directly to the dispenser without the need for substantial forecourt excavation and underground works, resulting in substantial installation-cost savings. The Council and the European Parliament adopted a new directive 2009/126/EC to ensure the recovery of petrol vapour. The Member States have until 31 December 2011 to transpose the Directive into national law. Stage II equipment is already installed in petrol stations in about half of the Member States. The proposed directive will extend this practice to the whole of the EU.

Inside a car’s petrol tank, petrol vapour exists above the liquid petrol. When the car is refuelled this vapour is displaced and escapes to the atmosphere. Stage II captures this escaping vapour. This is done by creating a vacuum to suck back the vapour through the dispensing hose and nozzle, either to the station’s underground storage tank or directly back to the fuel pump. This latter technology is newer and does not require any modification of the underground pipe work of the service station. Petrol vapour capture efficiency must be 85% or more.

### 6.2 United States

- **Vapour Recovery Stage 2**: Vapour Recovery Stage 2 was first developed in California and mandated in San Diego County in 1973. Orange and Bay Area Counties followed soon after, introducing Vapour Recovery Stage 2 in 1973. The 1990 amendments to the US Clean Air Act mandated Vapour Recovery Stage 2 in areas that had not consistently met ozone standards across the US, for service stations with throughputs greater than 0.5 million litres of petrol a year. US rules designate a vapour-recovery efficiency of 95 per cent and require California Air Resources Board (CARB)-type approval of VR2 equipment.

- Vapour Recovery Stage 2 is currently in place in urban areas in 27 US States, and state-wide in six States. It was introduced at a national level from November 1993 in areas that had not consistently met ozone standards.

### 7. IMPLEMENT ACTION PLAN TO REDUCE EVAPORATIVE LOSSES OF FUEL IN REFUELING STATIONS

The following strategies may be implemented to reduce benzene levels in and around petrol pumps and also the ambient concentration in Delhi.

#### 7.1 Owners of the refueling stations and the concerned oil companies should be made responsible for installation of vapour recovery systems with at least 90 percent efficiency for recovery within six months

Delhi will have to install vapour recovery systems in all its refueling stations to recover the petrol vapour and put it back in the storage tank/dispenser as well as vehicle tank. This can save fuel as well as fuel costs. Discussion with the oil companies are fuel
dealers association shows they are sensitive to the problem. According to the Petrol Dealers Association about 10-11 petrol stations out of about 215 refuelling stations in Delhi have installed some form of vapor recovery. The observed efficiency rate is about 50 per cent.

Immediate steps be taken to install Stage I and II systems of at least 90 per cent efficiency in all petrol pumps of Delhi within six months.

Action: Ministry of Petroleum and Natural Gas, Oil Companies

7.2 The Ministry of Road Transport and Highways to notify evaporative emissions standards for two-wheelers soon
The Ministry of Road Transport and Highways should notify evaporative emissions standards for two-wheelers and three-wheelers soon. The MORTH must also announce the next stage of exhaust emissions standards for two-three-wheelers. Ensure that all three-wheelers come equipped with catalytic converters.

Action: Ministry of Road Transport and Highways

7.3 The Ministry of Road Transport and Highways should notify onboard refuelling vapour recovery (ORVR) in vehicles
Onboard refuelling vapour recovery (ORVR) is the state of the art emission-control system in the vehicle itself that utilises a large activated carbon canister to capture fuel vapours from the vehicle's petrol tank during refueling. This is now being enforced in the US and Europe.

Action: Ministry of Road Transport and Highways

7.4 Ministry of Petroleum and Natural Gas to review the global best standards for benzene, aromatics and olefins in petrol for adoption and implementation
In the US benzene content in petrol has been further reduced to 0.6 percent. It is also important to carry out fuel quality monitoring to check for the actual level of benzene and aromatic. Cities require special checks for fuel adulteration as well.

Action: Ministry of Petroleum and Natural Gas

7.5 Ambient benzene monitoring
DPCC and CPCB to strengthen regular monitoring and reporting of VOC and benzene levels in and around refueling stations and in hotspots in Delhi to track change. Also investigate trends and source in benzene hotspots like Civil Lines and Airport.

Action: Central Pollution Control Board, Delhi Pollution Control Committee, and other state boards