Environmental Impact and Risk Assessment of Phthalate Contamination in Indoor Dust and PM_{10} from Car Repair Workshops

Nadeem Ali[1]*, Ahmed Saleh Summan[2], Muhammad Salman Zeb[2], Mansour A. Alghamdi[2]

[1] Center of Excellence in Environmental Studies, King Abdulaziz University, Jeddah, Saudi Arabia; [2] Department of Environmental Sciences, Faculty of Environmental Sciences, King Abdulaziz University, Jeddah, Saudi Arabia; ✉ nabahadar@kau.edu.sa

Background & Significance

Phthalate esters (PAEs) are high-production-volume plasticizers widely used in automotive materials including:

- ➢ Flexible PVC components
- ➢ Dashboard plastics
- ➢ Wiring insulation
- ➢ Lubricants and sealants

Because PAEs are not chemically bound to polymers, they readily migrate into indoor dust and airborne particles. While residential exposure has been widely studied, occupational exposure in small-scale auto-repair workshops remains poorly characterized, particularly in the Middle East.

Car repair workshops represent:

- ❑ High plastic material turnover
- ❑ Frequent mechanical abrasion
- ❑ Elevated indoor particulate generation
- ❑ Limited ventilation

This combination suggests potential for chronic adult occupational exposure.

Study Design & Methodology

- ○ This study quantified 14 priority phthalate esters (DMP, DEP, DiBP, DnBP, DMEP, DEEP, DPP, DnHP, BzBP, DnBEP, DCHP, DEHP, DnOP, DNP) in **25 paired indoor samples** (settled dust and PM_{10}) collected from active car repair workshops in Jeddah, Saudi Arabia.
- ○ A cross-sectional sampling design was applied. Settled floor dust was collected using a standardized vacuum-based method, followed by homogenization and sieving prior to analysis. Airborne PM_{10} was simultaneously sampled during active working hours using a Micro-Environmental Monitor 400 equipped with quartz fiber filters.
- ○ Phase partitioning between settled dust and airborne particles was evaluated to assess distribution behavior in workshop environments. Chemical analysis was performed using Gas Chromatography–Mass Spectrometry (GC–MS), with strict QA/QC procedures including blanks and calibration verification.
- ○ Occupational exposure via dust ingestion and inhalation was subsequently estimated to assess cumulative phthalate burden and environmental implications.

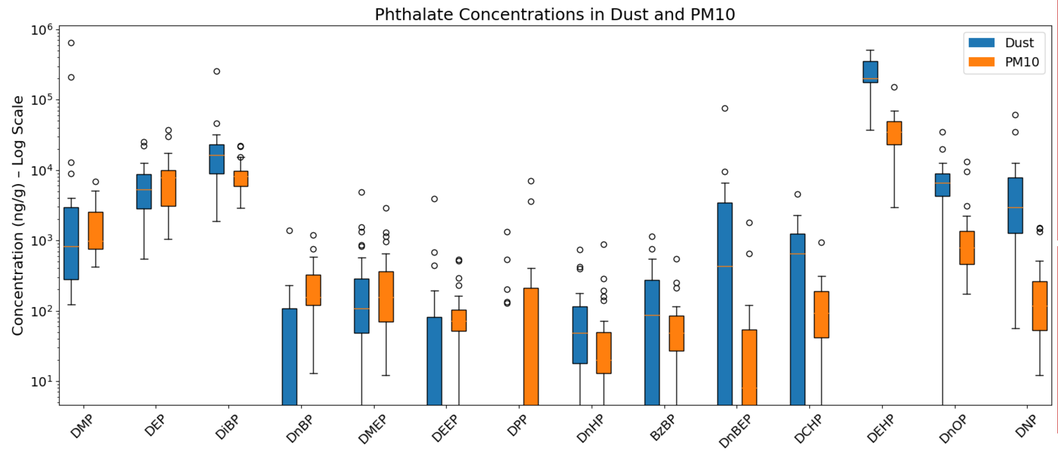

Figure. Log-scale box plots showing the distribution of phthalate ester (PAE) concentrations (ng/g) in settled dust (blue) and airborne PM_{10} (orange) collected from car repair workshops. Each box represents the interquartile range (IQR), the central line indicates the median, whiskers represent variability, and points denote outliers. The logarithmic scale was applied to accommodate wide concentration ranges across compounds.

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◆ Key Findings

- **Pervasive contamination:** All 14 phthalates detected in dust and PM_{10}.
- **Dust as dominant reservoir:**
  - – DEHP overwhelmingly dominant (Mean: 4.1×10^5 ng/g; Max: 8.0×10^5 ng/g)
  - – Elevated BzBP, DEP, DiBP
  - – Indicates continuous input from automotive plastics
- **Airborne pathway confirmed:**
  - – DEHP mean in PM_{10}: 2.8×10^3 ng/g
  - – DiBP, DEP, DMP also significant
  - – High variability suggests episodic emissions

◆ Occupational Exposure

- Exposure via dust ingestion + PM_{10} inhalation
- **DEHP drives cumulative burden:**
  - – Median: 538 ng/kg bw/day
  - – 90th percentile: 1055 ng/kg bw/day
- Other contributors: BzBP, DEP, DiBP, DMP, DnOP

◆ Environmental & Health Significance

- Phthalates linked to endocrine, reproductive, and developmental toxicity
- Extremely high DEHP suggests:
  - – Continuous release from plastics
  - – Dust accumulation under limited ventilation
  - – Possible enhancement under high temperatures
- Car repair workshops = under-recognized adult exposure hotspot

◆ Global Context

- Dust levels approach/exceed high-contact residential & industrial settings
- Occupational exposures comparable to certain manufacturing environments
- Highlights small-scale enterprises as overlooked exposure sources

◆ Risk Mitigation

- Phthalate-free material substitution
- Improved ventilation & dust control
- Worker hygiene training & PPE

◆ Conclusions

- Widespread phthalate contamination in auto-repair workshops
- DEHP overwhelmingly dominates environmental & occupational burden
- Dust reservoir + airborne PM_{10} = dual exposure pathway
- Targeted occupational risk management is warranted.