Evaluation of POPsME to assess Environmental Exposure to PAHs in Seoul and Neighboring Areas, Korea

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ABSTRACT

A multimedia fate and transport model named POPsME has been developed to describe the long-term average behavior of persistent and semi-volatile organic pollutants. It is an unsteady and spatially distributed mass balance model including compartments for air (gas and particles), water (dissolved and suspended solid), bottom sediment, bare soil, coniferous plants and the soil, deciduous plants and the soil, and farm land. The model has been designed to have variable spatial resolution and Monte-Carlo simulation capability. The model is in evaluation phase with 16 polycyclic aromatic hydrocarbons (PAHs) (which were measured for the purpose of model evaluation) in a domain of the Seoul metropolitan and neighboring areas (about 150km x 150km) of diverse land uses. As the emission history was highly uncertain, the average emission rate was back-calculated from the measured atmospheric concentration, which proved to be useful particularly when the emission occurs primarily via air and the wind transport dominates. The measured and predicted concentrations of benzo(a)pyrene agreed well for air, soil, and sediment at the levels of ~10^{-12}mol/m^3, ~10^{-5}mol/m^3, and ~10^{-5}mol/m^3, respectively. In water, the dissolved phase concentration was underpredicted by a factor of 10 while the suspended solid phase level was overpredicted by a factor of 10. The disagreement arouse mainly from large uncertainties in the description of runoff and the mass balance of suspended solids in the water body. Improvement is also necessary for the description of the exchange rate between dissolved phase and SS phase as better agreements were obtained under equilibrium assumption. Comprehensive evaluation is underway against other PAH compounds.

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Background

♣ **a part of project to build an integrated risk assessment system for sound management of PBT organic substances**

emission
→ *distribution in multimedia environment*
→ *multi-pathway exposure*
→ *risk assessment*

Hazardous Organic Substances in Multimedia Environment & Ecosystems, GSES, SNU, Korea

Objectives

♣ **Developing a multimedia environmental fate and transport model, POPsME (POPs in Multimedia Environment), to**

1. *understand changes in environmental levels of PAHs in time and space.*
2. *assess long-term environmental exposure levels for human and aquatic organisms.*
3. *identify activities and environmental processes and parameters significantly influencing exposure levels.*

Hazardous Organic Substances in Multimedia Environment & Ecosystems, GSES, SNU, Korea

Scope

1. Space
Seoul and neighboring areas (150km x 150km) with varying grid size
-will expand for entire Korean Peninsula

2. Time
unsteady output relevant to seasonal variation over periods of a few decades

3. Evaluation

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Structure

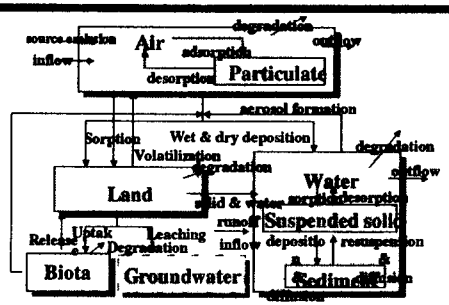


Fig. Schematic Diagram of This Model.

Evaluation

1. ***correctness and adequacy of the processes and their mathematical descriptions***
2. ***sensitivity and uncertainties***
3. ***grid size effect***
4. **test against multimedia monitoring data (B(a)P)**

Sensitivity and Uncertainties

1. ***emission history (forest fire ?)***
2. ***dry and wet particle deposition flux from air to land and water***

and, particularly during heavy rain periods,

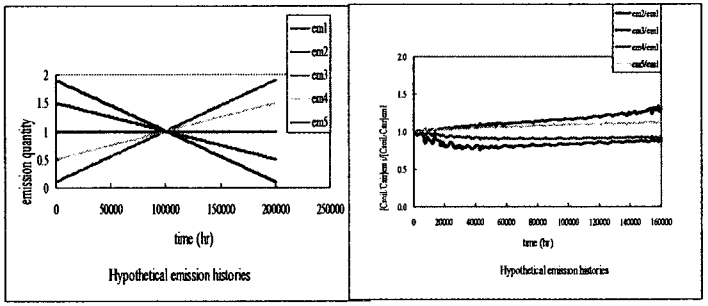
3. ***surface run-off (solids)***
4. ***SS balance (sedimentation, resuspension)***
5. ***sediment flushing***

Uncertainty in Emission Estimate

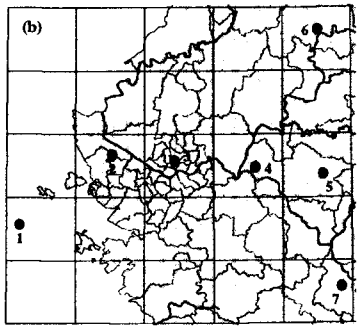
♣ **Use of ratios between media concentrations (e.g., C_{soil}/C_{air})**

- ***insensitive to emission rate or path***
- ***fast stabilization***

Effect of Emission History on Concentration Ratio



Model Domain and Monitoring Locations



Wind Profiles

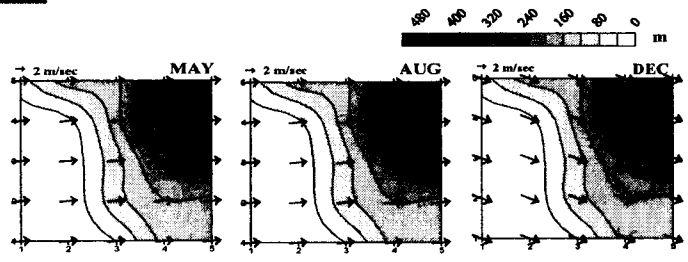


Fig. Wind Profile on May, August and December.

Measured

PAHs

1. ***seasonal concentrations in multimedia environment***
   - ***gas and particulates in air (10 size intervals)***
   - ***soils (bare, forest, rice field, other cultivated areas)***
   - ***water (dissolved & SS), sediment***
   - ***leaf (deciduous & coniferous)***
2. ***particulate flux to land via dry deposition***

Measured

Physical Parameters and Weather Conditions

1. ***TSP and particle size distribution in air***
2. ***dry deposition flux of particulates***
3. ***soil organic carbon fraction, bulk density, porosity, moisture***
4. ***temperature, humidity, wind velocity***

Assessment of Monitoring Data

1. **What do the data represent in time and space?**
   - ***seasonal vs. annual***
   - ***consistent with land use type?***
2. **Adequate data reduction to compare with model prediction**
   - ***individuals, mean, median, range,***
   - ***arithmetic mean or geometric mean***

Predicted vs Measured

1. **Qualitative Comparison**
   Trend/Pattern in time and space
2. **Quantitative Comparison**
   Concentration Ratios (Ci/Csoil)
   Dry deposition flux (particulate mass & chemical mass)
   Wet deposition flux (underway)

Absolute Concentrations in Multimedia Environment

Concentration Ratios : measured vs predicted

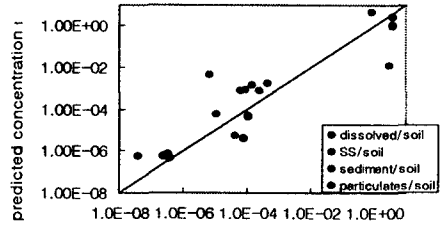
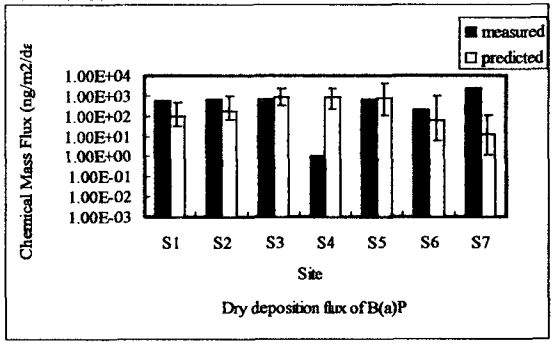


Fig. Predicted concentration ratios as compared to measured concentration ratios

Dry Deposition Flux-B(a)P



Dry deposition flux of B(a)P

Spatial Trend

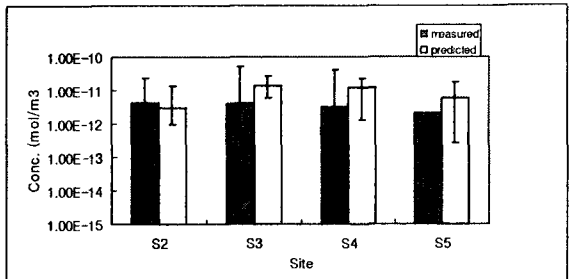


Fig. B(a)P levels in suspended particulates in air.

Dissolved phase in water

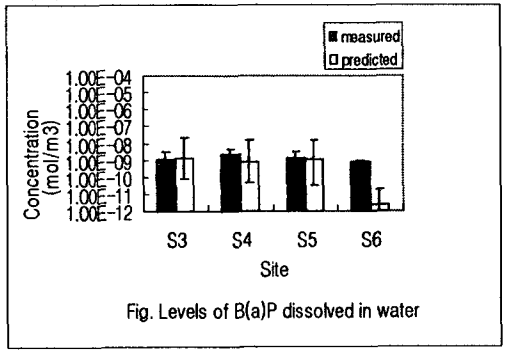


Fig. Levels of B(a)P dissolved in water

SS phase in water

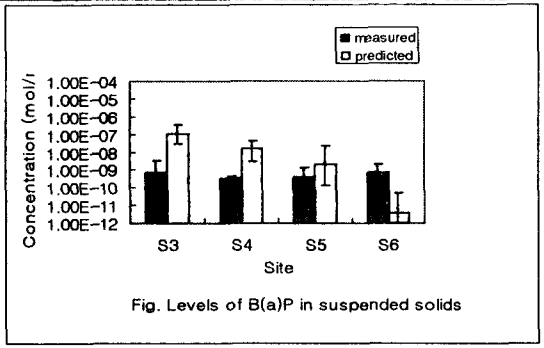


Fig. Levels of B(a)P in suspended solids

Sediment

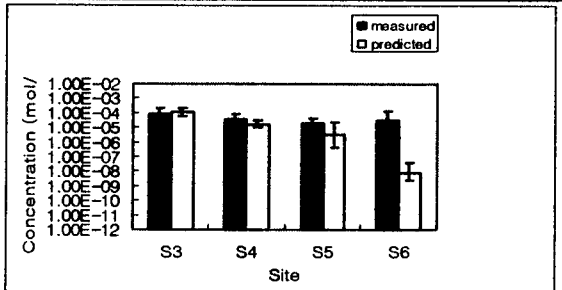


Fig. Levels of B(a)P in sediment

Soil

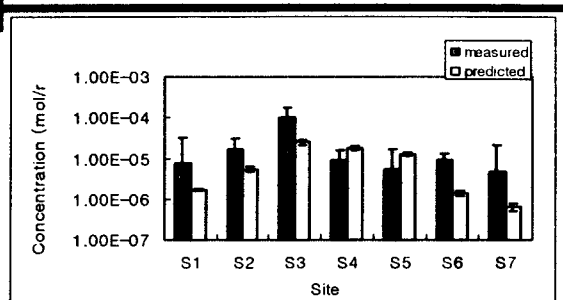


Fig. The B(a)P levels in soil

Model Performance

1. **Agreement between Prediction and Observation**
   - **agree within one order of magnitude except**
     - ***-concentration in SS***
     - ***-sites where local emission seems significantly underestimated.***

2. **Fulfillment of the Modeling Objectives**
   - **Implications to exposure assessment**
     - ***unacceptable particularly for aquatic ecosystem***

Questions

1. **Monitoring Design? or Limit Modeling Objectives?**

2. **Degree of Freedom: too high**
   Will multiple compounds monitoring data help reduce the degree of freedom?