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Sub-Theme 2: Development and application of risk tradeoff analysis

Bridging risk assessment and institution for advanced chemicals risk governance: A case study of PCE emitted by small dry cleaning factories

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Outline

- Background and objectives.
- Urban land use institution and chemicals risk.
- Spatial assessment of chemicals risk using a model and GIS; a case study.
- Scoping and targeting the risk reduction policy.

Background

- Urbanization progress and land use change.
- Industrialization intensified chemicals risks in the urban.
- Unorganized spatial mixture of urban functional land uses may raise chemicals risk. E.g. small factories in residential area.
- Risk aspects have been recognized and being implicated in urban land use policy against natural disasters since the mega-earthquakes.
- Similar institutions are probably effective in managing chemical substance risk in urban area combined with spatial risk assessment techniques.

Objectives

- To make a short review of present urban land use state and institutions, and their consequences to chemical substance risks.
- To assess chemical substance exposure risk using a model and GIS.
- To propose a linkage between assessment technique and institution for the higher order risk management.

Unban land use institution

- City Planning Act
  - To promote the sound development and orderly improvement of cities by stipulating the details of city planning and decision procedures.
  - Defines city planning restrictions, city planning projects and any other necessary matters concerning city planning.
- Use Districts
  - Land use classification in city planning areas; 12 categories.
  - Restrictions of floor area ratio of buildings, minimum site area for buildings , building coverage ratio, building height limit and uses of special buildings in specific use categories.
  - Other acts utilize the Use District system; Building Standards Act, Fire Service Act, Factory Location Act, etc.

PRTR and Use District

- PRTR of Japan exempts registration by small operators; number of workers, annual use amount of chemical substances.
- PRTR coverage tends to decrease in some substances by outsourcing production processes of large manufacturers.
- Factory Location Act allows small factories in non-industrial districts (residential and commercial).
- The two institutions substantially accept non-registered substance use in residential and commercial area.

Case study: PCE emission by small dry cleaning factories

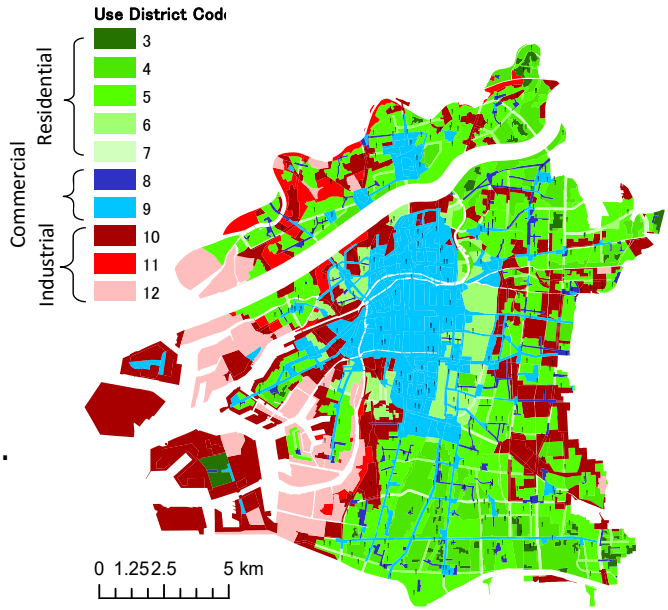
- Solvent emission from dry cleaning factories
  - Petrol solvents are banned in residential and commercial districts by the Building Standard Act.
  - Perchloroethylene (PCE) as an alternative non-flammable solvent.
- PRTR registered PCE emission covers only 8% of estimated total emission (METI, 2001).
- 70% of estimated PCE emission attributes to dry cleaning (METI, 2001).
- As a consumer service, dry cleaning factories tend to concentrate in residential and commercial district for business merits.

Health hazards of PCE

- Acute effects:
  irritation of the upper respiratory tract and eyes, kidney dysfunction, neurological effects, impairment of coordination, dizziness, headache, sleepiness, and unconciousness.
- Chronic effects:
  neurological effects and color vision decrements, liver damage, kidney effects, immune and hematologic effects, and on development and reproduction.
- Cancer risks:
  bladder cancer, non-Hodgkin lymphoma and multiple myeloma.

Case study area

- Osaka City, Japan
  - Population: 2.7 million
  - Geographic area: 223 km^2
- Use districts (codes)
  - Residential (3-7)
  - Commercial (8 and 9)
  - Industrial (10-12)
- Dry cleaning factories
  - Web telephone directory.
  - Positioned by an on-line geocoding service (U. Tokyo).
  - Screened PRTR registered factories.
  - 349 small factories in residential and commercial districts out of 400.



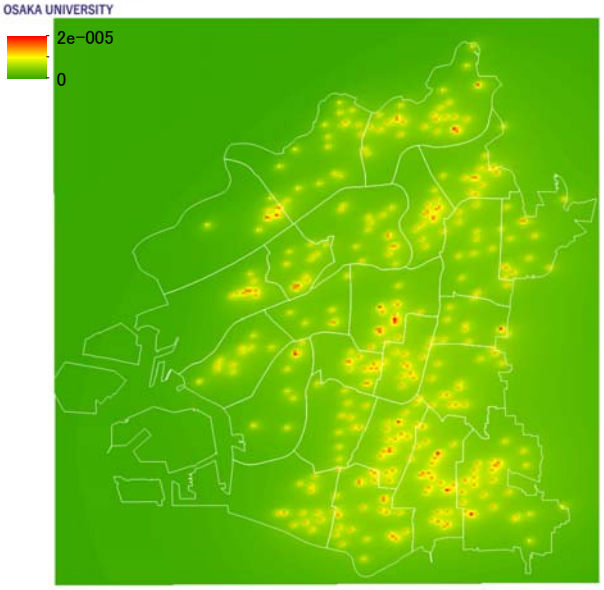
Analysis 1 : PCE exposure concentration

- AIST-ADMER v.3.0
  - Developed by the National Institute of Advanced Industrial Science and Technology (AIST)
  - A series of models and systems designed for estimating atmospheric levels of chemicals and assessing their exposure.
  - Calculates atmospheric transportation, deposition and chemical reactions to estimate concentration distribution.
- Emission estimation
  - Annual PCE use = 1.95 t year^{-1} factory^{-1}. (Osaka Prefecture, 2007)
  - Emission/use fraction = 0.54 (Environmental Planning Laboratory Inc., 2016)
  - Assume fixed PCE emission = 1.05 t year^{-1} factory^{-1}.
- Simulation
  - 1 Jan. – 31 Dec., 2013.
  - 100 m grid.

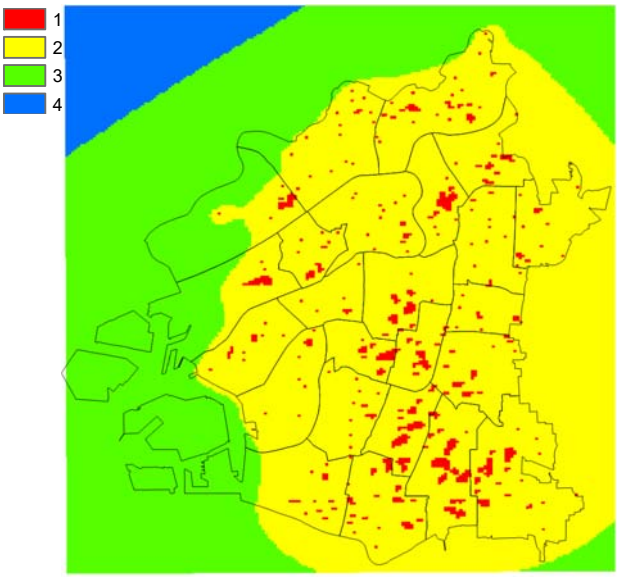
Analysis 2 : Risk assessment and implementation in governance

- Human health risk of TCE
  - LOAEL by animal inhalation exposure experiment.
  - Converted to human LOAEL = 210 mg kg^{-1} day^{-1}.
  - Margin of exposure (MOE): ratio of human LOAEL and exposure concentration. Uncertainty multiplier = 10^3.
  - MOE classes 1 (<10^5), 2 (<10^6), 3 (<10^7)…
- Implementation of assessment results in risk governance
  - Scoping high risk population.
  - Risk reduction by emission control.

Result: Annual mean PCE concentration and MOE



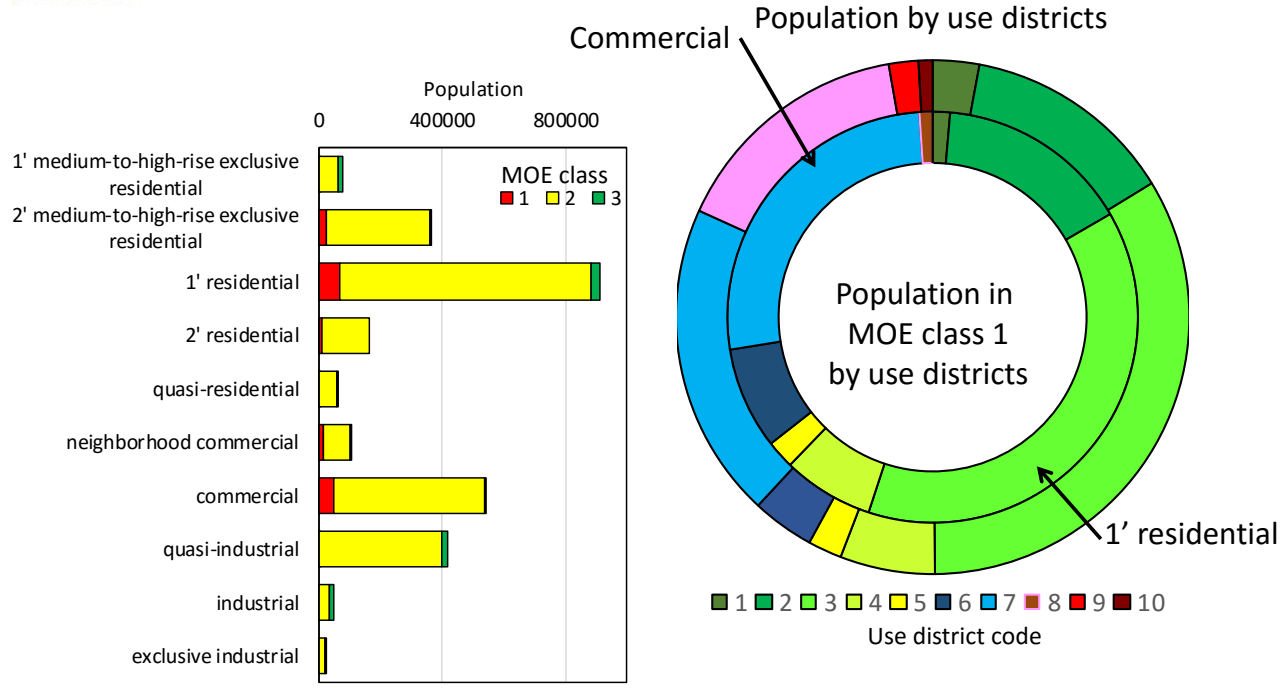
PCE concentration (g m^{-3})



MOE class

MOE > 10^4 , human health risk of PCE was below the level of consideration.

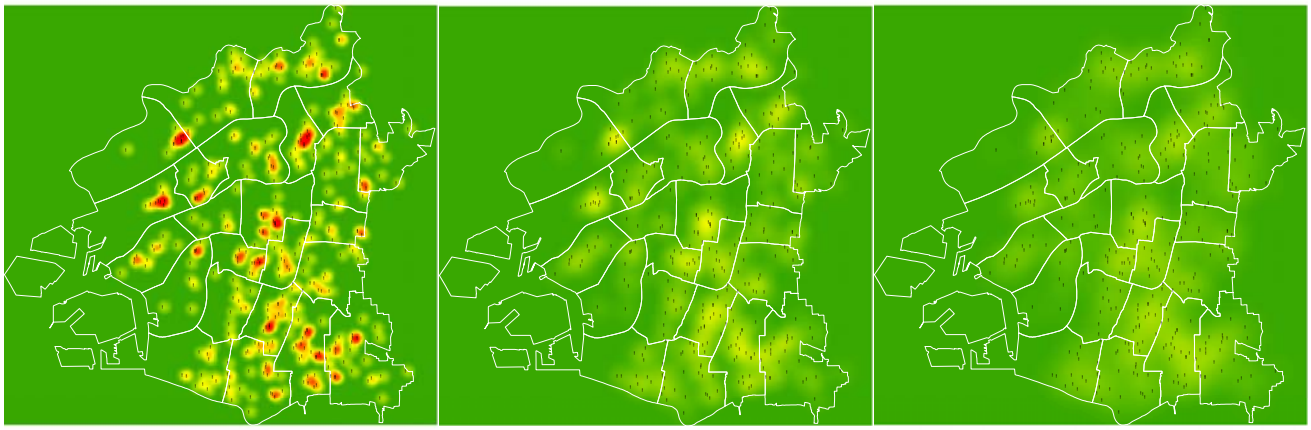
Scoping high risk population by the use districts



Risk reduction targeting by emission reduction

- Calculate emitter (factory) density.
- Relationship between emitter density and annual mean concentration.
- Determine emission reduction target.
- Validate the effect of emission reduction (AIST-ADMER)

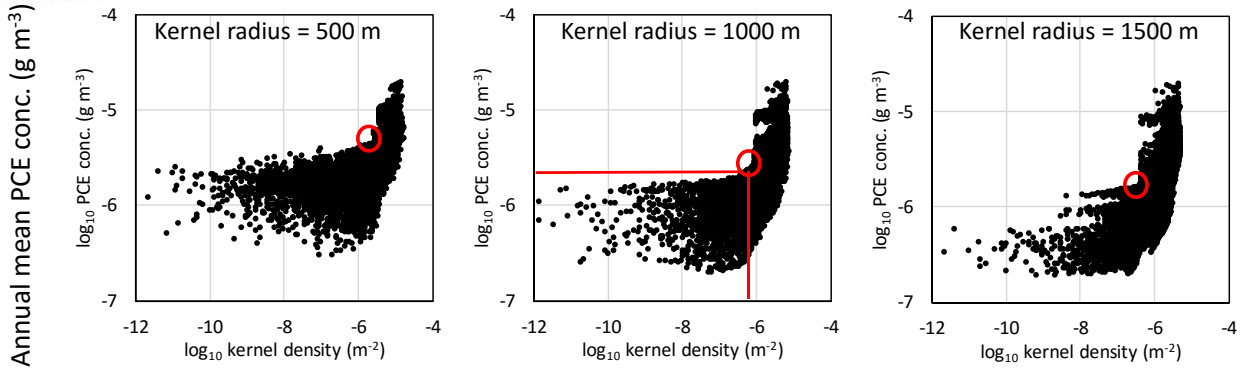
Emitter (factory) kernel density



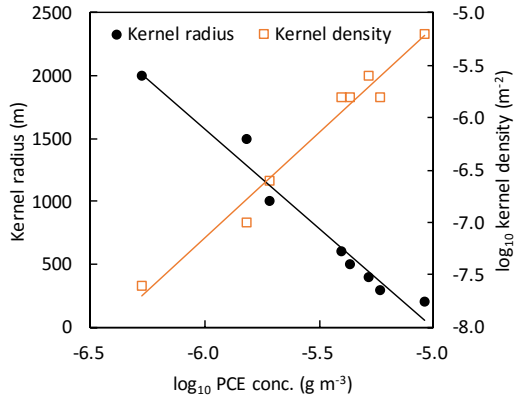
Kernel radius = 500 m | Kernel radius = 1000 m | Kernel radius = 1500 m

- Kernel density: density in a moving circle over cells with a kernel radius.
- Spatial change of density is smoothened with the larger kernel radius.

Emitter (factory) density and PCE concentration

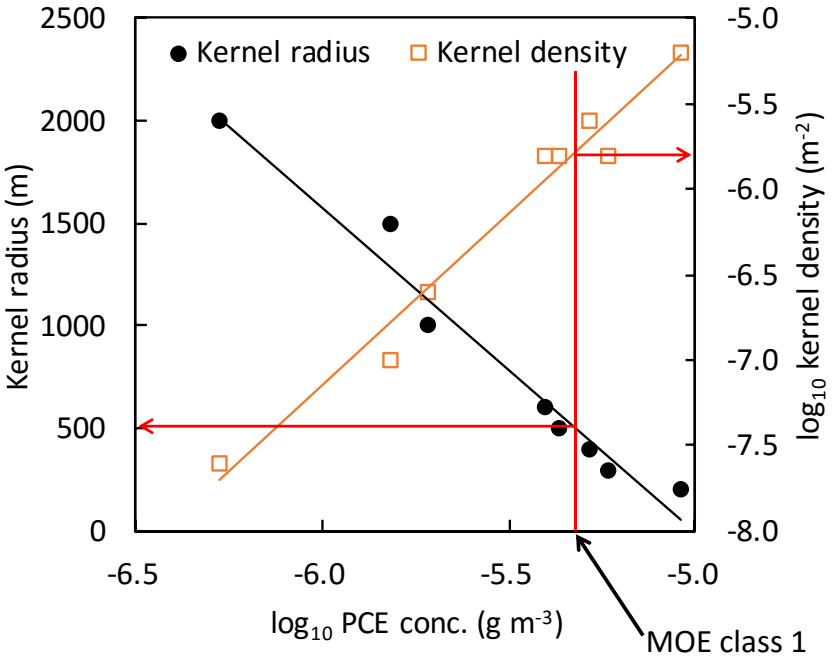


Emitter (factory) density (m^{-2})



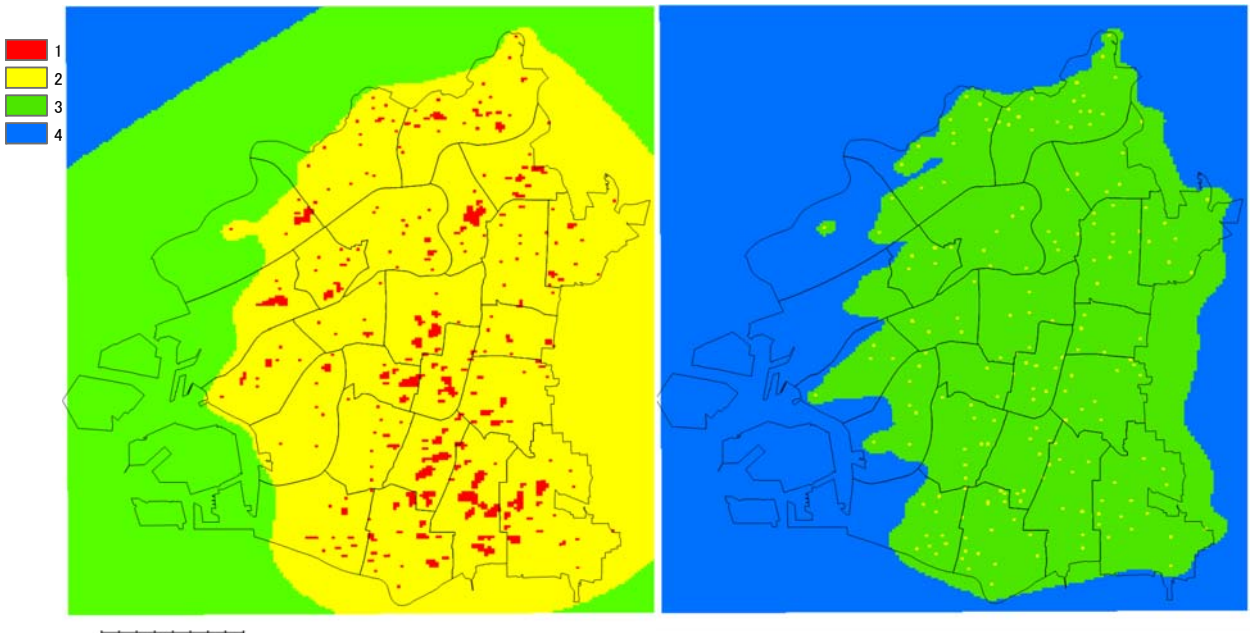
For a fixed emission intensity at 1.05 t year^{-1} factory^{-1}

How to determine emission reduction target



- Kernel radius and target factory density can be determined by target concentration.
- Emission reduction target options
  - Reduce factory density.
  - Reduce emission intensity of each factory.

MOE change by emission intensity reduction



Discussion on policy implementation

- Alternative policy options:
  - Emission reduction of existing factories to 20% of present.
  - Aggregating small factories, relocation to industrial districts and establish delivery service.
- Consumer services have the common difficulty of emission reduction or relocation.
  - Painting services (automobile repair factories)
  - Gas stations
  - Printing services
- Application of the method to small manufacturers using chemicals.
- Assessment reliability and policy validity depend on:
  - Rationale estimation of chemicals use/emission.
  - Reasonable uncertainty multiplier.

Conclusion

- PRTR and land district institution accept small scale unregistered emitters in residential and commercial districts.
- Assessed human health risk of TCE from small dry cleaning factories using a model and GIS.
- Proposed a technique to determine the emission reduction target from assessment result.