Prior Estimation of Dose Reduction as a Result of Decontamination in Fukushima Pilot Project

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Prior Estimation of Decontamination Effects

• After the Fukushima Dai-ichi nuclear accident, Japan Atomic Energy Agency (JAEA) was chosen by the Government to conduct decontamination pilot projects at selected sites in Fukushima prefecture.

• As a component of this work, a prior estimation of potential dose reduction over large areas was derived using the “Calculation system for Decontamination Effect (CDE)”, which was developed by JAEA.

• CDE is a simple computer program to estimate air dose rates before and after decontamination from measured (or estimated) surface contamination by gamma-emitters (Cs-134 and -137 in this case).
Calculation System for Decontamination Effect

- In general, calculation of air dose rate from gamma-emitters is very heavy work, because Monte Carlo transport simulation on large computer (cluster, supercomputer, etc.) is usually needed.
- In particular, large-scale calculation is almost impossible mainly due to limitation of computational resources.

- JAEA developed simplified computer program for easy estimation of the air dose rate.
- The name is “Calculation system for Decontamination Effect (CDE)”. 
- CDE is based on a key assumption for easy calculation on small PC, which is neglect of undulation in target area.

- CDE has been verified against a standard code for a planar surface test case.
**Procedure**

**Calculation scheme of CDE for evaluation of decontamination effect**

<table>
<thead>
<tr>
<th>Before decontamination</th>
<th>After decontamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output 1: air dose rate before decontamination</td>
<td>Output 2: air dose rate after decontamination</td>
</tr>
<tr>
<td>X 1/DF</td>
<td></td>
</tr>
<tr>
<td>Input 1: land-use map (mesh type)</td>
<td>Input 3: DFs</td>
</tr>
<tr>
<td>Example: Farmland, road</td>
<td></td>
</tr>
<tr>
<td>Input 2: surface contamination density</td>
<td></td>
</tr>
</tbody>
</table>

- We make mesh-type **land-use map** by hand using satellite images.
- **Surface contamination density** is put to the map.
- **Decontamination factors (DFs)** depend on land-use, e.g., soil removal for school ground, washing by high-pressure water for road, etc. We prepare the values of DFs obtained by measurements in the project.
- DF is applied to corresponding mesh.
- CDE calculates **air dose rate before and after decontamination**.
Results(1)

Target area
A part of Tamura city
- The place for first application of large-scale decontamination by the Government
- Distance from Fukushima Dai-ichi NPP is about 20km.
- About 4,200ha

CDE calculation

Before decontamination

After decontamination
Results(2)

• Estimation of total amount of waste

Once the mesh-type map is made, we can estimate total amount of waste.

An example of the mesh-type map (5m x 5m mesh)

![Mesh-Type Map Example]

- Dark green: Forest (excluded from decontamination area)
- Dark blue: Forest (decontamination area)
- Pink: Agricultural land (decontamination area)
- Dark grey: Road (decontamination area)
- Light pink: House (decontamination area)

We can know roughly areas for each land-use by counting the number of corresponding mesh.

Amount of soil waste generated by soil removal

<table>
<thead>
<tr>
<th>Land-use</th>
<th># of mesh</th>
<th>The number of waste package / 1ha [1/ha]</th>
<th>The number of waste package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>163,800</td>
<td>200</td>
<td>81,900</td>
</tr>
<tr>
<td>Ground</td>
<td>81,226</td>
<td>500</td>
<td>101,500</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>-</td>
<td>183,400</td>
</tr>
</tbody>
</table>

Average number of waste package obtained in the pilot project.
Summary

• A prior estimation of potential dose reduction over large areas has been done using CDE which has been developed by JAEA.

• CDE calculation requires 3 inputs:
  – Land-use map
  – Surface contamination density
  – Decontamination factors

• Application for a part of Tamura city, where is one of the places for first large-scale decontamination by the Government.
  – We can know potential dose reduction roughly before decontamination.
  – We can know approximately total amount of waste before decontamination.

• Note
  – Calculated decontamination effect depends in a large part on topographical relief and the value of DFs. Users must pay attention to this point.

• JAEA continues to develop CDE.
Backup Slides
Verification

Simulation setting

Distance from the center
Height 600m
Contaminated surface
Decontamination area

The results of CDE are in a good agreement with ones of PHITS. This result implies that CDE works well within this setting.

Comparison between CDE and PHITS*

Figures are taken from JAEA-Research 2012-020

* PHITS is a Monte Carlo simulation code
http://phits.jaea.go.jp
Validation

- Validation of CDE: application to Kawamata-machi in the pilot project
  - Figure shows deviation of a CDE result using measured DFs from air dose rate measured after decontamination.

Deviation is large at yellow and black circle

- Yellow circle represents undulating landscape
- Black circle represents residential area (screening effect by houses)

Conclusion

- CDE gives good result at flat landscape.
- If landscape is undulating, deviation becomes large.
Surface Contaminate Density

- Surface contaminate density is obtained from air dose rate measured by airplane.
- Transformation constant is used.
- This transformation gives one of origins of ambiguity in CDE calculation.