Development of human health risk assessment software for a chlorinated solvent contaminated groundwater site

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Outline

1 Introduction

2 Material and Methods

3 Results and discussion

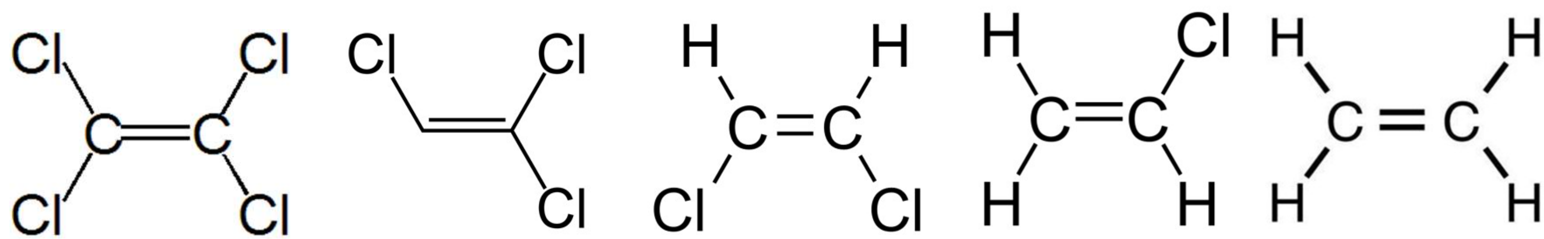
4 Conclusions

5 Future work

1 Introduction

Groundwater contaminant

- Chlorinated solvents are common contaminants in groundwater.



PCE → TCE → DCE → VC → ETH

USEPA	Group A	Group A		Group A	

USEPA: US Environmental Protection Agency
Group A: Human carcinogen

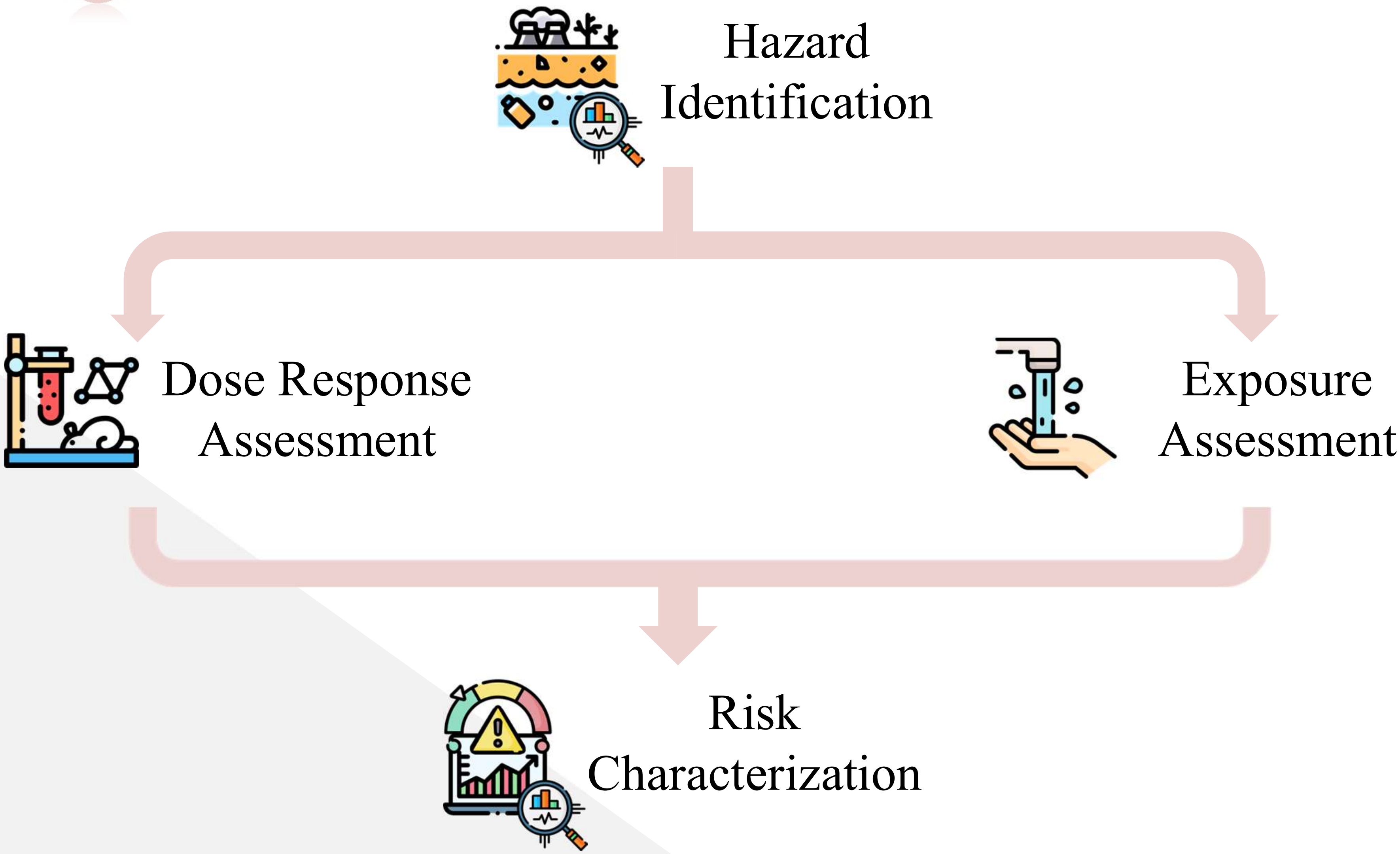
PCE: Tetrachloroethene
TCE: Trichloroethylene
DCE: Dichloroethylene
VC: Vinyl chloride
ETH: Ethene

Health risk assessment

- A process that estimates human health and environmental risks associated with chemicals of concern present in the environment.

- We can set the remediation goals and improvement methods of contaminated sites through the health risk assessment.

Health risk assessment



Target Risk (Cancer Risk)

Fate and Transport Model

↑

C_w: Contaminant Concentration (mg/L)

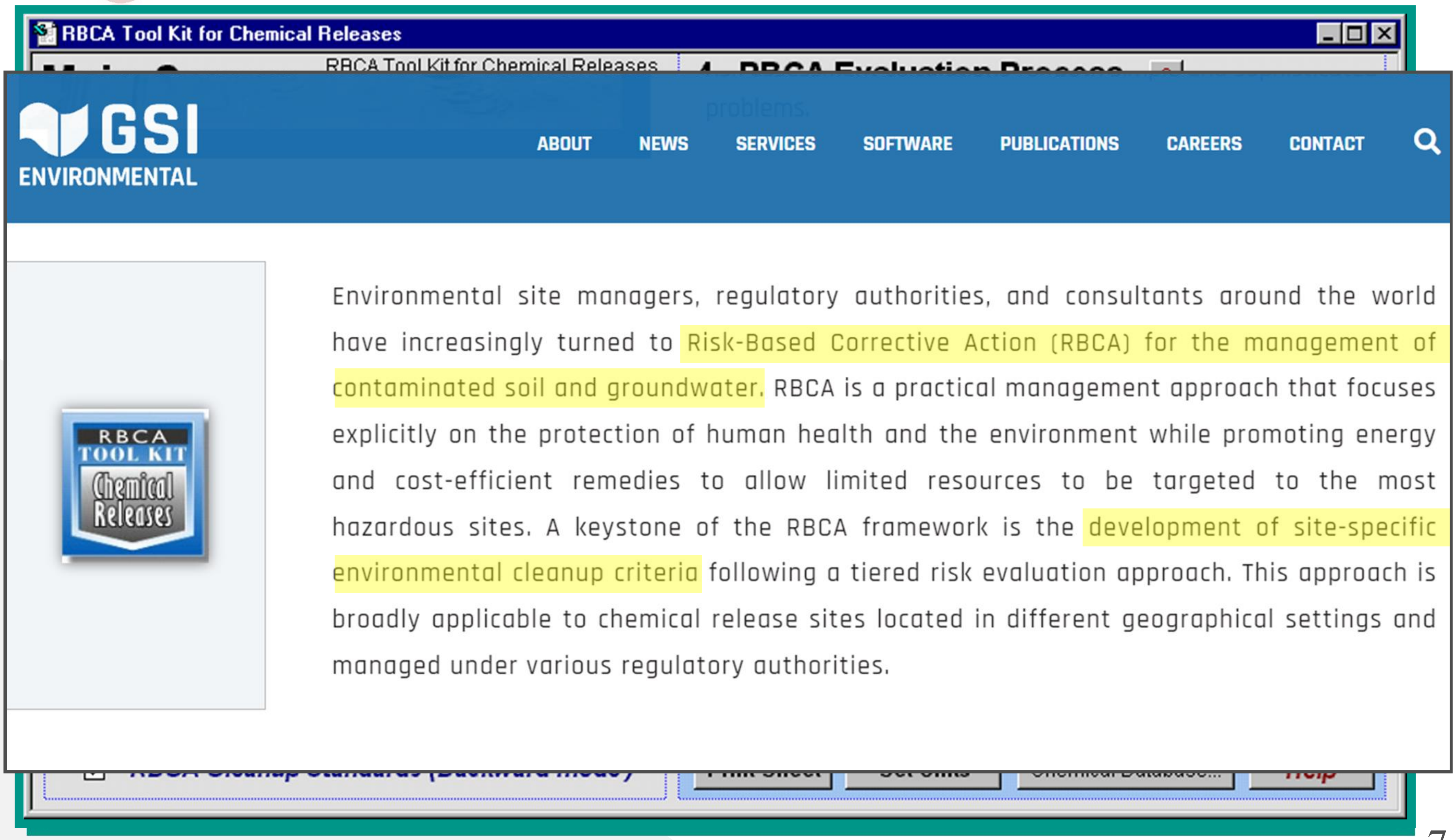
CSF: Cancer Slope Factor (mg/kg-day)

$$Risk = C_w \times \frac{IR \times EF \times ED}{BW \times AT \times 365\ day/year} \times CSF$$

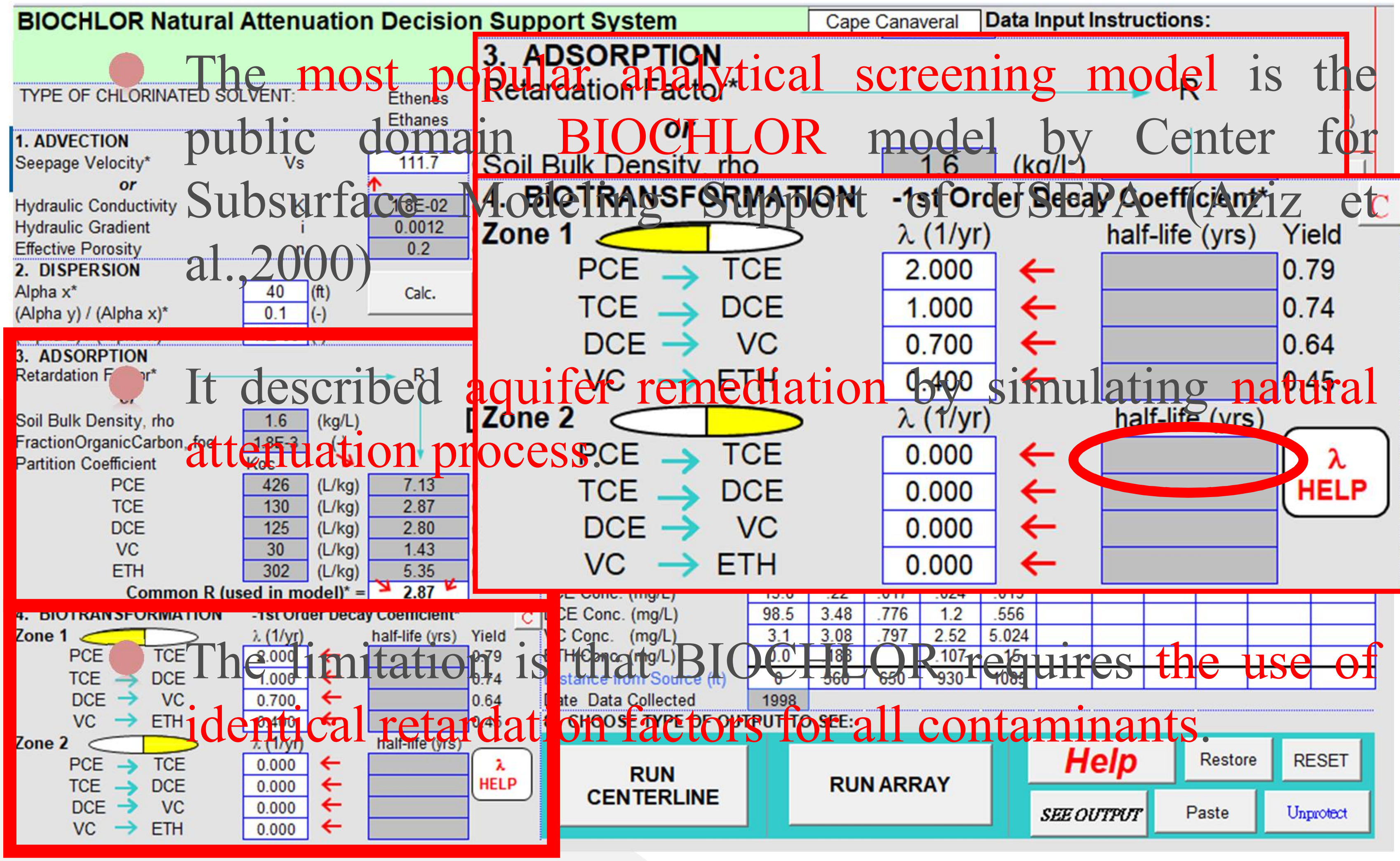
Exposure Factor

IR: Water ingestion rate (L/day)
EF: Exposure frequency (days/year)
ED: Exposure duration (years)
BW: Body weight (kg)
AT: Average lifetime (years)

RBCA Tool Kit



BIOCHLOR



- The most popular analytical screening model is the public domain BIOCHLOR model by Center for Subsurface Modeling Support of USEPA (Aziz et al.,2000)
- It described aquifer remediation by simulating natural attenuation process.
- The limitation is that BIOCHLOR requires the use of identical retardation factors for all contaminants.

MUltiSpecies Transport Analytical Model (MUST)

- MUST can use different retardation factor values among individual species.

MUST

Unit: (s)

	(Chen et., 2016)	(Chen et., 2019b)	MUST
PCE	6.3	1.5	0.0005
TCE	20.1	7.6	0.001
DCE	87.2	25.1	0.003
VC	103.3	62.1	0.01
ETH	184.9	125.3	0.02

- MUST can use different types of inlet source boundary conditions.
- MUST can use constant, Exponential decay, and Arbitrary time-dependents for source conditions.

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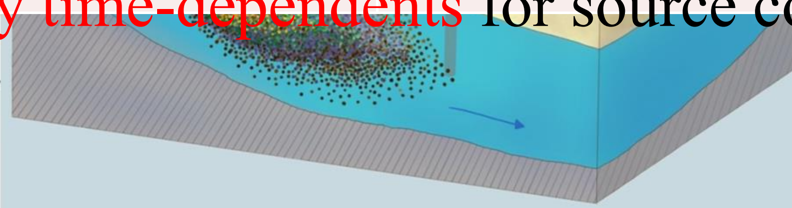
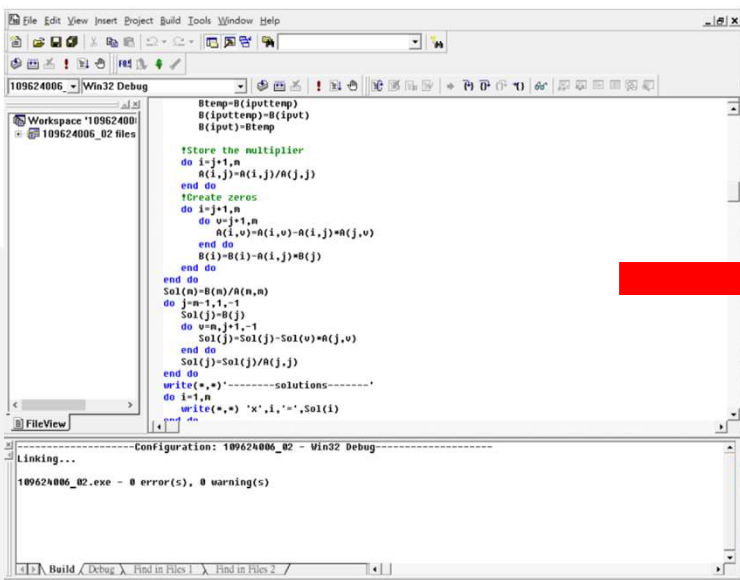
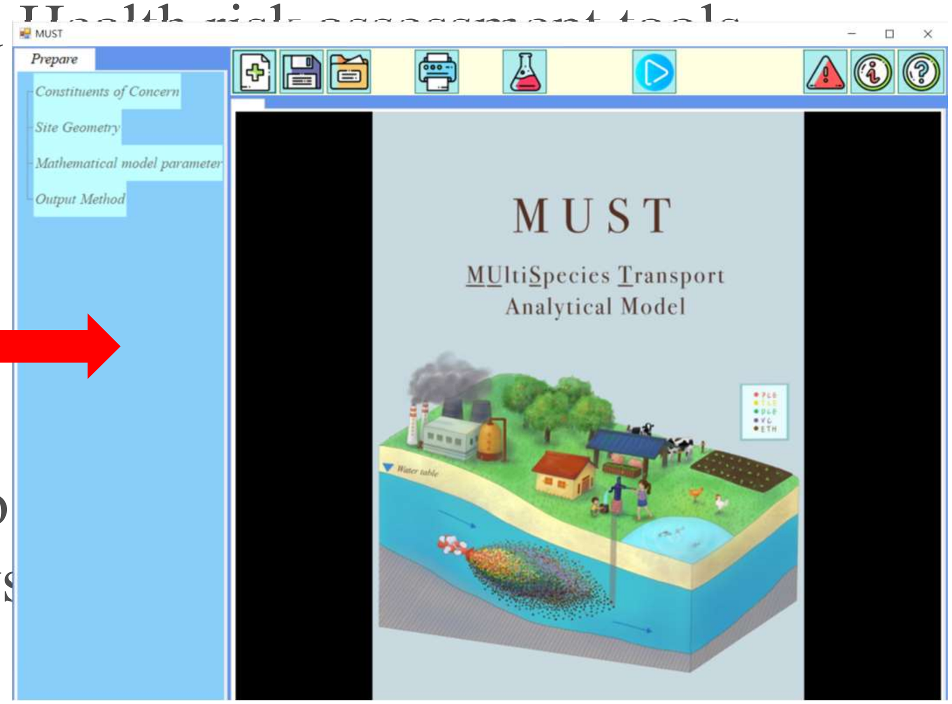


https://www.sciencedirect.com/science/article/pii/S0309170821001731 Open Assess

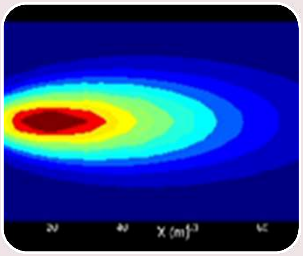
Graphical User Interface

- Fortran programming language is often used to develop Transport model and

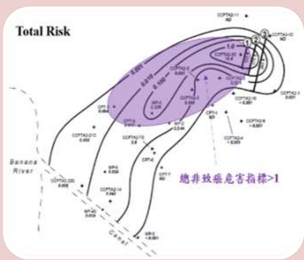




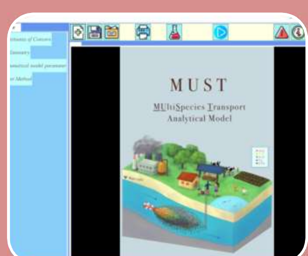
Objective



MUlti-Species Transport (MUST)



Development of Health risk assessment



Graphical User Interface

Objective

- To develop a computer software for human health risk assessment of a chlorinated solvent contaminated groundwater site using the most advanced multispecies transport analytical model (MUST) equipped with a user-friendly graphical interface.

2 Material and Methods

Flow chart

Fate and Transport Model → Contaminant Concentration (C_w)

↓

Exposure Factor → $$\frac{IR \times EF \times ED}{BW \times AT \times 365\ \text{day/year}}$$

↓

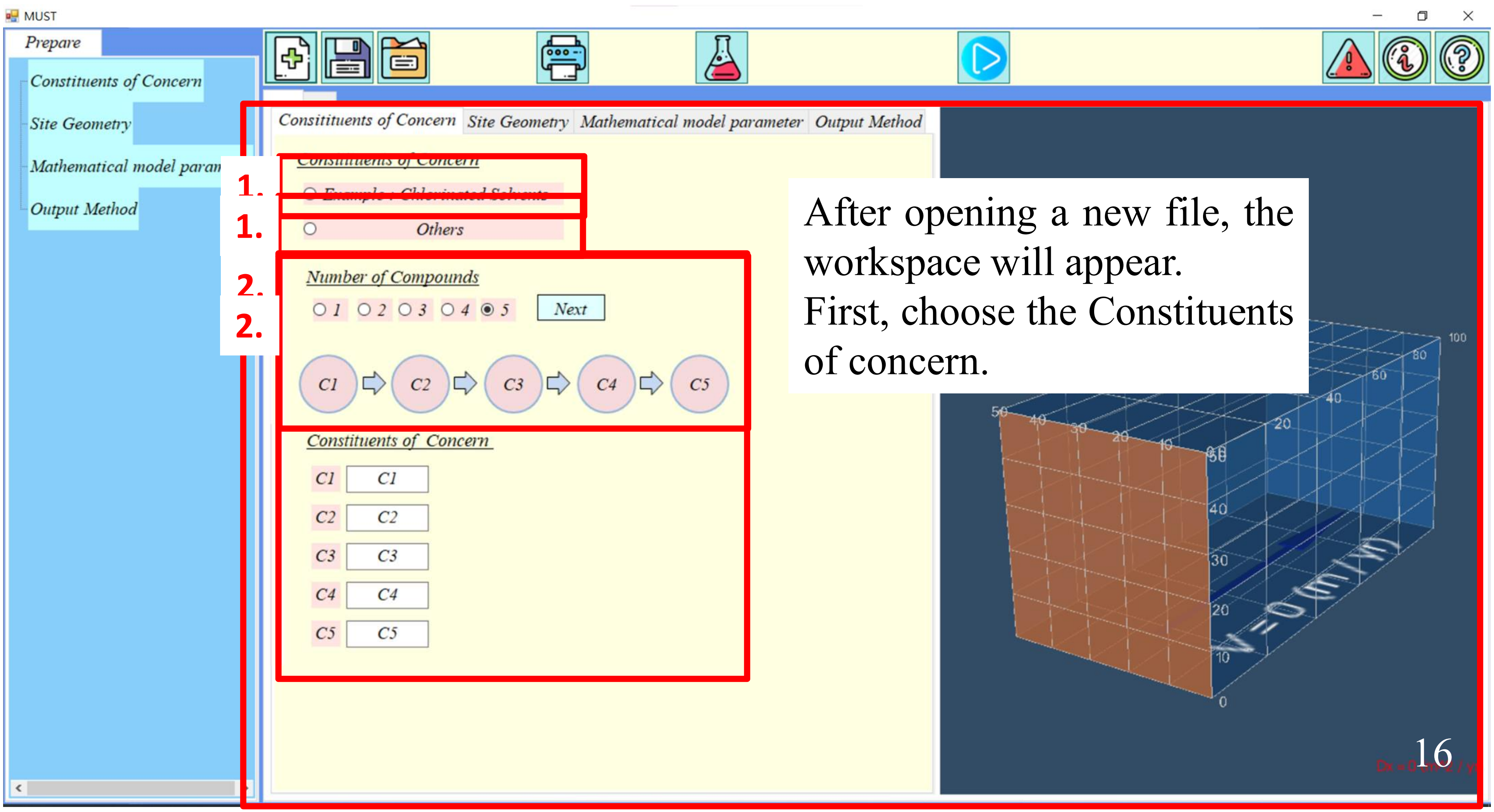
Chemical Toxicity Database → Reference Dose (RfD)
Cancer Slope Factor (CSF)

↓

Quantify the Health Risk → Hazard Quotient (HQ)
Cancer Risk (Risk)

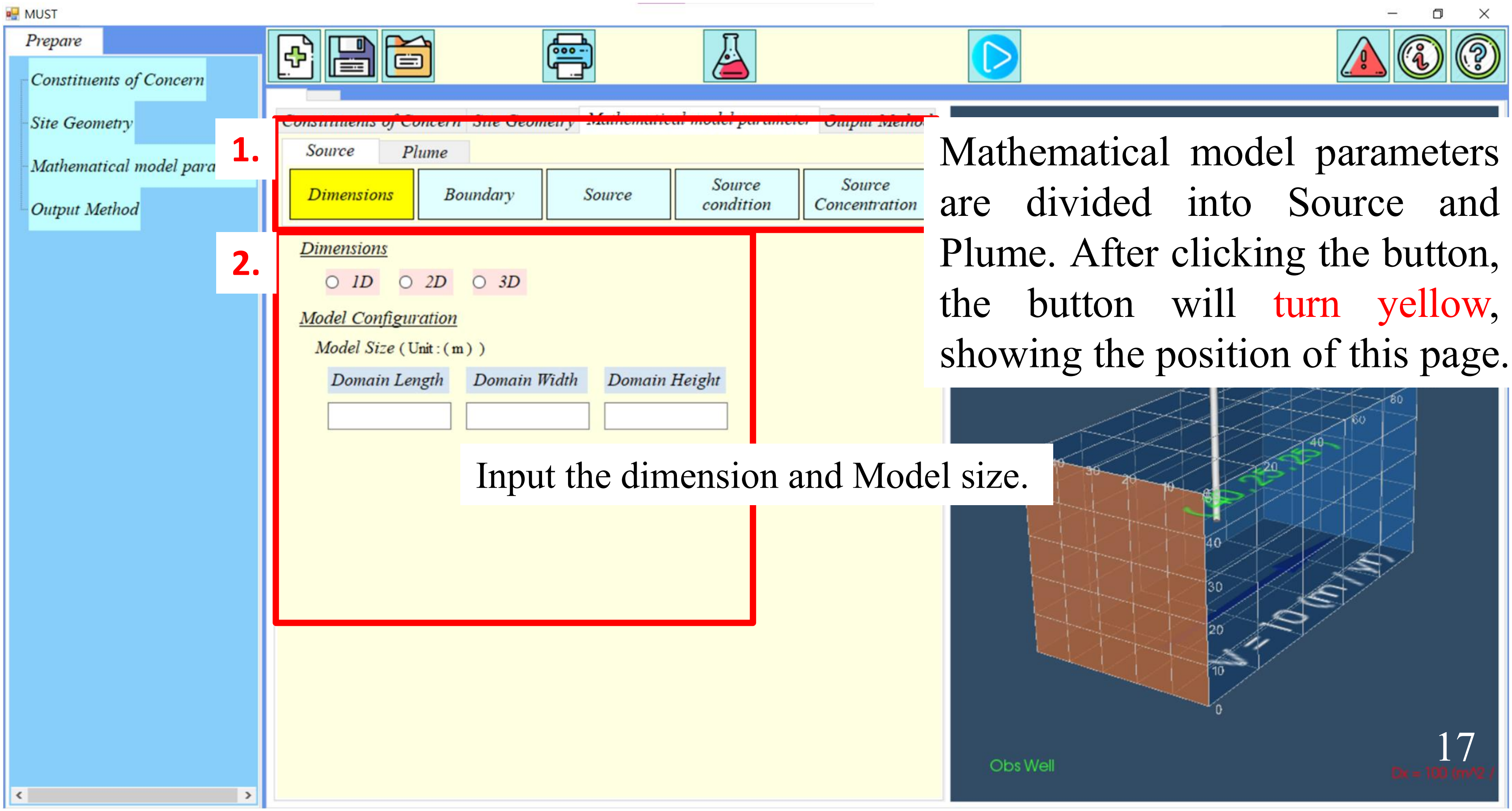
3 Results and discussion

Constituents of concern



After opening a new file, the workspace will appear.
First, choose the Constituents of concern.

Mathematical model parameter - Source



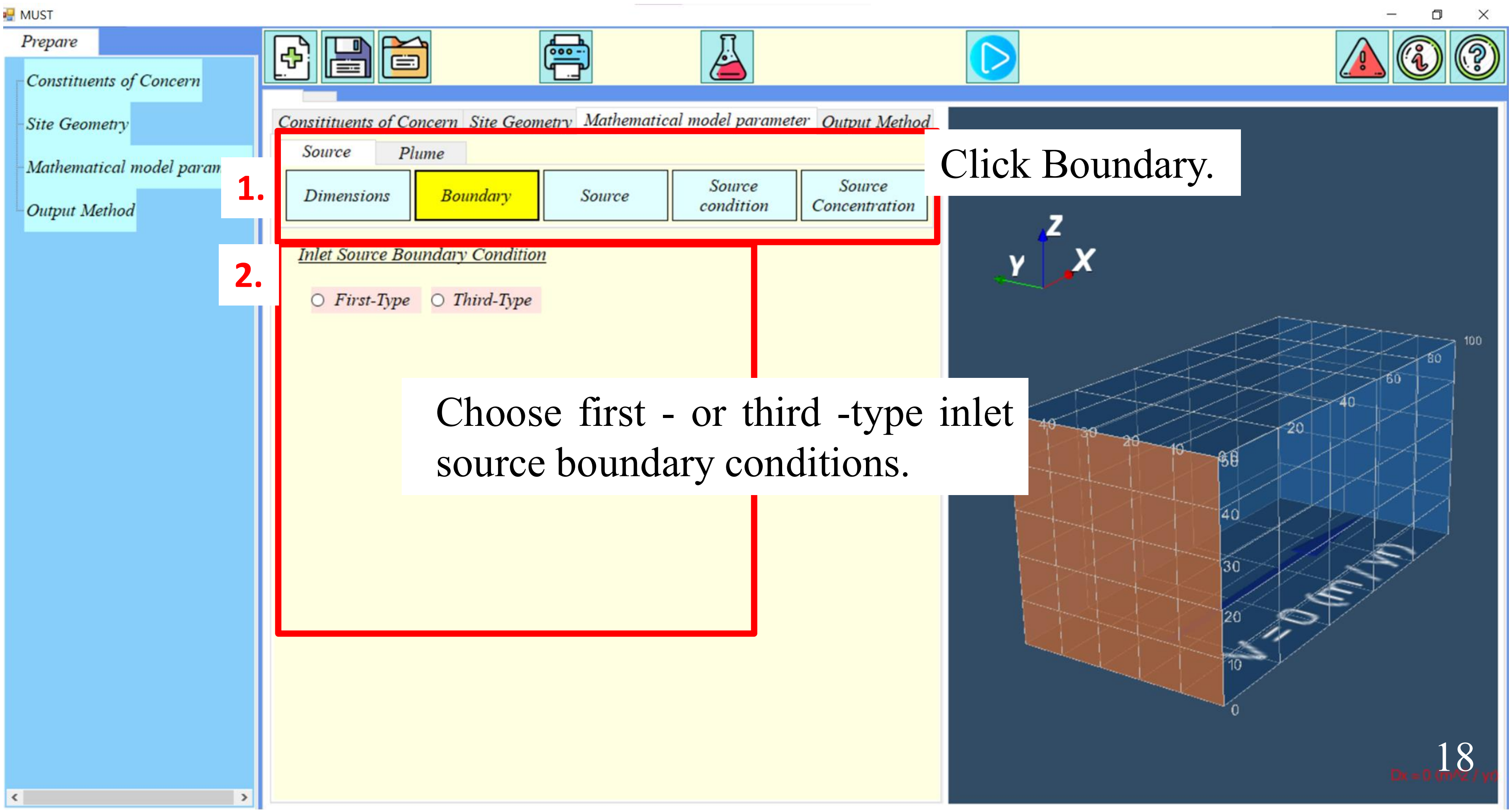
1\.

2\.

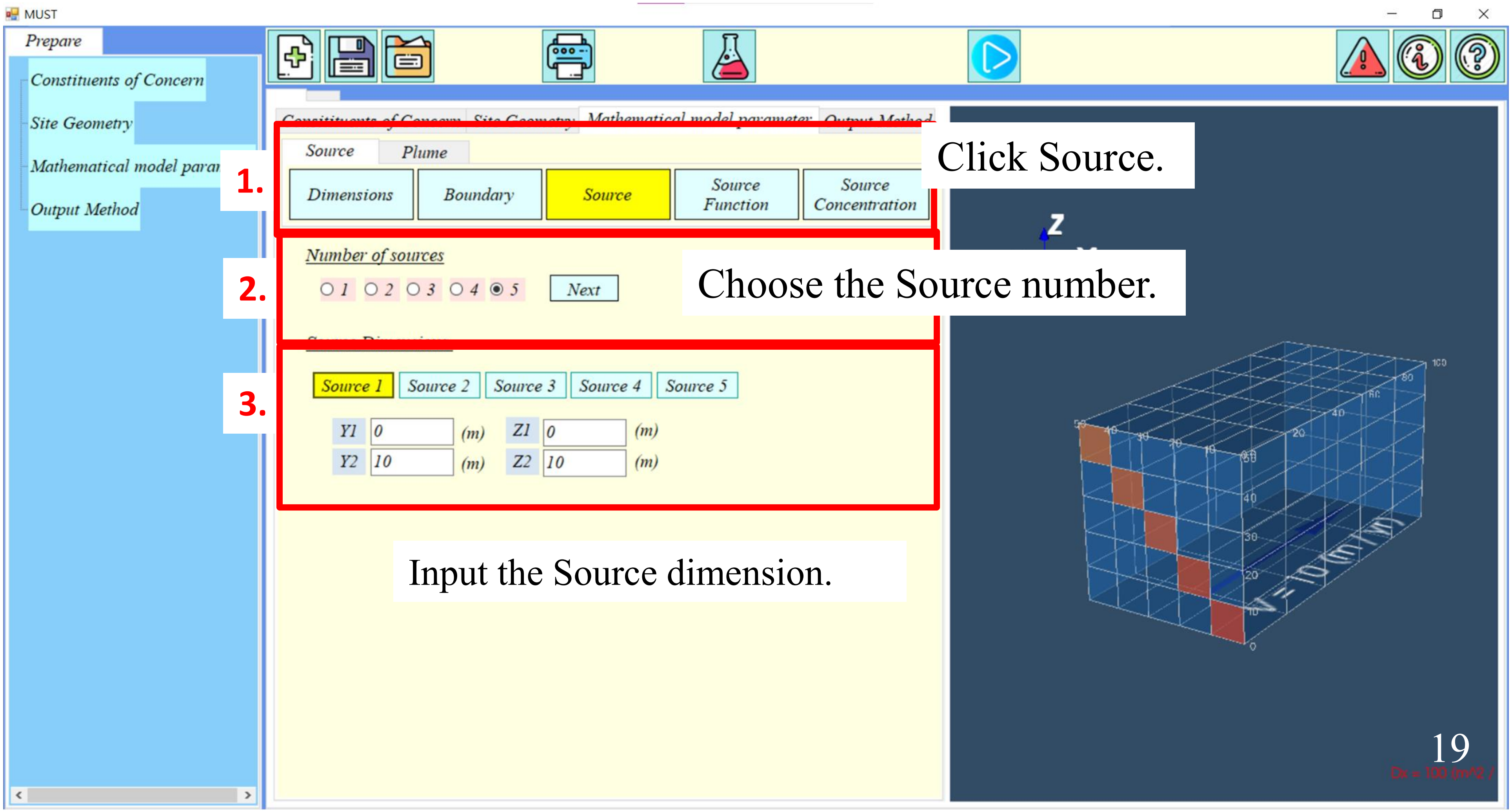
Mathematical model parameters are divided into Source and Plume. After clicking the button, the button will turn yellow, showing the position of this page.

Input the dimension and Model size.

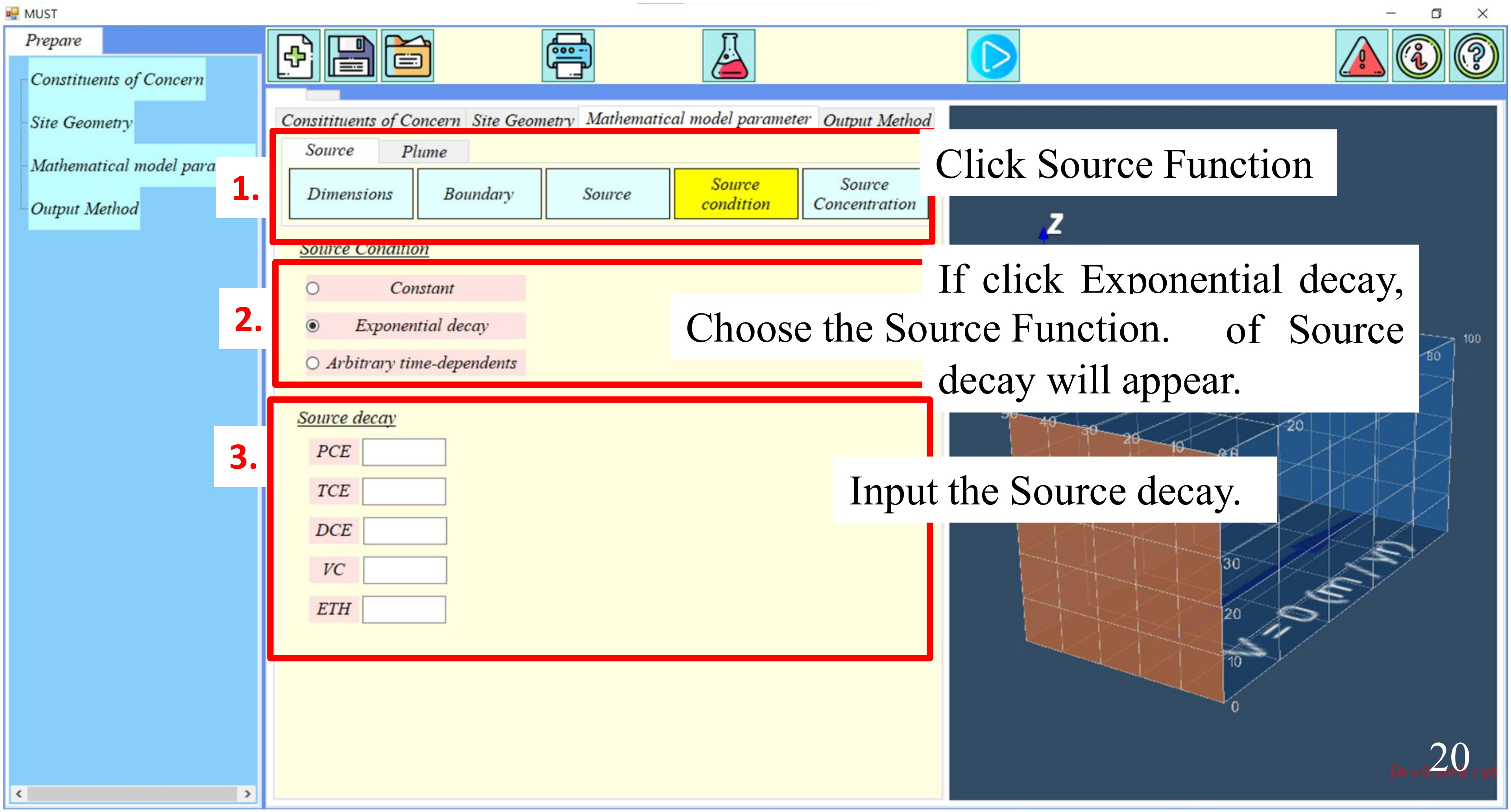
Step 3. Mathematical model parameter - Source



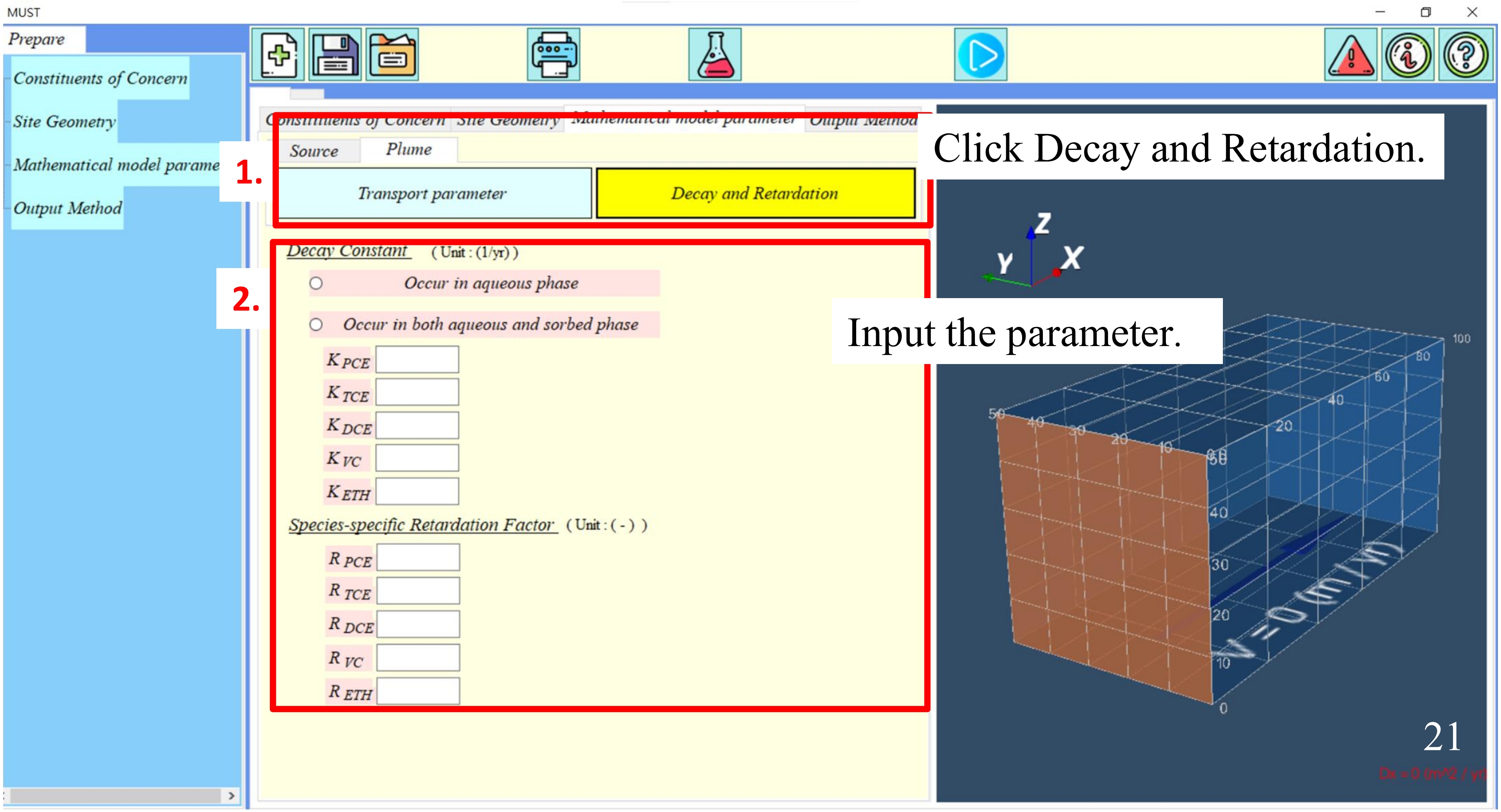
Step 3. Mathematical model parameter - Source



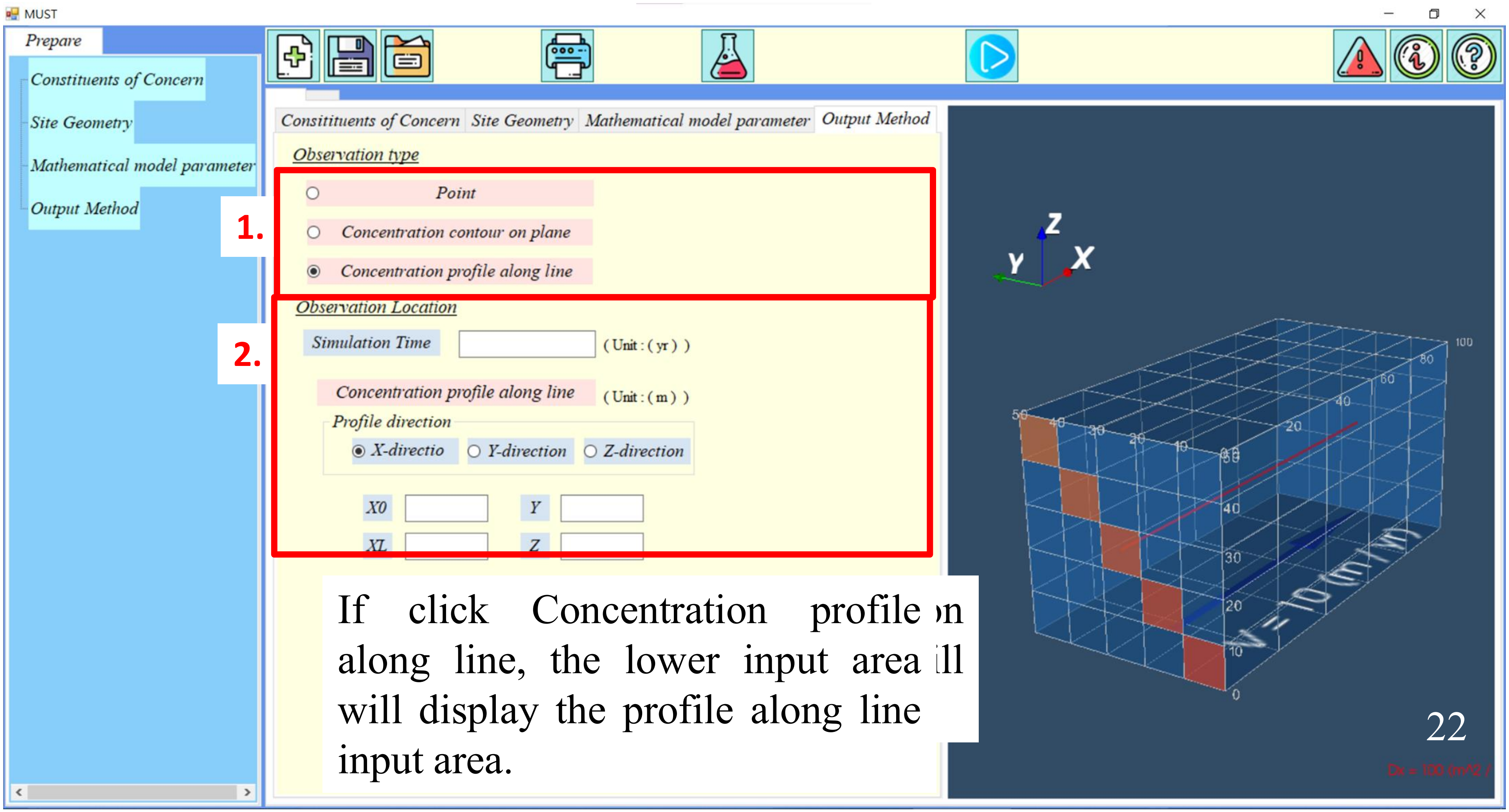
Step 3. Mathematical model parameter - Source



Step 4. Mathematical model parameter - Plume

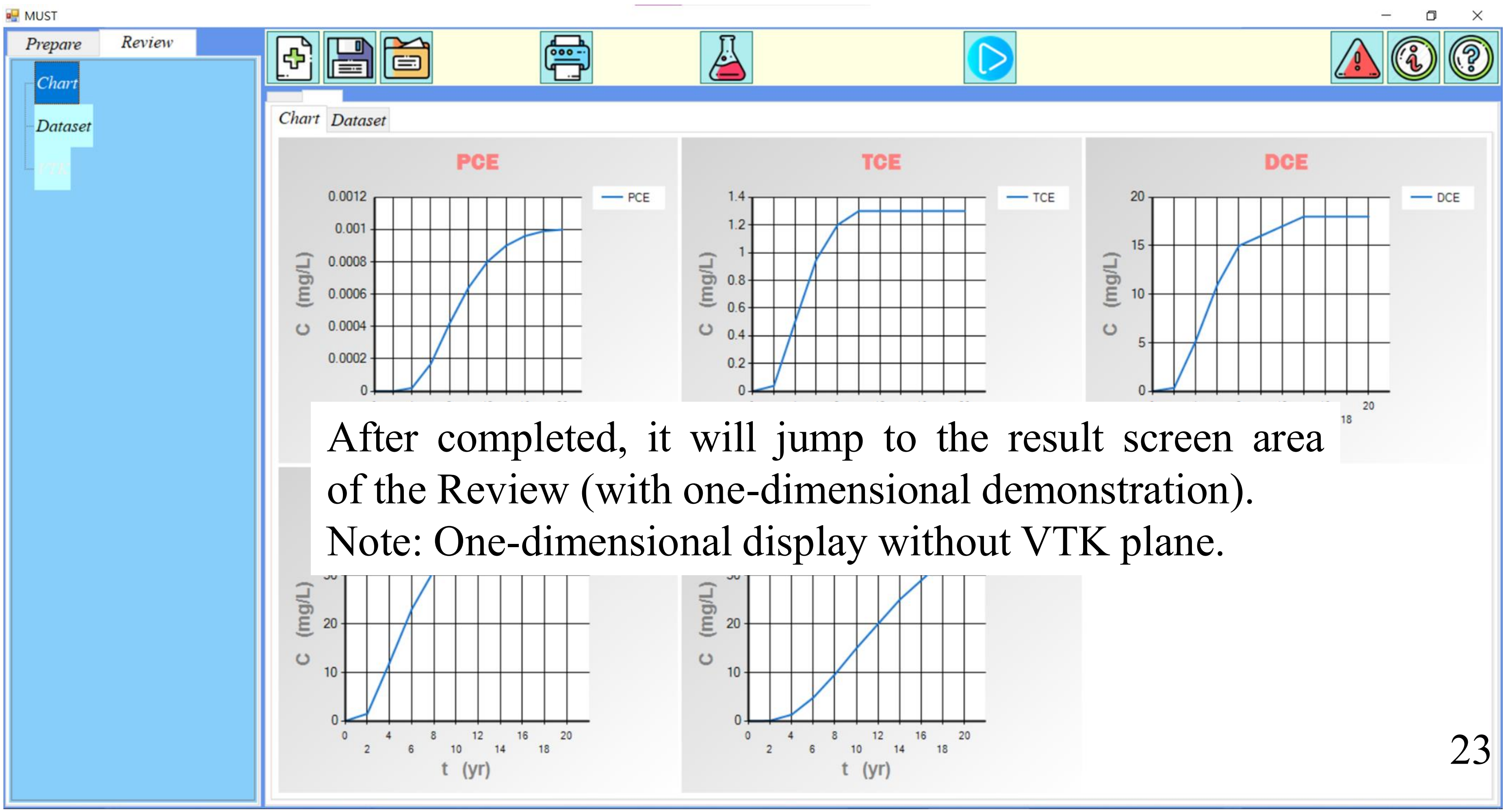


Step 5. Output Method



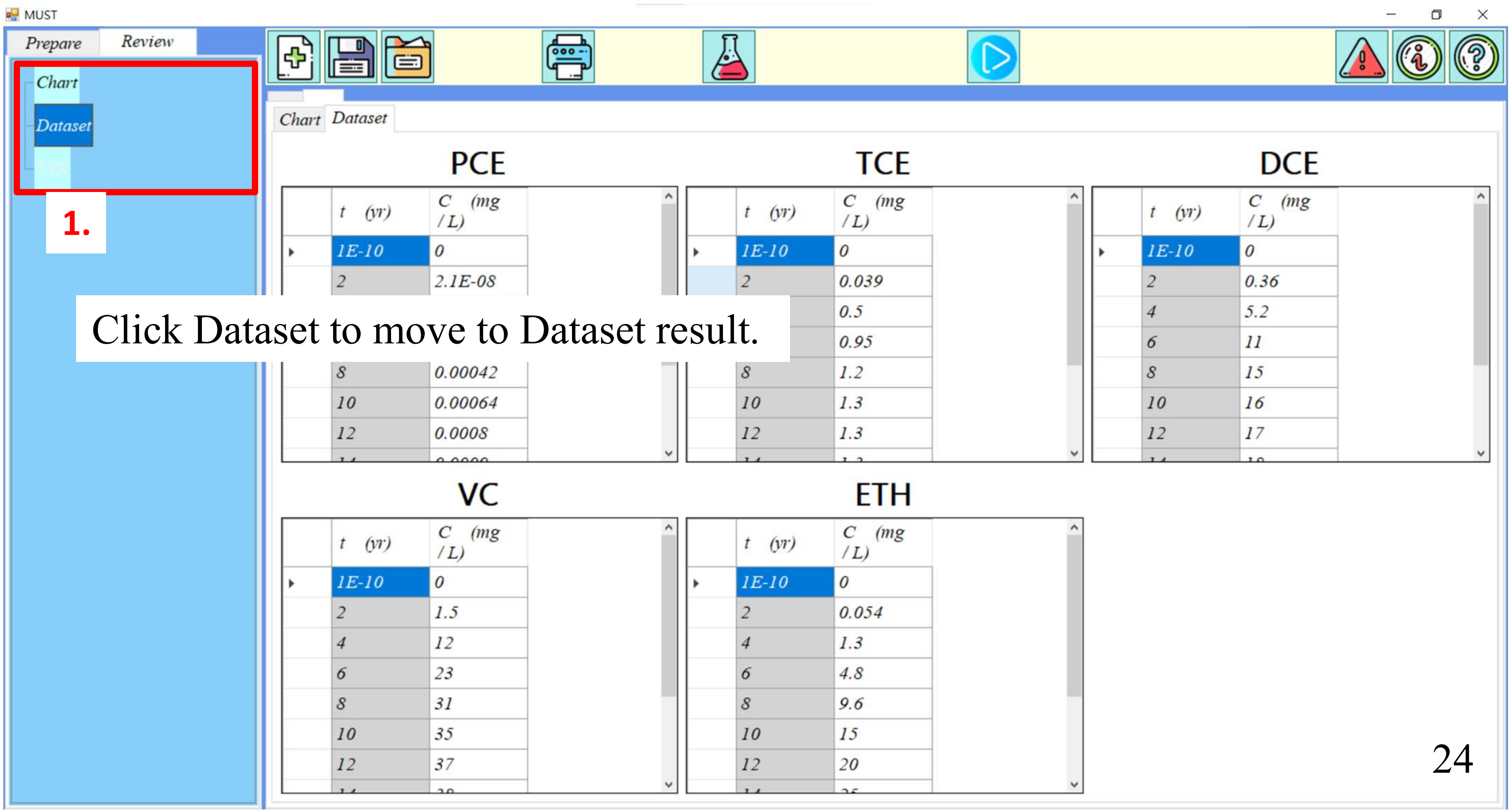
If click Concentration profile on along line, the lower input area will will display the profile along line input area.

Step 6. Result - Chart

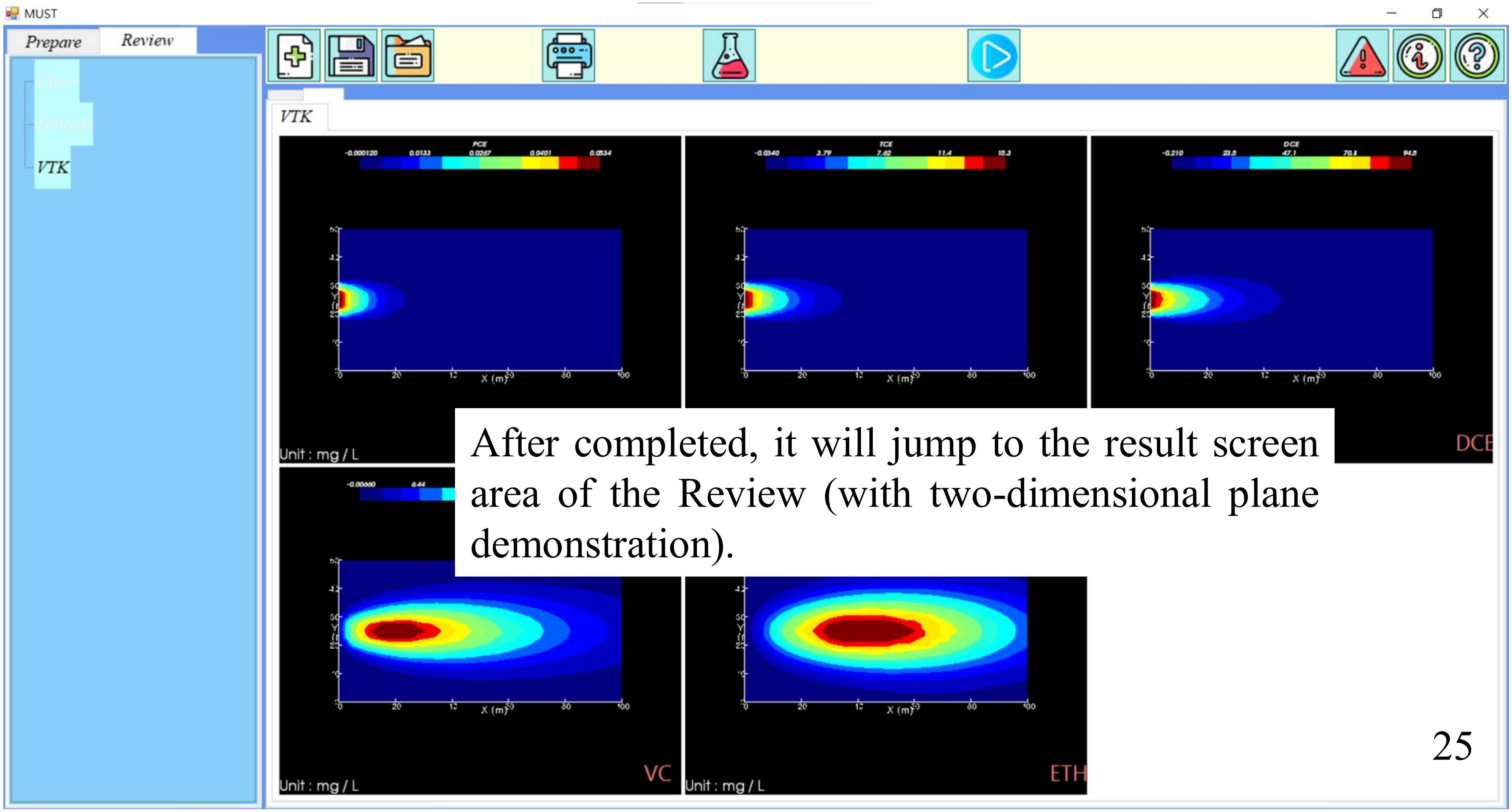


After completed, it will jump to the result screen area of the Review (with one-dimensional demonstration).
Note: One-dimensional display without VTK plane.

Step 6. Result - Dataset



Step 6. Result - VTK



After completed, it will jump to the result screen area of the Review (with two-dimensional plane demonstration).

4 Conclusions

Conclusions

- Now the Software is being tested and optimized.

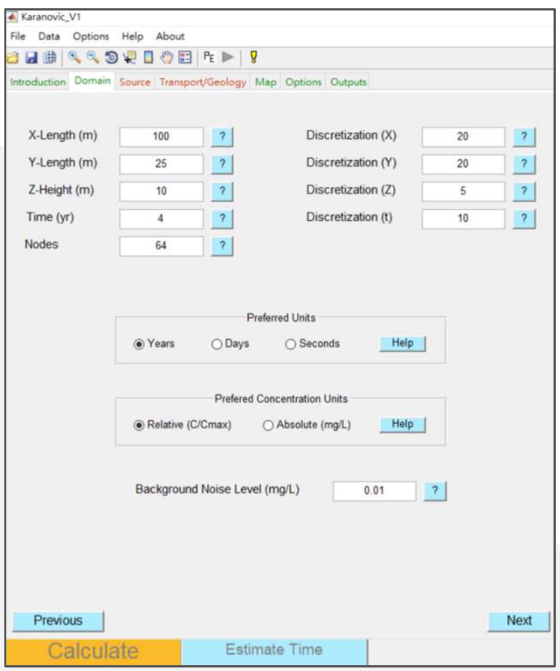
- Establishing a friendly interactive interface and visual display module will be more conducive to risk communication and risk management.

5 Future work

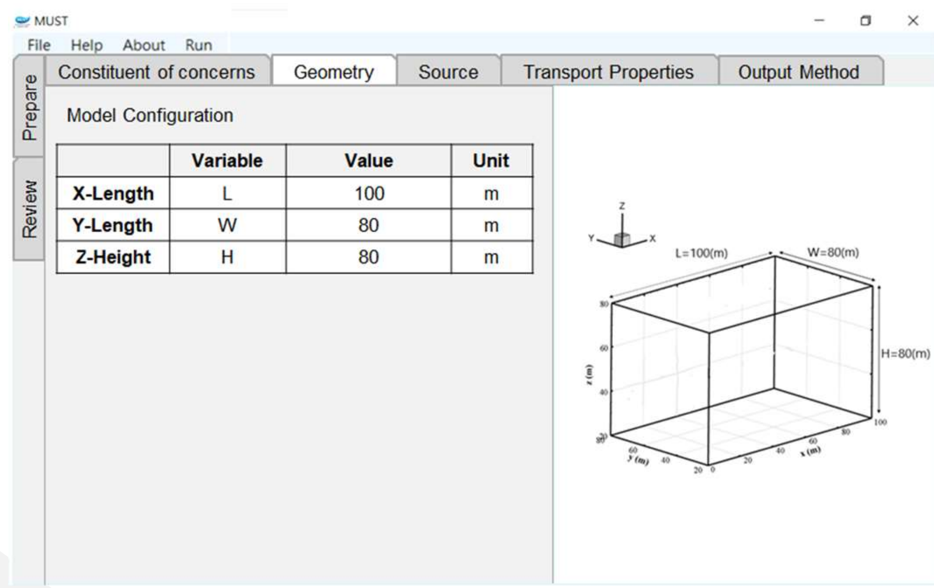
Future work

- To make the software easier to use, compare the user interface with HYDROSCAPE and optimize the software interface.

HYDROSCAPE



Risk Assessment Software



Thank you for your attention.