

# 2D Simulation of Advection Diffusion on Ground Water Flow on Joyo city in Kyoto

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**ABSTRACT:** The research of my paper on the Ground Water is to predict the extent of the pollutant source. These research paper purposes, by making 2D model, to analyze two dimensional seepage flow, to predict ground water flow and to analyze the advection diffusion of pollutant. The area of the simulation model is located in the southern part of Kyoto prefecture, it has a typical ground water basin shape. First, I made the 2D model with examining the material of the stratum, and divided 3 kinds of layers. That is divided into alluvial formations, clay formations, and, diluvial formations from the ground level. It is because that the most important purpose of this study is to the extension of the pollution in multiple layers. I made the analysis of the each seepage flow to get the speed of a moving fluid by using 2D model I have made. The next, I made the simulation analysis of advection Diffusion of pollutant source to predict the expansion of pollutant source. This pollutant source for this research is mercury.

## 1. INTRODUCTION

In Kyoto, the underground water has been used for daily life for a long time, such as making tofu and dyeing kimono. Kyoto has a typical groundwater basin where there are three main rivers; Uji River, Kizu River and Katsura River. These rivers flow into the area between Tennou-zan and Otoko-yama mountains, then flow out to Osaka. For this reason, Kyoto basin saves enough underground water. Due to the fact that the underground water in Kyoto basin flows out from this point only, it is estimated that abundant underground water is saved.

The quantity of underground water is calculated to 21.1 billion tons and is comparable to the volume of water in Lake Biwa (25 billion tons). This research is focused on Joyo city which is located in the southern part of Kyoto prefecture. In Joyo city 80 percent of water for daily life comes from ground water. So, if ground water is polluted, most of the people in Joyo city will suffer from illness caused by the contamination. To predict the extent of the pollutant source, these research paper purposes, by making 2D model, to analyze two dimensional

seepage flow, to predict ground water flow and to analyze the advection diffusion of pollutant.

## 2. GEOLOGICAL CONDITIONS IN KYOTO

Kyoto basin is surrounded by mountains made of basement rock such as Paleozoic strata and granite, as is shown in Fig.1. These mountains penetrate into the centre of the basin with a gentle gradient. The basement rock has a bowl shape and sedimentary layers made after the tertiary era accumulated on it. The basement rock is an impermeable bed; and, upon it, there are diluvial formations and alluvial formations consist of alternate layers of permeable and impermeable layers. This means that the sediment can save a lot of underground water. The simulation model of the area is rich in sand gravel in shallow layers (alluvial formations), and the deeper layers consist of clay and sand gravel.(diluvial formations)

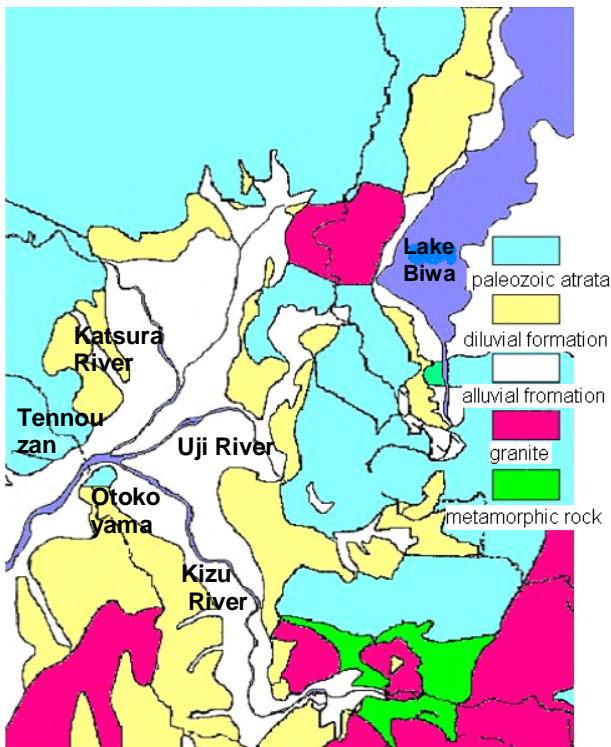


Fig.1 Geological profile on Kyoto basin

### 3. THE SIMULATION MODEL

The simulation model has been established by examining the material of the stratum taken from the data which is called “KANSAI GROUND INFORMATION DATABASE” in 2007. Since the most important purpose of this study is to predict the extension of the pollution in multiple layers, we divided 3 kinds of layers.

#### (1) The Area of the analysis

The analysis range in Joyo is shown in Fig 2. A-A' is the analysis range, and this simulation model is the vertical cross section, and the range is 3500m from the east to the west.

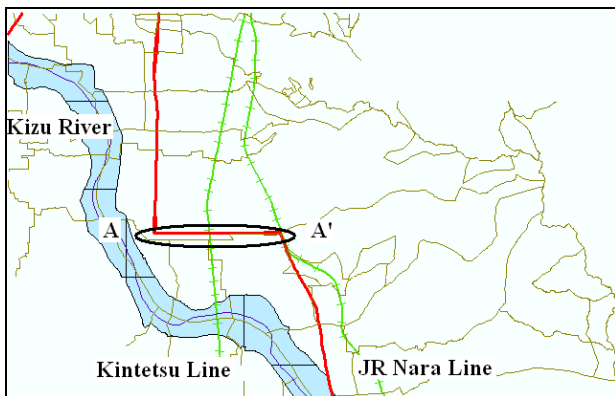
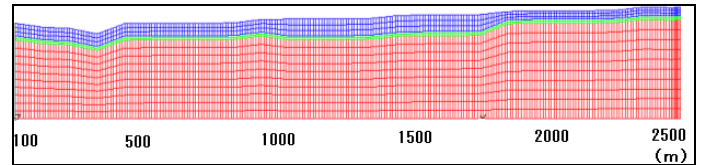


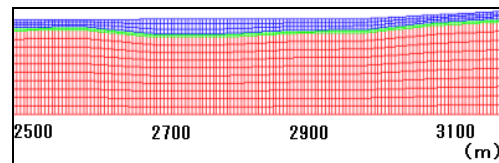
Fig.2 The analytical area in Joyo

#### (2) Mesh division

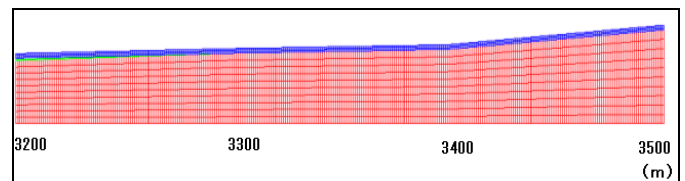
The completed model is shown in Fig 3, Fig4 and Fig5. It is divided into alluvial formations, clay formations and, diluvia formations from the ground level. That means the model is classified by colors at the vertical section. Blue is alluvial, Green is clay, Red is diluvia. The model is divided into 13053 node points and 12199 elements.



(a)from end of west to 2500m point



(b)from 2500m to 3100m point



(c)from 3200m to 3500m point

Fig.3 2D analytical model

### 4.THE RESULT OF ANALYSIS SEEPAGE FLOW

#### (1)The outline of the Seepage flow analysis

This study on 2D seepage flow analysis is FEM, and enables us to predict the speed of moving ground water flow.

#### (2)Boundary condition

As for boundary conditions, water fixed boundaries is set in both east and west. The east boundary is set at the average of actual ground water level, and the west is set at the average of Kizu river level.

### (3)Ground physicality parameter

As for the physicality of the ground parameter in this study, the coefficients of permeability are  $5.0\text{E-}05(\text{cm/s})$  in alluvial,  $1.0\text{E-}05(\text{cm/s})$  in clay, and  $5.0\text{E-}03(\text{cm/s})$  in diluvia.

### (4)The result of seepage

Fig 6 shows the result of analysis which is conducted at the point of  $1500\sim 2000\text{m}$  indicated in Fig 2. This result shows the speed of moving ground water flow in alluvial is about  $18\sim 33(\text{m/year})$ . Another result shows the speed of moving ground water flow in diluvia is about  $7(\text{m/year})$ . This result is used in the Advection Diffusion analysis.

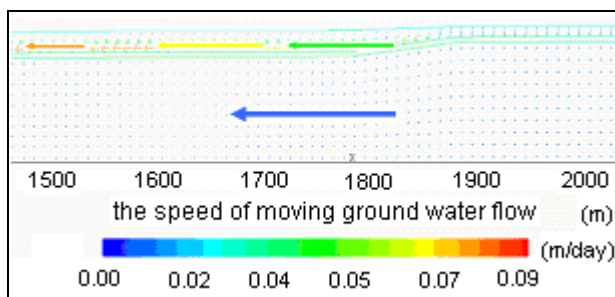


Fig.4 The vector diagram for the speed of moving ground water flow

## 5.The result of at ADVECTION DIFFUSION ANALYSIS

### (1)The outline of Advection Diffusion analysis

The present study predicts how 1 p.p.m source of the contamination spreads in 50 years in alluvial of in diluvia. This analysis can predict the behavior of mercury.

### (2)The result of Advection Diffusion analysis

Fig 5 shows the site where the contamination occurred in alluvial at the point of  $3000\sim 3100\text{m}$  shown in Fig 3(b). And Fig6 shows the one in diluvia at the point of  $3200\sim 3300\text{m}$  in Fig3(c). Both results show the behavior of mercury. The extent of mercury behavior for 50 years is estimated at 35 m in horizontal direction in alluvial. The extent of mercury behavior for 50 years is estimated at 17 m in horizontal direction in diluvia.

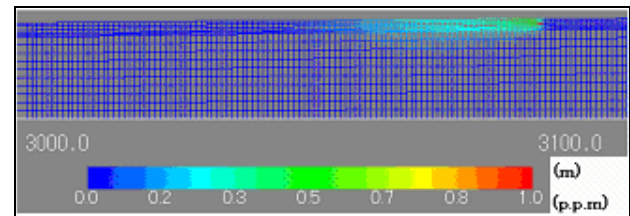


Fig.5 The result of Advection Diffusion of mercury at alluvial layer

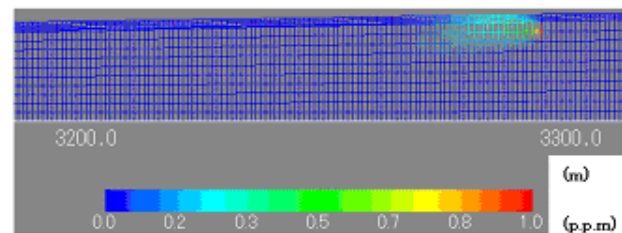


Fig.6 The result of Advection Diffusion of mercury at diluvial layer

### (3)The comparison of the concentration of the contamination

Fig 7 shows the comparison of the contamination concentration between alluvial formation and diluvia formation. It reveals that the pollutant in alluvia expands more than that in diluvia. However, concentration of diluvia is denser than that of alluvial near the source of the pollutant.

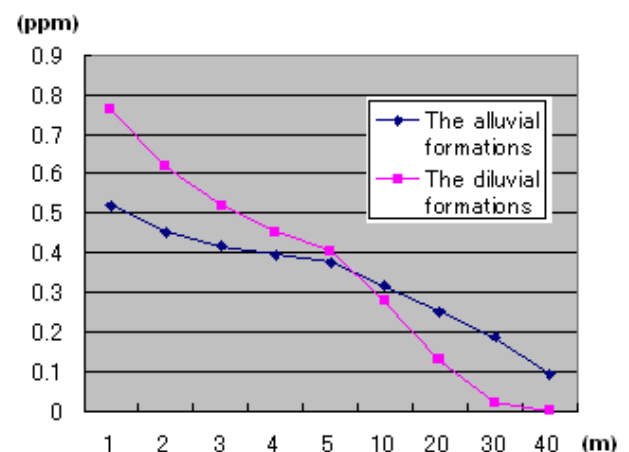


Fig.7 The comparison of contamination concentration between alluvial and diluvial formations

## **6.CONCLUSIONS**

The present study, the simulation model has been established in multiple layers. Furthermore, we succeeded to predict the ground water flow and the expansion of the pollutant. This simulation model predicts the extent of mercury behavior for 50 years is estimated at 35 m in horizontal direction in alluvial. The extent of mercury behavior for 50 years is estimated at 17 m in horizontal direction in diluvia. However, the analysis model should be made more accurately by altering the parameters. The challenges for the future will be the improvement of the model and reviewing the hydrological parameters.

## **REFFERNECES**

Kansai Ground Information Conference : Kansai Ground Information Database (in Japanese) CD-ROM, 2007.

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