# Database Architecture of Geosphere Environmental Informatics and its Application

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# Database Architecture of Geosphere Environmental Informatics and its Application

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**Abstract.** In this study, we examined the Pb concentration in river-bed sediments using GIS system of geosphere environmental informatics, which has been being developed for the integration of geoshpere environmental information such as catchment area, location of mineral deposit and elevation. Geomorphologic analysis was carried out in order to extract the stream network and the catchment area of sampling points from a digital elevation model in the Sendai Plain. We integrated the Pb concentration of samples in river-bed sediments and the basins extracted by geomorphologic analysis, and created the other information which shows the Pb concentration distribution map at each basin. In addition, the influence of elevation on Pb concentration in the basins was considered. Finally, we concluded that the integrated comparison of the basin, stream network, location of mineral deposit and elevation should be important for the evaluation of the Pb concentration in river-bed sediments.

**Keywords:** GIS, Geosphere environmental information, Geomorphologic analysis, Soil pollution, Heavy metal
**PACS:** 89.60.-k

## INTRODUCTION

Recently, many studies of an evaluation about geosphere environmental information have been done to clarify regional variations and the anthropogenic or natural contamination by metals of soils [1-6]. In Japan, investigation of soil pollution has been individually conducted by national institutions and private companies. Those results were however held by each research institute, nationwide database have not been systematized.

Reflecting such a situation, a new geochemical map was made covering whole country in Japan [7]. The map was innovative in terms of that distribution of hazardous elements on a nationwide scale was clarified for the first time in Japan. On the while, sampling point is only one site in the area of 10 km square, so local value of element concentration could not be plotted in the map, or one radical high concentration data would raise surrounding area's concentration. For these reasons it might be difficult to evaluate the concentration distribution of hazardous elements more in detail.

Soil contaminants such as heavy metals are determined for their object substance and standard value by environmental quality standards for soil.

Physical and chemical properties of heavy metals in farmland soil, mineral ore, and soil of urban area has been individually analyzed, however, the relationship between them was unknown. It would be necessary for the global evaluation of heavy metal's properties from various angles that many data should be weigh each other and integrated as a database.

It is important for the evaluation of concentration distribution of heavy metals included in soil to consider the process of occurrence, transfer and deposition of heavy metals that means the integration of information about heavy metal's properties.

We have started the industry-academic-government project (executed by Graduate School of Environmental Studies, Tohoku University, National Institute of Advanced Industrial Science and Technology, and Dowa Mining Co., Ltd.) called "System Development of Geosphere Environmental Informatics and its Nationwide Expansion" for three years from 2005. In the project, the integration of geoshpere environmental information such as geology, soil, vegetation, land use, position of mineral deposit,

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alteration, heavy metal's concentration in ground water, and so on was done using a geographical information system (GIS) and heavy metal behavior included in soil was evaluated. In this study, we will report the brief overview about the project and the result of examination about the Pb concentration in river-bed sediments in Miyagi prefecture using the GIS system.

## GEOSPHERE ENVIRONMENTAL INFORMATICS

In the project, we use ArcView 9.1 (ESRI Co., Ltd.) which has some extension tools such as ArcScan, Spatial Analyst and Geostatistical Analyst.

### Objected Geosphere Environmental Information

Soil contaminant objected at this study is heavy metal which is included in environmental quality standards for soil. Geosphere environmental information objected at this study is geology, topography, soil, vegetation, land use, position of mineral deposit, alteration, heavy metal's concentration in ground water and in soil.

### Characteristics of the System

*Integration of Geoshpere Environmental Information*

GIS software used in the study can overlay geosphere environmental maps with each other. GIS also can weigh attributes of two maps, and search correlated areas of them. Those functions enable to evaluate the relationship of heavy metal distribution in soil, geology and soil properties. Figure 1 shows the location of mineral deposits on a sedimentary rock of Upper Miocene called Onnagawa formation. A table in the figure shows information of mineral deposit such as the name of mine, prefecture, address, longitude and latitude, and type of mineral. Result of histogram analysis about Pb concentration in Tohoku district and in Onnagawa formation using Geostatistical Analyst shown in Fig. 2 indicates that the Pb concentration in Onnagawa formation was relatively higher than that of in Tohoku district.

We can integrate various type of information and take new insight from them by using the above system.

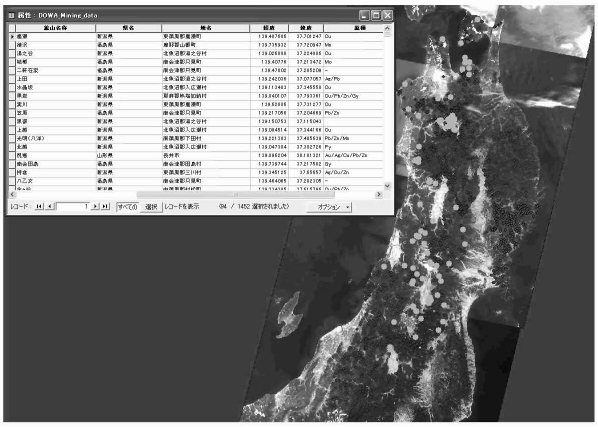

**FIGURE 1**. Mineral deposits located on Onnagawa formation.

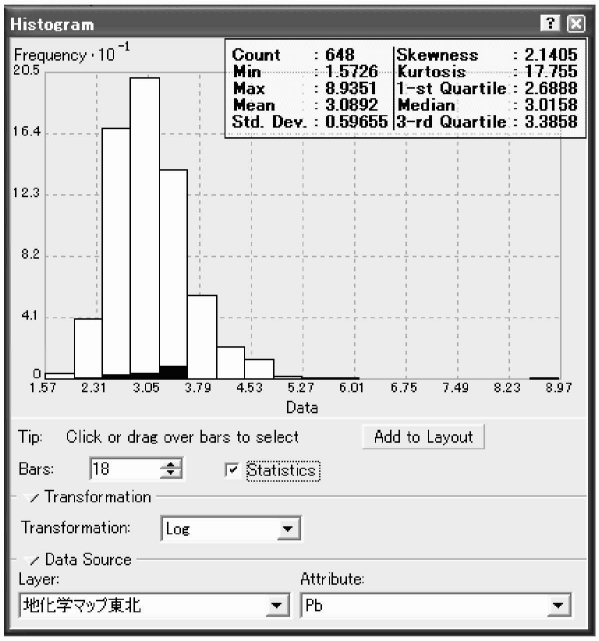


**FIGURE 2**. Histogram of Pb concentration.

*Consideration of Depth*

We are now developing the system of geosphere environmental informatics considering a geological depth. This will enable us to evaluate three dimensional heavy metal distributions. For example, if we have a data about a heavy metal concentration at each depth of boring core sample and we know a correlation with geology and heavy metal concentration at each depth, we can estimate a heavy metal distribution at a certain depth where heavy metal sampling was not done (see Fig. 3).

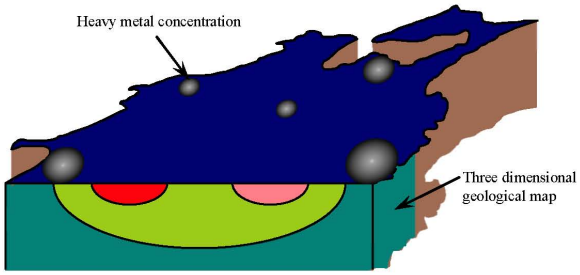


**FIGURE 3**. Schematic illustration of an integration of geochemical map and geological map considering depth.

This method will be fundamental information to decide an appropriate route taking into account a soil contamination in the case of tunnel excavation. In addition, this method will also be information for making a decision to distinguish between natural and anthropogenic contamination.

## EVALUATION OF HEAVY METAL DISTRIBUTION WITH GEOMORPHIC ANALYSIS

It is important for an evaluation of heavy metal's spatial distribution in soils to consider an influence of regional geography and geosphere environment. In this study, we tried to evaluate the relationship between heavy metal distribution and geosphere environmental information as represented by geography. We used the heavy metal's concentration data from geochemical map in Japan [7]. Analytical area is the Sendai Plain. In the analysis, we took consideration of stream network and catchment area as geographical effect, and of locations of mineral deposits as geosphere information.

### Analysis Method

Pb concentrations in soil samples which data are downloadable from the website "Geochemical map of Japan" (managed by Geological Survey of Japan, AIST) are used in the analysis. Digital elevation model (DEM) on a scale of 1 to 25,000 that is released from Geographical Survey Institute was used to consider stream network and catchment area in Sendai Plain.

### Result of Geomorphologic Analysis

Geomorphologic analysis was carried out in order to extract the stream network and the upper river basin of sampling points (see Fig. 4). We integrated Pb concentration of samples and the basins extracted by geomorphologic analysis, and created new information

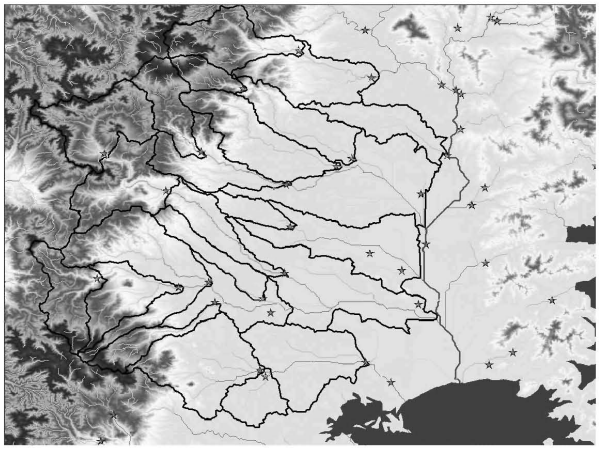

**FIGURE 4**. Extraction of stream networks (blue line) and chatchment areas (black line) in the Sendai Plain.

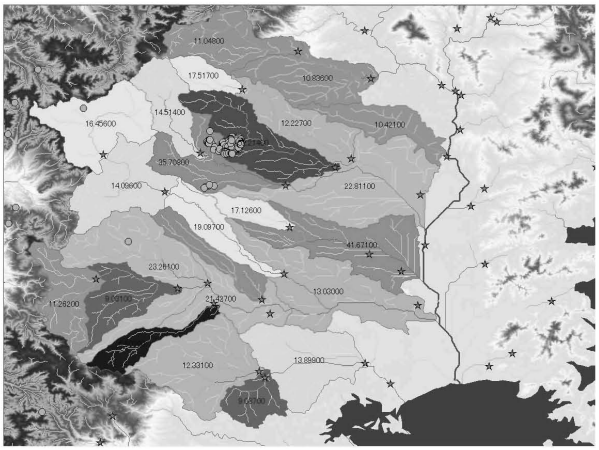

**FIGURE 5**. Integration of catchment areas hierarchized by Pb concentration (red is higher) and location of mineral deposits (green dots).

that shows Pb concentration distribution map at each catchment area (see Fig. 5). In addition, the influence of elevation on Pb concentration in the basins was considered. After that, we found that Pb concentration in a catchment area where is located at precipitous terrain showed that Pb was transferred from upstream by rapid stream and was deposited at downstream in which mineral deposits are located and its downstream site was higher than the other basins.

Finally, we concluded that the integrated comparison of the basin, stream network and elevation should be important for the evaluation of the process of occurrence, transfer and deposition of Pb in river-bed sediments using the GIS system.

## CONCLUSION

We have started the industry-academic-government project called "System Development of Geosphere Environmental Informatics and its Nationwide

Expansion" for three years from 2005 and are now developing the GIS system. In this paper, we introduced about the system and the geomorphologic analysis in the Sendai Plain was carried out to evaluate Pb concentration in river-bed sediments.

We will examine the relationship between heavy metal's concentration in river-bed sediments, soil, or rock samples, and geology, soil property and vegetation. In addition, we will have several kinds of dissolution tests to know heavy metal's mechanical and chemical properties.

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