Spatial Variability Analysis of Arsenic in Groundwater: A Case Study in Hetao Plain, Inner Mongolia

ZHANG Haoyue[1] and LIU Wenbo[2, *]

[1] *China University of Geosciences (Beijing), Beijing 100083*
[2] *China Institute of Geo-Environmental Monitoring, Beijing 100081*

Citation: Zhang et al., 2019. Spatial Variability Analysis of Arsenic in Groundwater: A Case Study in HetaoPlain, Inner Mongolia. *Acta Geologica Sinica* (English Edition), 93(supp.2): 374–375.

Abstract: The shallow higharsenic (As) groundwater has seriously affected the living and environment of local residents in the Hetao Plain areas. The predecessors have done a lot of research on the horizontal regionality, vertical differences and the formation mechanisms of groundwaterAs, but the spatial variation characteristics and its autocorrelation have not been reported. The variogramanalysis is one of the important methods of geostatistics. It is a powerful tool to analyze the spatial patternsand laws of variablesbecause it focuses on the spatial process of variable factors, considering spatial distribution characteristics and spatial autocorrelation. Fractal dimension, as an index to measure the degree of spatial dependence of a variable, can reflect the relative importance of the variation of variables at different spatial scales. The value of the fractal dimension can be used to reflecta certain scale of variation that controls the spatial distribution pattern. The data in this paper consist of 753 shallow groundwater (8–35m) samples ofAsin Hetao Plain. The adjacent sampling points are uniformly controlled within 3–4 km, and to 2km when the As concentration is high (>0.1 mg/L). The raw data are transformed byBlom algorithm normal transformation methodin SPSS. ArcGISis used to spatially project, calculate the average lag size (2377m), and determine the number of lags (30), ensuring that each lag group contains at least 350 pairs.After removing the spatial trend, the semivariogram analysis is carried out to reveal the spatial variability of groundwater As concentration, and the influencing factors are analyzedin Hetao Plain. Results show that the spatial distribution of groundwater As concentration in Hetao Plain is fitted toalmost the pure nugget effect modelunder the assumption of isotropic conditions. The value of nugget/sill is 98%, close to 100%, which is random on the scale measured, so there is no spatial autocorrelation, and the variation is large in a short distance. The fractal dimension value of groundwater As concentration is large (D=1.999), further indicating that the variation on the smaller scale is significant, that is, the geochemical process on the small scale plays a controlling role on the spatial pattern of groundwater As. The reasons why the spatial distribution of groundwaterAs concentration varies greatly in a short distance are as follows. Firstly, it is related to the attachment form of As itself. The high As groundwater mainly exists in the state of colloid, originate from Quaternary sediments containing As in Hetao Plain, which leads to uniformly deposited ofAs in the colloidal form during the deposition process, but close relationships with the physical

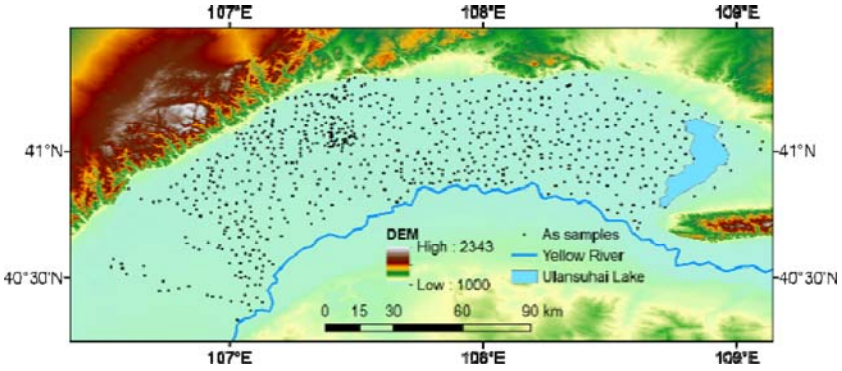


Fig. 1. The sketch of groundwater As samplinglocationsfor spatial analysis in Hetao Plain.

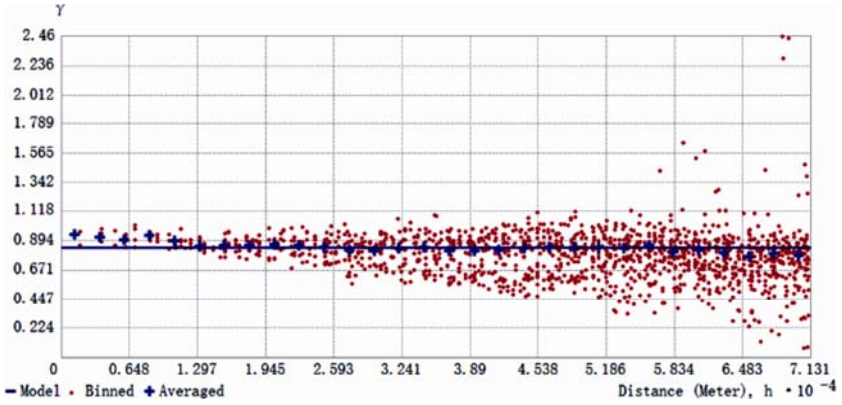


Fig. 2.The semivariogram of groundwater As concentration.
Binned values are shown as red dots, generated by grouping (binning) empirical semivariogram/ covariance points together using square cells that are one lag wide. Average points are shown as blue crosses, generated by binning empirical semivariogram/covariance points that fall within angular sectors. Black line represents fitting model based on the average value.

* Corresponding author. E-mail: 106690009@qq.com

and chemical conditions of the sediments, thus further resulting in the heterogeneity of the As concentrationand large variation in the sediments. Secondly, the content of organic matter, especially total organic carbon (TOC), is quite various. TOC affects the dissolution of iron oxides and desulfurization under the reaction of microorganisms, and redox potential of groundwater, which ultimately affects the release of As. The palaeo channels of the Yellow River have been migrating since the late Pleistocenein Hetao Plain. The varying sedimentaryfaciestriggerdifferences of organic matter content in the sediments, so the reductive dissolution of As-containing oxidized minerals and desulfurization are significantly spatiallyvarious. The third reason is the flow properties of groundwater. Groundwater hydraulic gradient is too small in Hetao Plain, influenced by topography, structural closure, sediment lithology and particles, so the flow and transportare extremely slow, resulting in groundwaterAs concentration vary widely over short distances.

Key words: As concentration, groundwater, geostatistics, semivariogram, spatial variation

Acknowledgments: This work is granted by the CGS Project: Demonstration of Groundwater Exploration and Water Supply Safety in High Arsenic Area inHetao Plain, Inner Mongolia (Grant No. 1212010634702) and CGS Project: Hydrogeological Survey in Chengde area (Grant No. DD20190311).

References

Gao, C.R., Liu, W.B., Feng, C.E., et al., 2014. Research on the formation mechanism of high arsenic groundwater in arid and semi-arid regions: A case study of Hetao Plain in Inner Mongolia, China. *Earth Science Frontiers*, 21(4):13-29 (in Chinese with English abstract).

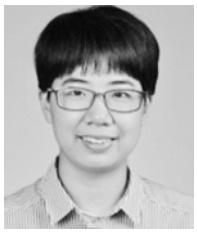
Guo, H.M., Zhang, B., Zhang, Y., 2011. Control of organic andiron colloids on arsenic partition and transport in higharsenic groundwaters in the Hetao basin, Inner Mongolia. *Applied Geochemistry*, 26(3): 360–370.

Zhou, Q.S., Zhang, X.J., Ye, P.S., et al., 2017. The distribution and period division of Holocene palaeo channels of the Yellow River in Hetao area. *Journal of Geomechanics*, 23(3): 339–347 (in Chinese with English abstract).

Zhou, Y.Z., Guo H.M., Zhang, Z., et al., 2018. Characteristics and implication of stable carbon isotope in high

arsenic groundwater systems in the northwest Hetao Basin, Inner Mongolia, China. *Journal of Asian Earth Sciences*, 163:70–79.

About the first author



ZHANG Haoyue, female, born in 1993 in Taizhou City, Jiangsu Province; Ph.D. candidate; study in China University of Geosciences (Beijing). She is now interested in the study on hydrogeologyandecohydrology. Email: 1065386155@qq.com; Phone: 13716801642.

About thecorresponding author

LIU Wenbo, male, born in 1977 in Tianmen City, Hubei Province; Ph.D.; graduated from China University of Geosciences (Beijing); Hydrogeological engineer, work in China Institute of Geo-Environmental Monitoring. He is now interested in the study on hydrogeology and hydrogeochemistry. Email: 106690009 @qq.com; Phone: 18611518200.