A NEW TWO-DIMENSIONAL ANALYTICAL SOLUTION OF GROUNDWATER FLUCTUATIONS IN COASTAL AQUIFER

JING CHEN[1] and ZHIFANG ZHOU[2]

[1] Doctor, College of Civil Engineering, Hohai University,
XiKang Road 1#, Box.278, Nanjing, China, 210098
(Tel: +0086-25-83787540, e-mail: dqjz@163.com)
[2] Professor, College of Civil Engineering, Hohai University,
XiKang Road 1#, Nanjing, China, 210098
(Tel: +0086-25-83787540, e-mail: zhouzf@hhu.edu.cn)

Tide-induced head fluctuations are a natural phenomenon in a coastal aquifer. For an unconfined aquifer, groundwater level changes corresponding to the tidal waves. As the tidal propagate inland, their amplitude is attenuated and phase-shifts occur. A typical damping distance for tidal water table fluctuation in an unconfined aquifer is several hundred meters whereas the tidal influence on a confined aquifer can extend landward by several thousand meters. According to the facts showed above, the groundwater flow and transportation are largely affected by tidal fluctuation. Some analytical solutions based on one-dimensional Boussinesq equation have been derived to describe the relationship between the tidal effect and water table in aquifer.

Recently, Sun solved analytically a two-dimensional transient groundwater floe equation for a confined nonleaky aquifer with an estuary tidal-loading boundary condition. The solution is more advanced than the traditional one-dimensional analytical solution with a one-dimensional tidal-loading boundary condition. The tidal loading varies along the estuary, i.e, a non-uniform boundary condition

$$h(x,0,t) = A\exp(-k_{er}x)\cos(\varpi t - k_{ei}x)$$

where $h(x,0,t)$ is the fluctuation of water level in the estuary; A and ω are the tidal amplitude and frequency, respectively. And x is the distance along the estuary from the entry. k_{er} and k_{ei} are the amplitude damping coefficient and wave number of the tidal wave in the estuary, respectively. Li(2000)pointed out that the analytical solution of Sun described only the aquifer 's response to the tidal loading in the estuary. The aquifer is actually affected by both oceanic tides along the coastline and the tides loading in estuary and these two tides propagate and influence each other. So it must lead to more complex pattern of tidal head fluctuation than previous solution. The Sun's solution can not satisfied the condition mentioned above except for the area far from the coastline. The interaction zone can be very large at natural coast and it is affected by the angle at which the estuary intersects with the coastline. For a confined aquifer may be of several kilometers. The analytical solution of tidal head fluctuation is derived using Green's function method. Li Hailong(2002) made a more simple approximation of the solution instead of the initial-boundary considered by Li(2000). An analytical solution is presented to describe the tidal groundwater level fluctuation in an aquifer bounded by two water-land boundaries that forms a right angle. It just because that the coastlines are very

irregular and full of inlet, bays, and headlands and cannot always be regarded as straight lines, an idealized coastline that bent at a right angle is as a special situation in Li hailong's solution. Its periodic analytical solution has improved the Li's for L-shaped aquifer.

Although it is believed to be of some practical use, the study on groundwater level fluctuation cannot be localized in the approximation of L-shaped area. This paper also setups a two-dimensional model of groundwater fluctuation in estuarine area and derives an analytical solution based on green function method. Analytical solution describes how groundwater's response to tidal loading in an estuary and ocean in the polar coordinate system. So the solution presents groundwater level fluctuations in fan-shaped aquifer. The angle which the estuary intersects with coastline can vary in such condition so that the solution of Li Hailong's can be seen as the special case of it. The result shows its more extensive application than recent studies.

REFERENCES

Xue, Y., Zhu, X., and Wu, J. (1997). *Dynamic of Groundwater.* Beijing : Geological Publishing Company.

Sun H. (1997). "A two-dimensional analytical solution of groundwater response to tidal loading in an estuary," *Water Resour. Res.*, Vol. 33, pp. 1429±35.

Li, L., D.A.Barry, C.Cunningham, F. Stagniti, and J.Y.Parlange, (2000). "A two dimensional analytical solution of groundwater response to tidal loading in an estuary and ocean," *Adv. Water Resour.*, Vol.23(8), pp.825-833.

Li, H., Jiao, J.J., Luk, M. and Cheung, K. (2002). "Tide-induced groundwater level fluctuation in coastal aquifers bounded by L-shaped coastline," *Water Resour. Res,* Vol. 38(3), pp.6-1~6-8.

Shimakura, N. (1992). *Partial Differential Operator of Elliptic Type(Translated from Japanese by N.Shimakura)*, Am.Math. Soc, Providence, R.L.

Li, H. and Jiao, J.J. (2001b), " Tide-induced groundwater fluctuation in a coastal leaky confined aquifer system extending under the sea". *Water Resour. Res.*, Vol. 37(5), 1165–1171.