Estimation of groundwater flux based on a cation exchange mass balance method -a case study in northeastern Osaka Basin-

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The objective of this study is to estimate an amount of natural recharge in Northeastern Osaka Basin (NEOB), where confined aquifer system is well developed, by using mass balance method based on cation exchange reaction.

The shallow confined groundwater (above depths of 100m) in NEOB modified its chemistry from Ca-HCO3 type through Mg-HCO3 type to Na-HCO3 type along the flow paths. (The areas with the water types expressed as zones A, B, and C, in that order.) In addition, exchangeable cation (EXC) in argillaceous aquiclude distributes in concordant with caition of groundwater and NEOB had suffered transgression. These facts indicate that distributional patterns of both cation compositions were outcomes reflecting the adsorption affinity onto clay. Namely, EXC of aquiclude had been fairly enriched in Na and Mg with marine origin directly after regression, and had released Na and Mg in turns by cation exchange reaction with Ca-HCO3 type recharge water. As the consequent of such 'displacement chromatograpy' for a long-term period, it is considered that cations of both groundwater and EXC have been spatially distributed in turns of Ca type, Mg type and Na type from recharge area to down-flow area.

We tried to estimate a necessary amount of natural recharge to differentiate the EXC as in present from Na type after regression. Parameters of aquiclude (thickness, bulk density and cation exchange capacity) allow us to grasp a total amount of EXC in each zone's aquiclude. Deduced from equilibrium of EXC with seawater directly after regression (9630 a B.P.; Itihara and Kigoshi, 1962) and spatial distribution of EXC in present, Na-X and Mg-X2 (X: exchange substrate) have been exchanged by 18.1*10^13meq Ca (Q Ca) originated from recharge water for this period (T AR-P = 9630+50 a). On the other hand, supplied Ca amount per 1m3 recharge water to aquiclude (C Ca) can be suspected from the difference of Ca contents between Akuta-Hio Rivers as recharge water and Na-HCO3 type groundwater in zone C, and is 14.6*10^3mg/m3 (0.73*10^3meq/m3). Then, the annual groundwater flux into into shallow confined aquifer system (F GW) can be expressed by the following equation:

F GW = Q Ca /(C Ca * T AR-P)

Consequently, these values give us approximately 2.57*10^7m3/a as F GW. This amount corresponds to 2.3 times of the pumping amount (1.14*10^7m3/a) in highly pumping area of NEOB. Furthermore, assuming that mountainous area of Akuta-Hio-Minase River drainage basin (70.9km2) is recharge area of confined groundwater, recharge rate to the confined aquifer is 0.99mm/day. This value is compatible with the average recharge rate in Japan (1mm/day), indicating that mass balance method based on cation exchange reaction can provides us reliable estimation of natural recharge to confined aquifer.