Quantitative analysis of groundwater effluent and reservoir water influent in a pond using ^{222}Rn- and water-balance equations

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Objectives

It is essential to quantify groundwater effluent and reservoir water influent in ponds in order to use water resources effectively and to predict water quality. However, conventional methods measure only the amount of surface water inflow and outflow, and can only reveal differences between groundwater effluent and reservoir water influent. It is not possible to quantify both parameters simultaneously. In this study, we concentrated on the radon-222 (^{222}Rn) content in the environment and developed an analytical method using ^{222}Rn- and water-balance equations.

Results

Fig. 1 shows ^{222}Rn- and water-balance in a pond. Although groundwater influent and reservoir water influent are unknown quantities, it is possible to quantify them both by constructing ^{222}Rn- and water-balance equations. The dispersion of ^{222}Rn into the atmosphere, an important factor contributing to ^{222}Rn loss, is calculated assuming that there is a stagnant film between water and air. The thickness of this stagnant film was empirically estimated to be 830 μm.

The developed method was applied to a pond near a landslide-prone area in Japan, where it is considered that reservoir water influent is a major cause of landslides. Table 1 shows the results of the field investigation. Using these data, we constructed ^{222}Rn- and water-balance equations, and groundwater effluent and reservoir water influent were calculated to be 0.67 L/s and 0.41 L/s, respectively. As stated above, conventional methods could not quantify groundwater effluent and reservoir water influent simultaneously, but our new method has made this possible.

The on-site application of the method is expected to facilitate effective water use, predict water quality, and prevent landslides.

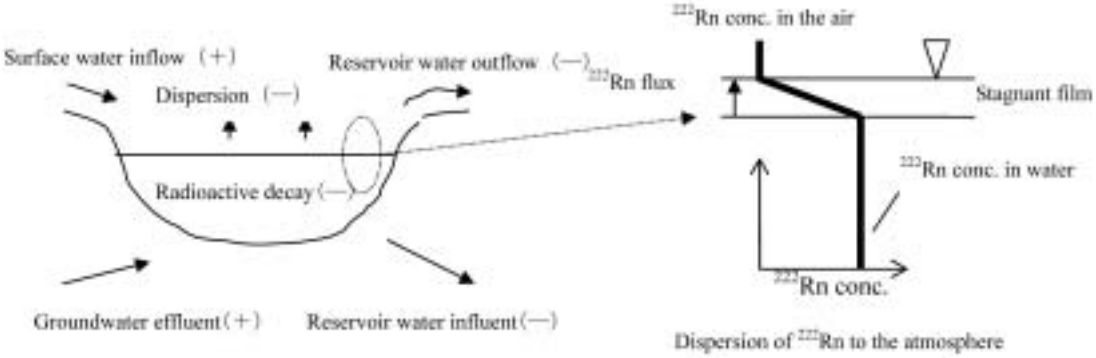

Fig. 1. ^{222}Rn- and water balance in a pond (+ : supply, – : loss.). Water balance was maintained (water level remained constant) when the amount of surface water inflow and groundwater effluent was equal to the amount of reservoir water outflow, evaporation, and reservoir water influent. ^{222}Rn balance was maintained (concentration remained constant) when the amount of surface water inflow and groundwater effluent equaled the amount of radioactive decay, dispersion, reservoir water outflow, and reservoir water influent.

Table 1. Results of field investigation.

	Discharge (L/s)	^{222}Rn conc. (Bq/L)	Amount of ^{222}Rn (Bq/s)
Spring	0.11	6.54	0.72 (discharge × conc.)
Surface water	0.15	0.00	0.00
Groundwater effluent	x	6.54	6.54x (dischage × conc.)
Radioactive decay			3.74 (decay const. × volume × conc.)
Dispersion			1.00 (area × diffusivity × conc./thickness of stagnant film)
Reservoir water outflow	0.43	0.41	0.18 (discharge × conc.)
Reservoir water influent	y	0.41	0.41y (discharge × conc.)
Evaporation	0.09		

The area of the pond is 1550 m^2. The average depth is 2.8 m. The thickness of stagnant film is 830 μm.
^{222}Rn concentration in groundwater equals that of the spring.

References

Hamada, H. and Kishi, S. (2004): Quantitative analysis of groundwater effluent and reservoir-water influent in a small pond using ^{222}Rn- and water-balance equations. JARQ, 38, 253–258.

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