Spatial Variavility of Hydrochemical Dynamics in Weathered Granite Catchments

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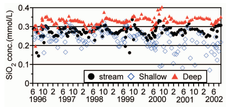
Introduction

Two-Layers Model for Hydrochemical Processes in Headwater Catchment

From the results of our previous studies, streamwater chemistry is controled by the mixing of two groundwater aquifers in headwater catchments
(SiO_2:Katsuyama, 2002; NO_3^-:Ohte et al., 2003; SO_4^{2-}:Kim, See Poster No. D-034)

Riparian Shallow layer: Effects of Saturated Throughflow
Low SiO_2, High NO_3^-, Large seasonal variations
Riparian Deep layer: Effects of Bedrock Groundwater, infiltrated at Hillslope zone
High SiO_2, Low NO_3^-, Small seasonal variations

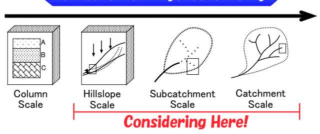


Two-Layers Mixng of Streamwater SiO_2 concentrations

Question:
How Does Spatial Scaling Effect on Hydrochemical Processes?

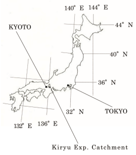
Comparing the Hydrological/Hydrochemical processes in various spatial scales in weatherd granite catchment

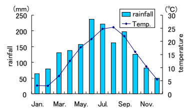
Pick up the scaling factors for catchment hydrochemistry



Site Description

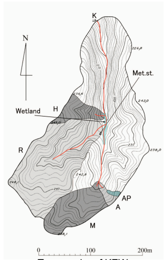
Kiryu Experimental Watershed(KEW), Japan





Monthly rainfall and air temperature in KEW

Location	Central part of Japan(34°58'N 136°00'E)
Vegetation	Chamaecyparis obtusa Sieb. et Zucc. Pinus densiflora Sieb. et Zucc. some deciduous species
Climate	Temperate
Annual Temperature	13.9°C
Bedrock material	Weathered Granite



Topography of KEW

Observation Network

Catchment Scale(2-order catchment)
K: the whole of KEW

Subcatchment Scale(0- or 1-order catchment)
A,M,H,&R

Hillslope Scale(0-order catchment)
AP:Study Hillslope for monitoring subsurface flow using trench

Wetland
Some stonemasonry dams constructed to prevent soil erosion along the main stream.
A small wetland is formed in sedimentation area
The area of the wetland corresponds to 0.5% of the area of KEW

Stonemasonry dam

Results & Disscusion

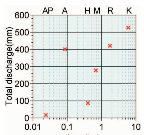
Comparison of Discharge rate / Hydrographs

Water Budget and Runoff ratio in each catchment

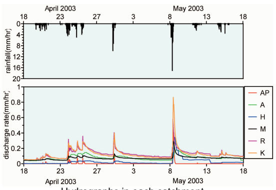
Observed Period From 1/Jun/2002 To 31/May/2003

Catchment		K	R	M	H	A	AP
Area	(ha)	5.99	1.75	0.68	0.40	0.086	0.024
Rainfall	(mm)	1341.87					
Discharge	(mm)	527.09	421.10	277.68	86.81	401.25	17.09
(ratio)	(%)	39.3	31.4	20.7	6.5	29.9	1.3
Direct Runoff※	(%)	12.8	10.2	3.1	2.7	12.1	

※ Calculated following the method of Hewlett and Hibbert(1967)



Catchment area vs. Discharge rate



Hydrographs in each catchment

Stream flow was...
Ephemeral in AP and H
Perennial in A,M,R, and K
K&R had similar runoff characteristics
Runoff characteristics was different among smaller catchments(A,H, and M)

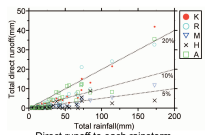
Considering water budgets...

$$P = Q + E + \Delta S + BS$$

P,E was assumed equal between catchments
ΔS was assumed Zero for a observed period(one year)

BS(Bedrock Seepage) was larger in smaller, headwater catchment
⇕
Q(Discharge) was increased in larger catchment

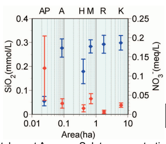
Bedrock groundwater, seeped at headwater catchments, contributed to runoff from the larger catchments



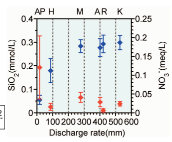
Direct runoff to each rainstorm

Agree with Two-layers model !

Comparison of SiO_2 / NO_3^- concentrations



Catchment Area vs. Solute concentrations



Discharge rate vs. Solute concentrations

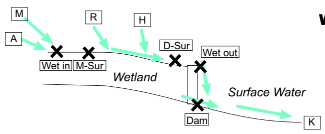
SiO_2 concentrations increased and stabilized with the increase of catchment area / total discharge

NO_3^- concentrations decreased with the increase of catchment area / total discharge,
HOWEVER had not stabilized!!

- Streamwater in M catchment is relatively high because of forest disturbance (Pine Wilt Disease)
- AP has especially high NO_3^- comparing the others

Roles of Wetland / Hyporheic zone

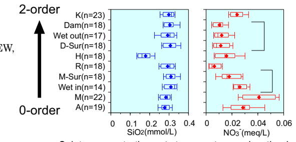
Wetland in KEW



Wetland has anaerobic, reducted environment

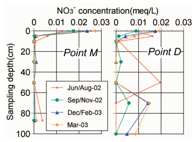
NO_3^- removed from surface water in wetland
(SiO_2 was not affected)
HOWEVER, NO_3^- in K(outlet of KEW) increased again!!
⇒ Effects of Hillslope near the KEW outlet(Similar to AP)

Concerning Wetland in KEW, Please see Poster NO. D-039



Solute concentrations at streamwaters and wetland

NO_3^- concentration decreased
↑
Passing through Wetland



NO_3^- Profile in Wetland

Concluding Remarks

Two-Layers Model for Hydrochemical Processes in Headwater Catchment

is applicable for SiO_2 concentrations in 2-order catchment
- Groundwater infiltrated into bedrock contributed in Downstream, and Total discharge increased
- Bedrock Groundwater had high SiO_2, thus SiO_2 increased in larger catchment

is incomplete for NO_3^- concentrations in 2-order catchment
- NO_3^- decreased in two ways; Mixing of Bedrock Groundwater/Removal in Wetland
- Increased at the outlet of 2-order catchment

The scaling factors for catchment hydrochemistry...
Distributions, Roles, and Contributions of each geographic component
---Headwater catchment / Wetland / Hillslope / Bedrock

References

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