Estimating the characteristics of woody debris mechanism in Terauchi dam reservoir catchment

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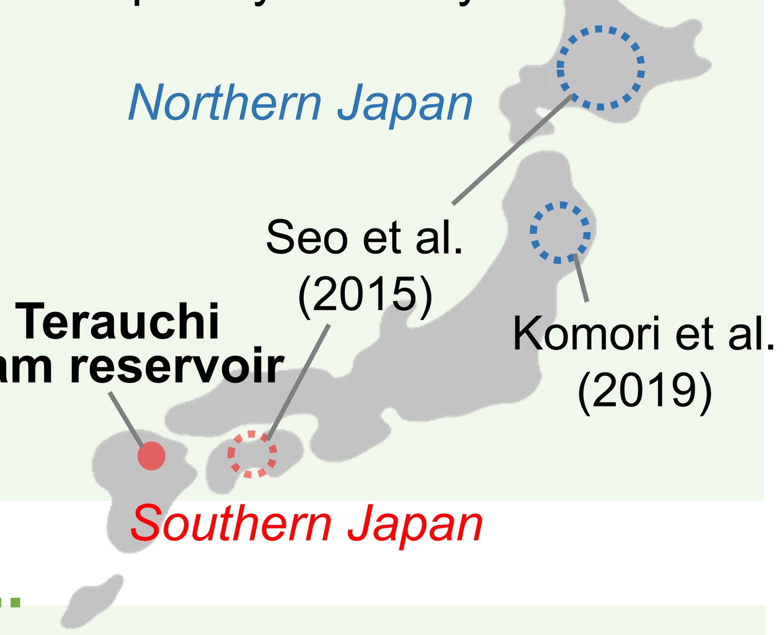
Introduction

- In 2017, large amounts of woody debris flowed into human living area caused by heavy rain in Northern Kyushu. Many buildings were damaged because of this incident.
- In Terauchi dam reservoir, which is located in Fukuoka prefecture, 8536m^3 of woody debris were exported and it took a very long time and high cost to remove all of the woods from the reservoir.
- It is important to understand the detailed mechanism of woody debris throughout a catchment.

Figure1. Woody debris accumulation in Terauchi dam (Sumi et al., 2018)

Previous research and Objectives

- Komori et al.(2019) established the woody debris transport model assuming two types of woody debris exports; the flood flow typed export and the base flow typed export. They adapted the model to dam reservoir catchments in Iwate prefecture.
- Seo et al.(2015) clarified that there were less amounts of accumulated woody debris in southern Japan than northern Japan. They assumed that it was because of the difference in frequency of heavy rain.
- The objectives of this study were;
  1. To understand the mechanism of woody debris caused by heavy rain in 2017 in Terauchi dam reservoir catchment by applying the woody debris transport model.
  2. To analyze the characteristics of woody debris export in Terauchi dam reservoir catchment by comparation with the previous results obtained by Komori et al.(2019).



Method

1. Estimation of amounts of woody debris production

- Woody debris was assumed to be produced by landslides.
- Factor of security (FS) was calculated by Eq(1), and the grids with FS<1 were regarded as the points where landslides happened.

$$FS = \frac{c' + [(h\gamma_{sat}) + (D-h)\gamma_t - (\gamma_w h)]cos^2\beta tan\varphi'}{[(h\gamma') + (D-h)\gamma_t + (\gamma_w h)]sin\beta cos\beta} \quad (1)$$

where c' is cohesivity (kPa), h is groundwater level (m), γ_{sat} is saturated unit weight (kN/m3), D is soil depth (m), γ_t is total unit weight (kN/m3), γ_w is water unit weight (kN/m3), β is gradient (rad), φ' is internal friction angle (rad), and γ' is submerged unit weight (kN/m3)

2. Estimation of amounts of woody debris export

- The woody debris transport model expresses the two types of woody debris export by Eq(2)-(5).

$$q_1 = S_1 - Z \quad (2)$$

$$P_{inf} = b \cdot S_1 \quad (3)$$

$$\frac{dS_1}{dt} = P - P_{inf} \quad (4)$$

$$\frac{dS_2}{dt} = P_{inf} - q_2 \quad (5)$$

where q_1 is woody debris export from the first tank (m^3), S_1 is woody debris storage in the first tank (m^3), Z is the capacity of the first tank (m^3), P_{inf} is infiltration from the first tank to the second tank (m^3), b is parameter, P is woody debris production (m^3), q_2 is woody debris export from the second tank (m^3), S_2 is woody debris storage in the second tank (m^3).

Result

1. Application of the woody debris transport model

- The flood flow typed export happened in 2012 and 2017.
- Along with woody debris production in 2012, void ratio in the first tank dropped to almost 0, and that should have caused the incredible amount of woody debris export in 2017.

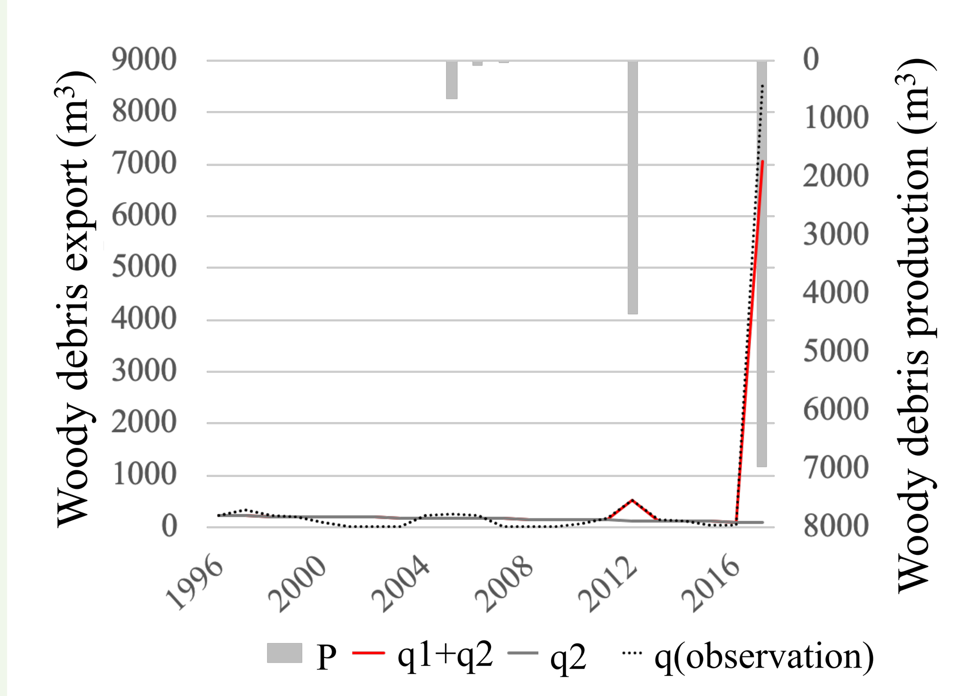


Figure2. Calculated amounts of woody debris production and export

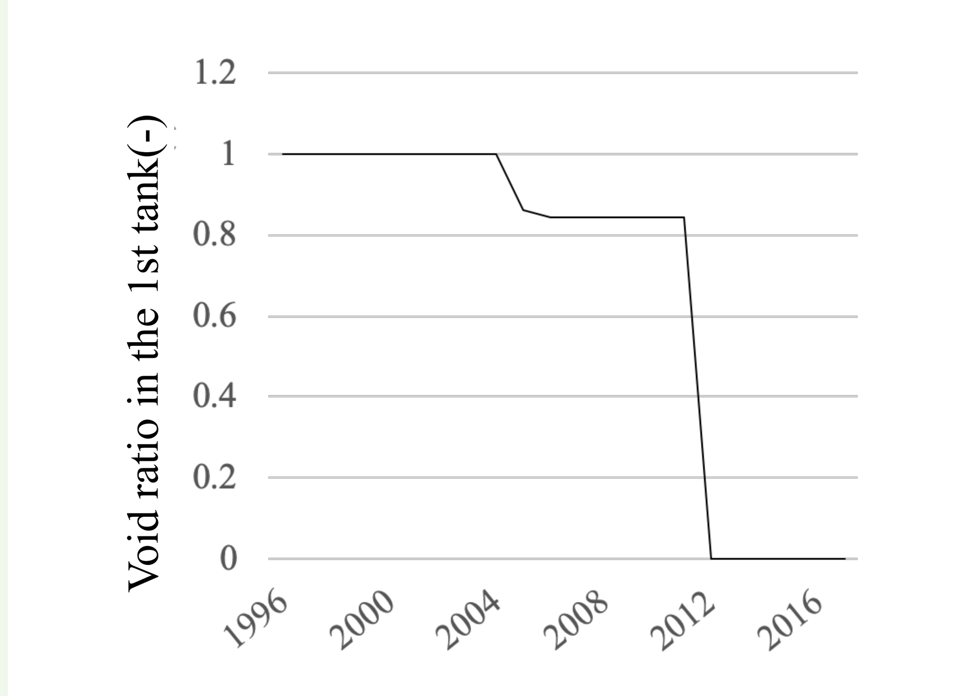


Figure3. Void ratio (S_1/Z) in the first tank

2. Comparation with the previous results in Iwate prefecture

- Parameter b, which is considered to indicate effectiveness of infiltration of woody debris from the first tank to the second tank, was relatively low in Terauchi dam reservoir catchment.
- In case the woody debris are produced frequently in a limited time, the flood flow typed export can easily happen in Terauchi dam reservoir catchment.
- Terauchi dam reservoir catchment had higher value of export ratio in the second tank, which means accumulated woody debris can be easily exported in a normal condition as the base flow in Terauchi dam reservoir catchment.
- The results obtained here could be a quantitative evidence which explains Seo et al. (2015) 's assumption.

Table1. Comparation of the parameters

	A(km^2)	Z(m^3)	Z/A(m^3/ km^2)	b(-)
Terauchi	51	4700	92.2	**0.00010**
Gosyo	635	91200	143.6	0.10
Yuda	583	22800	39.1	1.0
Ishibuchi	154	32900	213.6	0.090
Tase	740	79100	106.9	0.010

* A indicates catchment area.
* Gosyo, Yuda, Ishibuchi, Tase are the dam reservoir catchments in Iwate prefecture from Komori et al.(2019)

Table2. Export ratio in the second tank

Terauchi	Gosyo	Yuda	Isibuchi	Tase
10.06	0.60	0.13	3.02	4.60

Conclusion

- The vast amount of woody debris export to Terauchi dam reservoir catchment in 2017 was caused by woody debris production related to heavy rain in 2012 and 2017.
- Terauchi dam reservoir catchment has a high risk of the flood flow typed export occurring in a condition of frequent woody production in the short term.
- Accumulated woody debris in Terauchi dam reservoir catchment tends to be exported easily as the base flow compared to the dam reservoir catchment in Iwate prefecture.

Reference

- Sumi et al., 2018, *DPRI annuals*
- Komori et al., 2019, *Advances in River Engineering, JSCE*
- Seo et al., 2015, *Hydrological processes*