Assessment on influence of watershed environmental factors on minimizing of high turbid water generation in river stream

Univ. of Miyazaki Student Member ○ Donny HARISUSENO
Univ. of Miyazaki Member Satoru SUGIO
Kyushu Electric Power Co.,Inc., Engineer Jun NAKAMURA

1. Introduction

High turbid water generation phenomena in river stream directly associated with disturbance on riparian ecosystem. Basically, high turbid water occurrence in river stream is a reflection of erosion and sediment transport processes in watersheds, which are controlled by terrain form, soil, surface cover, and rainfall related watershed environmental factor. The Hitotsuse river watershed, which is located in the middle of Miyazaki Prefecture, Kyushu Island, Japan, until recently, has been perceived in problem of high turbid water generation in river stream. By considering the importance of minimizing high turbid water generation, it is very important to understand watershed environmental factors which influence on high turbid water generation in river. The present study, therefore, has an objective to investigate what most essential watershed environmental factors which control high turbid water generation in river stream.

2. Characteristics of study area

This study will focus on the upstream region of the Hitotsuse River watershed, which has a drainage area of 209.3km^2 and 25.6km of river length (**Fig.1)**. The geology of the study area is dominated by sandstone mudstone which covers approximately 33.4% of study area. Major parts of the study area are mainly dominated by brown forest soil which covers 54.2% of the total study area.

3. Materials

(1) Turbidity and rainfall measurement

Turbidity measurements were carried out from July until October 2007 for the 14 tributaries in the upstream region of Hitotsuse River watershed as shown in Figure 1. Rainfall data were collected from 8 gauges for the same period with turbidity measurement (**Fig.1**). Discharge was estimated from rainfall-runoff relationship by applying Tank Model analysis. The potential degree of high turbid water generation in each tributary was determined based on value of specific volume of turbid material which was obtained by dividing volume of turbid material calculated from turbidity and discharge in each rainfall event by drainage area of each tributary. **Table 1** displays result of calculation of average specific volume of turbid material.

(2) Watershed environmental factors

Six watershed environmental factors which were assumed to be influential on the high turbid water generation were presumed in each tributary, namely existence of buffer zone between slope failured area and river stream, geology type, length of filter zone, area of slope failured, topography slope, and existence of forest cut area. DEM resolution 50 x 50 m was used for morphological analysis for deriving watershed environmental factors, while geology type is obtained from 1/2000 geological map. Location of slope failured area and topography slope between slope failured area and stream underlie the determination of length of filter zone which defined by measuring the distance from location of slope failured to stream in each tributary. A 2.5m resolution SPOT satellite image acquired in 2006, February integrated with GIS techniques are applied for delineating slope failured area and forest cut area.

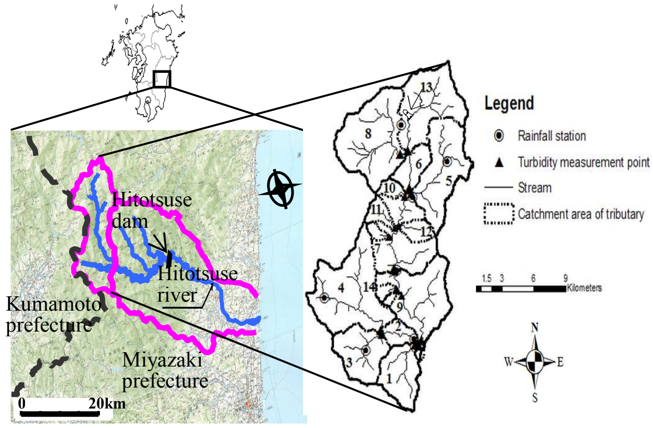

Fig.1 Location of study area

Tabel 1. Average specific volume of turbid material

Tributary	Drainage area (km^2)	Average specific volume of turbid material (t/s/km^2)
1*	13.03	0.31
2*	4.49	51.22
3*	15.05	1.46
4*	33.73	2.31
5*	24.29	5.31
6*	7.06	61.61
7*	1.62	3641
8**	30.96	0.87
9**	0.89	1284
10**	3.48	3741
11**	3.54	3779
12**	4.04	36835
13*	0.14	4393
14**	1.63	33976

*) Measurement period: August 2-3, August 22-23, August 26-27, September 3-4, September 15-17, and October 9-10

**) Measurement period: July 2-4, July 13-15, August 2-3, and September 15-16

3. Categorization of watershed environmental factors

Six watershed environmental factors were given as categorical variables, while specific volume of turbidity material was taken as two criterion variables. Each watershed environmental factor was subdivided into two categories as shown in **Table 2** where symbol v represent the response of sample (tributary) in a category of a watershed environmental factor to the corresponding criterion variable. Geology type was categorized based on the characteristic of its parent material. The categorization of topography slope, slope failured area, and filter length were determined by plotting them against average specific volume of turbid material and then judging the boundary value of those factors manually from the diagram whether they contribute to low or high potential.

Table 2. Criterion of categorization for quantification theory type II analysis

Tributary	Group number	Geology type		Topography slope (%)		Slope failured area (km2)		Existence of forest cut area		Existence of buffer zone		Filter length (m)	
		1: Granodiorite	2: Melange facies, sandstone, mudstone	1: <52%	2: >52%	1: <0.04km^2	2: >0.04km^2	1: not exist	2: exist	1: exist	2: not exist	1: >730m	2: <730m
1	1		∨	∨		∨		∨		∨		∨	
2	1		∨	∨		∨		∨		∨		∨	
3	1		∨	∨		∨			∨	∨		∨	
4	1		∨	∨		∨			∨	∨		∨	
5	1		∨	∨			∨	∨			∨	∨	
6	1		∨		∨	∨		∨		∨			∨
7	1		∨		∨	∨		∨			∨	∨	
8	1	∨		∨			∨		∨	∨		∨	
9	1		∨	∨		∨			∨	∨			∨
10	1	∨			∨	∨		∨			∨	∨	
11	1	∨		∨		∨		∨			∨		∨
12	2		∨	∨		∨		∨			∨		∨
13	2		∨	∨			∨		∨		∨		∨
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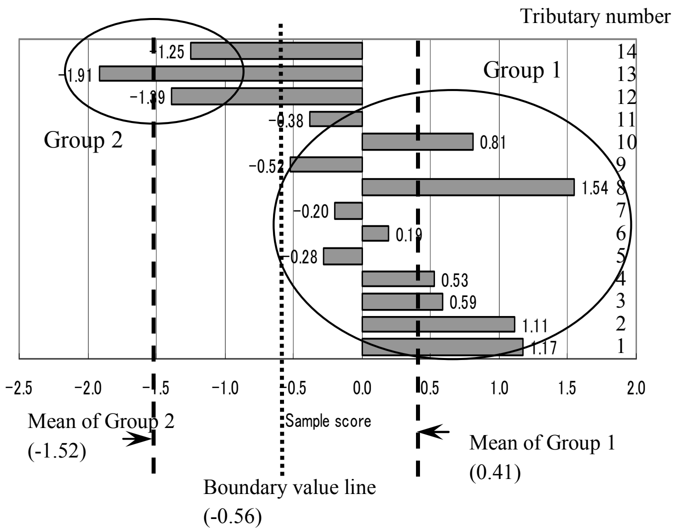

Fig.2 Sample score of potential degree of high turbid water generation in each tributary

4. Result and Discussion

Quantification theory type II analysis was applied to distinguish 14 tributaries. **Fig.2** displays the sample score predicted from quantification theory analysis. Mean values of sample score in each group are shown in **Fig.2.** The average value of -0.56 was obtained from the mean values. This value indicates the boundary to categorize the potential degree of high turbid water generation in each tributary where value of sample scores smaller than -0.56 categorized in Group 2 (high potential), otherwise in Group 1 (low potential). The result shows that there are 3 tributaries have sample score smaller than -0.56 which directly categorized in Group 2 (high potential), and the remaining tributaries (11) categorized in Group 1 (low potential). This result shows that the potential degree of high turbid water generation in tributaries were 100% predicted correctly using quantification theory type II.

The influences of each watershed environmental factor on high turbid water generation are listed in item range in **Table 3**. The resulted analysis showed that the existence of buffer zone has the highest range (1.44), which indicated that the category two of buffer zone become the most influential high turbid water generation in river stream followed.

The potential degree of high turbid water generation in each tributary resulted from quantification theory type II analysis was shown in **Fig.2.** The resulted analysis showed

Table 3. Result of category score of each item factor based on quantification theory type II

Item	Category	Distribution of each category	Category score	Range
Geology type	1	3	0.75	0.95
	2	11	-0.20	
Topography slope (%)	1	10	-0.04	0.14
	2	4	0.10	
Slope failured area (km^2)	1	7	-0.03	0.06
	2	7	0.03	
Existence of forest cut area	1	9	0.21	0.58
	2	5	-0.37	
Existence of buffer zone	1	7	0.72	1.44
	2	7	-0.72	
Filter length (m)	1	8	0.45	1.05
	2	6	-0.60	

that Tributary No.13 have the highest category score (-1.91) which indicate highest potential of occurrence of high turbid water generation. Field campaign which was conducted in the Tributary No.13 found that there was a largest collapsed area situated slightly on the riverside with nearly no buffer zone between collapsed slope area and river stream. These site description become an evidence that there is a high potential of occurrence of high turbid water generation in this tributary.

5. Conclusion

The following results were obtained in this study:

1. The accuracy prediction of 100% resulted from quantification theory type II analysis showed that the method was reliable and very useful tool for analyzing the influence of watershed environmental factors on the high turbid water generation in river stream.
2. Buffer zone was clearly proved as the most influential factor which contributed to high turbid water generation occurrence in river stream.
3. The quantification theory analysis resulted clarified that Tributary No. 13 has the highest potential of occurrence of high turbid water generation.
4. The result of this study confirmed that rehabilitation and conservation of buffer zone along river stream was the most essential in order to minimize high turbid water generation in river. The management of watershed should be focused, especially on Tributary No.13.

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