PREDICTION OF URBAN INUNDATION IN YOKOHAMA AND KAWASAKI CITY BY USING "S-UIPS"

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Introduction

The damage caused by torrential rain has been occurring frequently in Japan with the extremes of weather on a global scale in 2019. In order to prepare for the unprecedented heavy rainfall countermeasures in the future, accurate flood risk assessment and hazard map creation are desired. Previous studies by Shibuo et al. (2018) aimed at improving the accuracy of river water level prediction for the Tsurumi River have been conducted. In addition, Murase et al. (2018) conducted a study on inland water inundation analysis in Kasugai City, Aichi Prefecture, using the results of sewer internal water level measurement. In this study, using the sophisticated inundation prediction method "S-uiPS"(Sekine, 2011) developed by the first author, we evaluated the inundation risk in the eastern part of Yokohama and the eastern part of Kawasaki, and clarified the inundation process.

Analysis overview

Overview of the target area

- ✓ Target area is made up 5 drainage treatment zones in Yokohama City and 2 drainage zone in Kawasaki City.
- ✓ The total area is 239.3 km^2.
- ✓ The Tsurumi River that is the typical urban rivers in Japan exists in the center of this area, and the total length of river is 42.5 km.
- ✓ The Katabira River, the Ooka River and some more small urban rivers are in this area.

Prediction calculation method

In this study, we calculate the inundation prediction using the sophisticated inundation prediction method "S-uiPS" developed by the first author. In highly urbanized areas, rainwater hardly penetrates into the ground due to the asphalt paved roads and the densely packed blocks. Therefore, the flow of water in the target area can be solved only based on the principle of hydraulics. In this research, the road database, the sewer database, and other urban infrastructure information were reflected in the calculation, and the reproduction calculation was performed. S-uiPS does not include any parameters to be tuned.

Overview of the target area

In this study, computation was conducted by using XRAIN data which was measured by the X-band radar system of the Ministry of Land, Infrastructure, Transport and Tourism of Japanese Government (see in Figure 1 (b) and (c)).

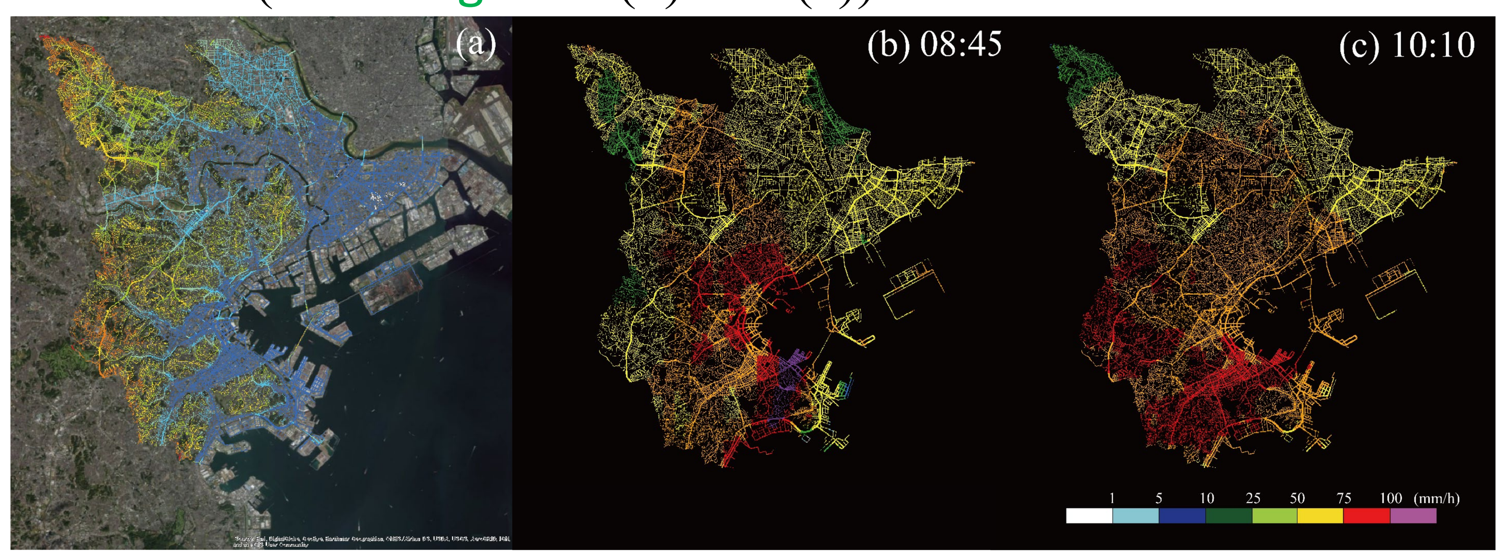

Figure 1. Contour maps in the target area: (a)elevation (b)(c)rainfall intensity on October 6, 2014 at 8:45 and 10:10

Results

Figure 2 is the results of computation by using XRAIN data to reproduce what inundation occurred on October 6, 2014.

In the period from 6:15 to 8:00

Rain clouds have moved northwest. During 30 minutes from 7:30 to 8:00, rainfall intensity became over 50 mm/h mainly in the western part of this area.

- ✓ Inundation started in the entire area at 8:00, but the inundation depth was about 0.1 m or less, and no serious inundation occurred.
- ✓ A red drainage pipe in the contour map of the drainage fullness at 8:00 denotes the water in the pipe has already been filled with rainwater. The drainage pipe attains such full-packed state due to the local rainfall exceeding the designed rainfall intensity. At this stage, the rainwater removal system worked normally.

In the period from 8:00 to 10:00

Heavy rainfall of 75 mm per hour and then the one more than 100 mm per hour occurred in this area.

- ✓ The number of drainage pipe in full-packed state increased. Inundation occurred on the road in lowland area during this time. At 10:00, inundation depth in the center of Yokohama City became about 0.1-0.5m. In some area there, there are some location whose inundation depth is 0.8m or more than it.
- ✓ Flooding started to occur at the same time in several urban rivers including the Tsurumi River. It is because rainwater had been transported in drainage pipes to the rivers and the flow discharge in the river increased rapidly.

In the period from 10:00 to 11:00

Inundation became more serious. During the first 30 minutes from 10:00, rainfall exceeding 50 mm/h occurred over the entire area. In the southern part of this area, the rainfall exceeding 75 mm/h occurred for the 20 minutes from 10:00.

- ✓ The remarkable inundation area is the same as above, and the depth there became much larger. When the rain weakened at 11:00, the inundation area decreased because the ability to remove the rainwater on road became larger than the rainfall intensity, the area of Inundation was reduced. the local rainfall exceeding the designed rainfall intensity. At this stage, the rainwater removal system worked normally.
- ✓ As to the river flooding, overflow was not predicted from the Katabira River and the Ooka River, which is coincide with the actual event.

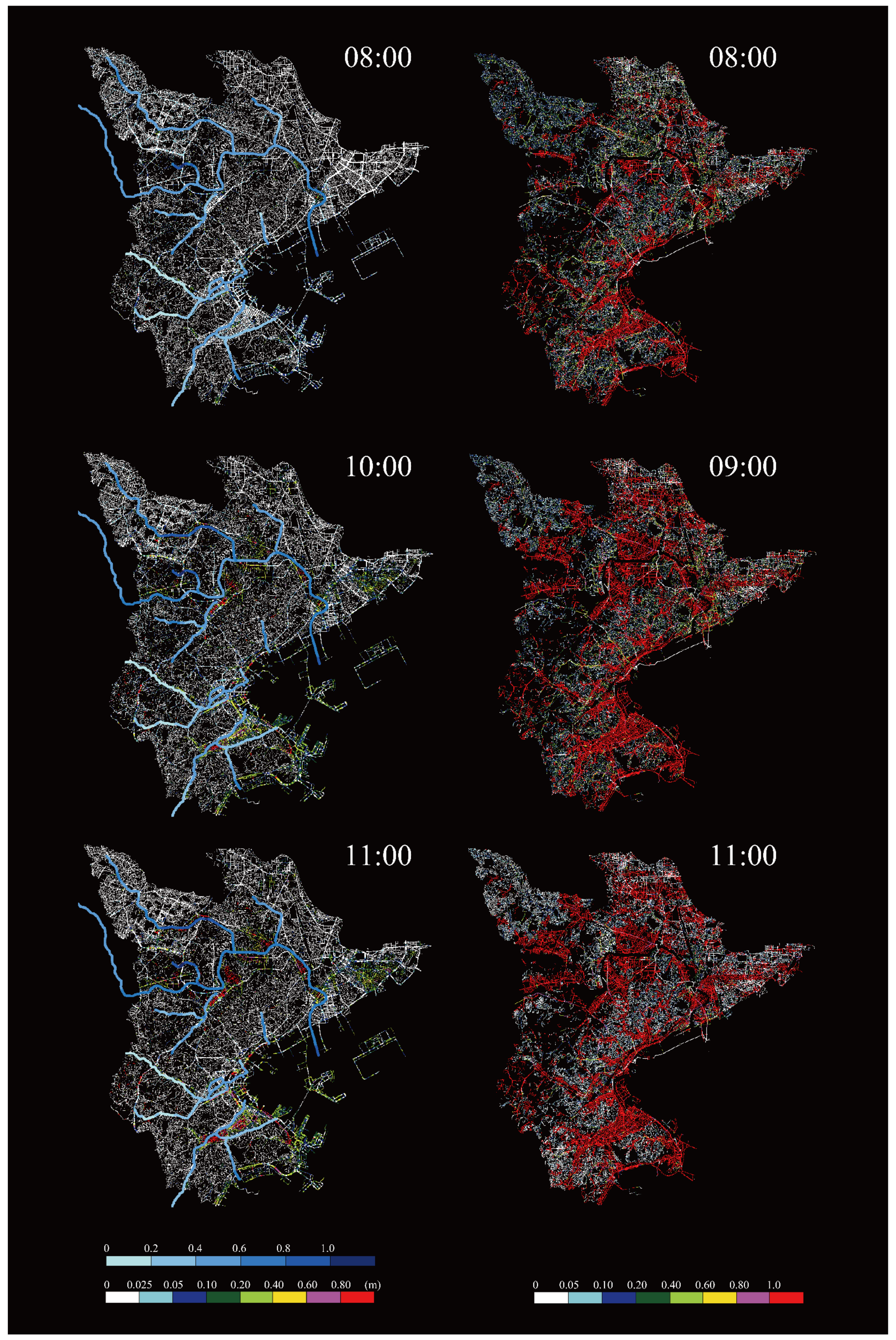

Figure 2 Contour map of Inundation depth on road and relative water depth of the river (in left) and state in drainage pipe (in right) predicted for the rainfall event on October 6, 2014.

Summary

Even if the rainfall exceeds the designed rainfall intensity, the rainwater removal system works relatively well for about 30 minutes or so. But if such level of rainfall keeps for more than one hour, the drainage pipe attains the full-packed state of water. And then, inundation depth grows larger in lowland area because drainage pipe cannot remove the water on the ground surface. It was found from this computation that the inundation area is limited and no large inundation depth was predicted in the areas far from the river. And it was verified that the state of drainage pipe is improved and inundation itself starts to disappear gradually after the rain stops.

Conclusion

In this study, inundation prediction was conducted in Yokohama City and Kawasaki City in Kanagawa Prefecture on October 6, 2014 by using the XRAIN data. As this study, the area where inundation depth is relatively higher were found in these cities. It was also confirmed that the inundation depth becomes 0.8m or more than it in the lowlands. In addition, the characteristics of rainwater removal system including drainage pipe and urban river was made clear. when the rainfall weakened, the sewage fill rate decreased at high altitudes, but there were still many pipes with a fill factor of 1 in lowlands, and the drainage function did not recover immediately.

References

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