DESIGN OF EFFECTIVE DATA COLLECTION SYSTEM FOR IDENTIFYING INLAND FLOODING PROCESSES IN THE LOWLAND URBAN AREA

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1. INTRODUCTION

Inland flooding is one of the most frequent disasters at urban area of tropical or monsoon climates, and could be worsen especially in developing countries with insufficient infrastructures preventing inundation (Kundzewicz and Takeuchi, 1999; Balk, 2013). However, there have been conventionally few studies not only to visualize, but also to observe the inland flooding processes (e.g. Tashiro and Min, 2017). To collect data related to the inland flooding is required to monitor these practical situations, and then to analyze causes and effects of the storm water drainage system of urban area during heavy rainfall events, toward the mitigation of inundations for decreasing the suffering costs. Consequently, the present study proposes to design effective data collection system for identifying inland flooding processes.

2. MATERIALS AND METHODS

We conducted a survey in a local small city, situated a lowland flat plain that has often suffered from inland flooding that caused inundation damage during heavy rainfall. There are four survey sites such as Stations 1 to 4, including six total observation stations are set up at the three main stems of channels which flows into the same stream. The specification of channels such as height and width at each of the stations were measured and shown in Table 1. Self-recording water depth loggers (HOBO U20L-01, Onset Computer Corporation) were simultaneously installed at these observation stations in storm water drainage channels. Station 1 and 2 are set in straight channel sections, station 3 is in a junction with the three directions flow, and Station 4 is located at the last effluent stream receiving drainage water. The time series data of water level elevations could be obtained by adding the measured water depth to the altitude value around each of the stations in the GSI map based on the digital elevation model acquired by airborne laser surveying with 0.3 m resolution level (Geospatial Information Authority of Japan, https://maps.gsi.go.jp/).

The survey period is about 450 days from October 2017 to January 2019, however the water level is not measured in some non-flooded seasons. Overflow of water channels at the survey sites are recorded by using loggers and these results had tried to describe the inundation area from the altitude distribution of the area surrounded by these sites. The rainfall data during the survey period was available at the nearest local rain gauge station from the website of Japan Meteorological Agency, the Ministry of Land, Infrastructure, Transport and Tourism (http://www.jma.go.jp/jma/index.html).

Table 1 Main characteristics of drainage channels at observation stations

	Channel width (m)	Channel height (m)	Channel bed elevation (m)	Note
St. 1-1	2.00	1.25	-2.15	straight channel
St. 1-2	2.00	1.18	-2.08	straight channel
St. 1-3	2.00	0.99	-2.09	straight channel
St. 2	2.15	1.14	-2.44	straight channel
St. 3	1.20	0.65	-2.35	junction of drains
St. 4	5.00	1.28	-2.68	effluent stream

3. RESULTS AND DISCUSSIONS

Figure 1 shows the water level fluctuations at each station along with the rainfall distribution. The heaviest rainfall was recorded as 32 mm / hour (23 o'clock on October 23) at the time of the Typhoon No. 21 (LAN) approaching on October 2017, and the second heaviest one was as 30.5 mm / hour (21 o'clock on July 7) at the time of the Heavy Rain Event in July 2018. According to this survey, overflowing from the drainage channels was observed at all of survey sites during these two heavy rain events. During the survey period, the overflowed water were respectively observed in Sts. 1 and 2 for a total of 8 hours and 10 hours in these two events. Whereas, the overflow occurrences were observed 11 times for a total of 34 hours at St. 3 where drainages merge from three directions, and those were observed 3 times for a total of 12 hour period at St. 4 where drainages poured.

Figure 2 shows the inundation area at the peak of flooding estimated with the water level at each of the stations and the terrain altitude distribution of the surrounding area at the time of the 2017 typhoon No.21 approaching where the overflow lasted the largest hours. It was clarified that the inundation expanded along drainage channels and roads at relative lower area. Because the Typhon No 21 approached in this area and inland flooding occurred at midnight, it did not cause significant damage. However, it could become serious if it occurred within the office hours. These figures might contain very important information, considering that the inland drainage process during heavy rainfall in urban

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areas has hardly been analyzed empirically until now. In the future, we plan to verify the simulation model and its application method through comparison with the numerical results at the target area, and to deepen the consideration of the practical situation of the inland basin.

4. CONCLUSION

In this study, we presented the estimating procedures of local inland flooding processes in urban areas with water depth loggers and digital elevation model, which might not be required latest technology and relative great expense. The logged observation data in storm water drainage systems could be applied to track the inland drainage process, by combining with the high-resolution altitude distribution.

Nowadays, high-resolution elevation data could be easily collected from remote sensing using satellite images, the water depth collection with pressure sensor furthermore would have been acquired all over the world, by linking with a rain gauge via IOT (Internet Of Things) technique. With these application, the proposed observation method could be developed as new monitoring system for inland flooding, which might be remotely controlled, monitored and visualized, in real-time inland drainage situation more efficiently. Finally, we would like this kind of system to be adopted in the lowland urban areas where inundation damages due to serious rainfall occurs.

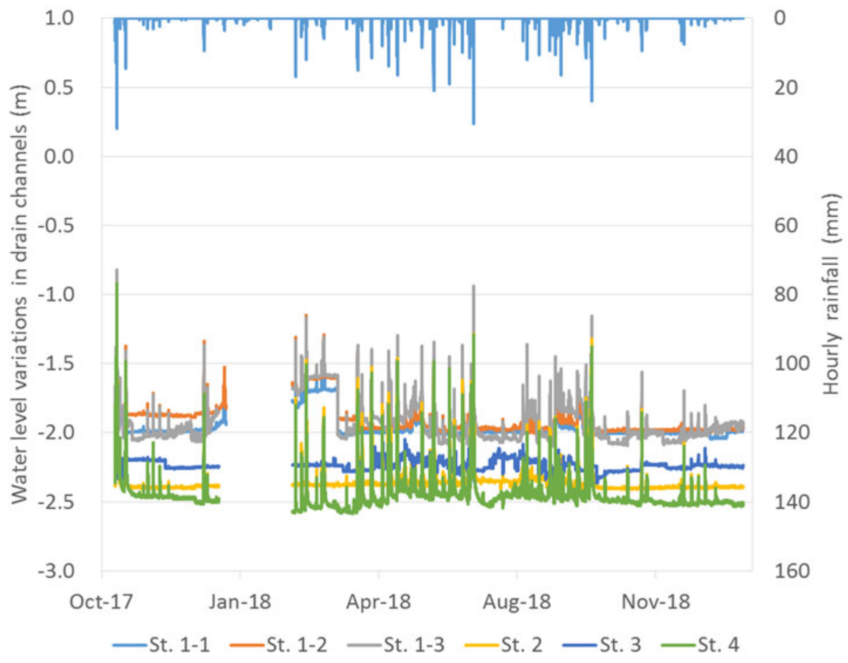

Fig. 1 Water level variations in the drainage channels and rainfall distributions in the target area during the survey period (rainfall data source: Japan Meteorological Agency)

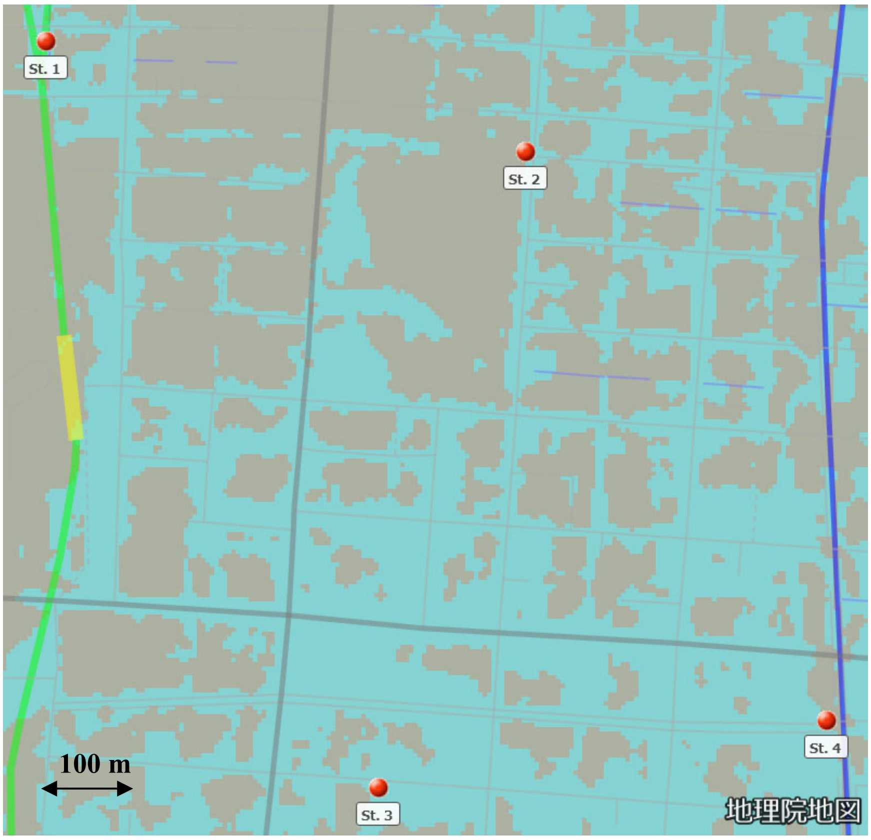

Fig. 2 A case of inundation (blue colored area lower than -1.0 m in altitude) map with networks of roads (gray lines), railroads (green line), drainage channels (blue lines) and observation stations (Sts. 1-4) in the target area, estimated with collected water level variations and digital terrain model during the Typhoon LAN approaching, Oct. 2017 (altered from the GSI Maps)

REFERENCES

Balk, D., Montgomery, M, R. and Liu, Z.: Urbanization and Climate Change Hazards in Asia, Population Association of America 2013 Annual Meeting Program, New Orleans, LA, April 11-13, 2013, 20p.

Kundzewicz, Z.W. and Takeuchi, K.: Flood protection and management: quo vadimus?, Hydro. Sci. J. 44(3), 1999, pp. 417-432.

Tashiro, T. and Min, A.K.: Flood Risks and Their Management in Urban Japan - Modeling Inner Flooding in Tsushima City, Tokai Region, Towards the Implementation of the New Urban Agenda – Contributions from Japan and Germany to Make Cities More Environmentally Sustainable (Müller, B., and Shimizu H. (eds)), Springer, 2017, pp.117-126.