

論文の内容の要旨  
Abstract of Dissertation

論文題目 Characterization of urban inundation impacts by distributed model simulation and pathogenic pollution monitoring in the downtown of Hanoi.

(分布型モデル解析及び健康関連微生物調査に基づくハノイ市街地における浸水インパクトの評価)

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(本文) (Abstract)

Hanoi, the 1000-year-old capital of Vietnam, had a population of 3.4 million in 2007. The old sewerage system and the quite flat floodplain made Hanoi more sensitive to urban flood. Frequent inundation caused the damages to infrastructure, transport, environment and human health. Sewerage system constructed between the years 1905-1945 and only covered an area of 1000 ha in the central part of the old city. The effluents drain to the South of Hanoi to the settling ponds in Thanh Tri district before eventually discharging to the Red River.

Drainage and sewerage form a combined system that flows by gravity into lakes, ponds and rivers. Inner parts of the city have an underground drainage network, while outer parts still rely entirely on open drains. From an engineering point of view, the system has major limitations. The total length of the central sewerage and drainage system, placed under maintenance and management of Hanoi Sewerage and Drainage Company (HSDC), is about 318 km, approximately the 60 % of total road. It is estimated that the total coverage of the drainage system just accounts for 40 % of the city's total area. The ratio of sewer length per capita in Hanoi city is about 0.3 m/person, much less than average ratio in other developing countries, i.e. 2 m/person.

Inundation takes place quite often in Hanoi downtown, 5-7 times per year. When inundation occurs, solid waste, stormwater, wastewater from domestic, industrial, hospital sources without any treatment were mixed in the sewerage system, lake. This situation not only affects to the local areas during the inundation but also brings about environmental pollution and human health risk to downstream areas.

Several local studies mentioned about fluvial flooding, however, the urban inundation caused by internal runoff was not paid much attention. Inundation simulation and risk assessment of inundation in urban areas were also studied but mainly focused on flooding due to rivers and not discussed about water quality such as pathogenic indicators. This study was aimed to answer some questions as follows:

- What are the main reasons of inundation in Hanoi, what could affect to inundation situation in Hanoi?
- What is about characteristics of inundation in Hanoi? Which areas are more sensitive to inundation?
- How is about environmental impact and potential of human health impact when inundation occurs?
- Hanoi is city of lakes. How could we include these lakes as storage facility for contributing to inundation mitigation?

The overall objective of this study is (1) to characterize inundation situation and (2) to evaluate potential of environmental impact and human health impact regarding to pathogenic indicators under wet weather condition in Hanoi downtown.

The specific objectives were (1) to collect input data and elaborate for fitting requirement of inundation simulation and calibration, (2) to clarify which factors which could affect to inundation in Hanoi downtown, (3) to make inundation hazard map using simulation results and water quality monitoring for evaluation impact of inundation to human health and human activities, (4) to evaluate the role of lakes in inundation mitigation for Hanoi. Outcomes from this study may contribute to several aspects, such as:

- Providing useful suggestions for input data collection used to simulate inundation. Proposals of modified parameters for calibration model when applied to Hanoi.
- Getting deeper understanding about inundation characteristics in Hanoi (e.g. due to backwater, water clogging, deposit sediment in sewer system etc.), about the role of rivers and lakes system in urban drainage operation and management for Hanoi.

- Providing concrete evidences about potential impact of inundation to environment and human health in downtown of Hanoi
- Results could be applied to Hanoi drainage project Phase II (2008 - 2012) with the aim to integrate environmental aspect into urban drainage management

Dissertation was divided into 8 chapters; the main content focused on Chapter 4, 5, 6, and 7.

**Chapter 1**, sewerage system including sewer pipe, lakes, rivers are introduced to understand more about inundation condition in Hanoi and its impact to environment and human health. In this Chapter the main objectives, scope of research and content of dissertation are also presented to get an overview of the research scheme.

**Chapter 2** discussed about related studies and research in Vietnam and other countries. The originality and new ideas also were introduced to make clear the strong points of this study.

**Chapter 3** introduces the methodology and materials used to reach final objectives. Study area was introduced together with the detail methodology to collect and to elaborate input data for inundation simulation, in which, ground elevation data were described more detail. Water sampling procedures in Hanoi also were mentioned together with inundation simulation scenarios to characterization inundation conditions.

**Chapter 4** provides results from input data collection and elaboration. Input data for inundation simulation in Hanoi were not available or quality was too rough. For example, rainfall data existed only in 1-hour interval, DEM data, landuse data were not available, sewer system was in a hard copy form. Other input data for model simulation such as infiltration parameter, wastewater profile, relation of area and water level in lake etc. also were not applicable. Output from this chapter will be used for inundation simulation in Chapter 6 and inundation hazard mapping in Chapter 7.

**Chapter 5** shows water quality sampling and results on surface water environment, at inflows and outflows of lakes, road runoff and inundated water to get more concrete evident of inundation impact to surface water environment. The monitoring data showed that surface water quality exceeded the Vietnamese standard for surface waters in downtown area of Hanoi and polluted by discharging wastewater from sewerage system. The levels of COD, T-N, and pathogen indicators such as total coliform were also considerably high and comparative to the influent of sewage treatment plant. High values of Coliforms also indicated strong potential of human health impact when inundation occurs.

**Chapter 6** introduces inundation simulation results using distributed model, XP-SWMM. Inundation conditions with different cases were applied to the selected areas to investigate the dependence of sewerage system under wet weather condition and characterizing inundation in Hanoi. Inundation characterization was investigated using different cases (different water level kept in lakes, boundary conditions, and structural measure to mitigate inundation etc.). Using some scenarios we also realized the role of lakes in inundation mitigation, inundation could be reduced by better operation and management of sewerage system.

**Chapter 7** introduces the results of inundation hazard mapping and inundation impact evaluation including water quality monitoring in Chapter 5 and simulation results in Chapter 6. Simulation results with different rainfall return period (0.2, 0.5, 1, 2, 5, 10 years) were integrated with water quality monitoring on streets, on lakes and during inundation to make inundation hazard map. This map could provide information about depth, area of inundation and water quality at that point that mainly focused on pathogenic indicators. When overlapping inundation hazard map with population density, streets and communes having more potential of human health impact under wet weather condition were indicated.

**Chapter 8** shows conclusions and recommendations Hanoi sewerage management and operation. Proposals to improve inundation condition in this area and other suggestions for further study also were provided.