water

MDPI

Editorial

Urban Water-Related Problems

Akira Kawamura [1,*] and Kei Nakagawa [2]

[1] Department of Civil and Environmental Engineering, Tokyo Metropolitan University, Hachioji 192-0397, Japan
[2] Institute of Integrated Science and Technology, Nagasaki University, Nagasaki 852-8521, Japan; kei-naka@nagasaki-u.ac.jp
* Correspondence: kawamura@tmu.ac.jp

1. Introduction

Urban areas are considered to be the most vulnerable to water-related problems, which involve a lack or excess of water problems from the perspectives of quantity and quality. These specific phenomena include flash floods and inundation, droughts and water shortages, surface and ground water pollution, tsunamis and storm surges, landslides and mudflows, the degradation of fluvial and aquatic ecosystems, and unsanitary conditions and epidemics, among others. In urban areas, water-related problems cause immense human losses and economic damage. Water-related problems frequently reoccur in urban areas, and are intricately linked with each other, posing major obstacles to the achievement of human security and the sustainable socio-economic development of cities. Thus, it is crucial that they are scientifically and comprehensively discussed, so that they can be better understood, in order to fight against and mitigate these problems.

The special session "Urban Water-Related Problems" has been held in the AOGS (Asia Oceania Geosciences Society) annual meeting since 2017. Thus far, we have discussed a very wide range of urban water-related problems. For this Special Issue published in *Water*, we intend to invite studies on these broad topics and encourage a collective perspective on urban water-related problems.

This Special Issue comprises four review papers and nine research articles, with contributions from 55 authors of six countries. All four of the review papers are related to the problems associated with flash flood phenomena, among the many broad topics mentioned above, but they focus on very different aspects of the phenomena, such as urban runoff modeling in Japan [1], real-time urban flood forecasting systems for Southeast Asia [2], frequency analysis of urban floods [3], and the reduction of non-point pollution as well as flood runoff by porous concrete infiltration [4].

On the other hand, among nine research articles, five articles are related to water quality problems, of which two articles investigate groundwater pollution in Japan and Sweden [5,6], one article deals with lake contamination by phosphorus in Sweden [7], another targets lakes or reservoirs from the perspective of the hydrodynamic response by wind [8], and the last one considers the water pollution problem for a riverbank area in Bangladesh [9]. Three research articles out of the nine are related to problems of urban flood phenomena, in which studies on urban flooding area characteristics in Japan [10], water level forecasting caused by urban floods in Japan [11], and barriers to IFRM (Integrated Flood Risk Management) adaptation in the Philippines [12] are carried out. The last article is related to water resource problems, investigating the urban domestic water supply system from the viewpoint of willingness to pay [13].

Unfortunately, studies dealing with the phenomena related to tsunamis and storm surges, landslides and mudflows, and the degradation of fluvial and aquatic ecosystems are not published in this Special Issue.

check for updates

Citation: Kawamura, A.; Nakagawa, K. Urban Water-Related Problems. *Water* **2023**, *15*, 3280. https://doi.org/10.3390/w15183280

Received: 28 August 2023
Accepted: 12 September 2023
Published: 16 September 2023

2. Overview of the Contributions of This Special Issue

The review paper "Urban Flood Runoff Modeling in Japan: Recent Developments and Future Prospects" [1] summarizes, discusses, and shares key outputs from some of the main research directions in urban flood runoff modeling, significant parts of which have been uniquely developed in Japan and only published in Japanese. In the paper, after a general introduction to urban runoff modeling, the authors present key historical works in Japan, followed by a description of the situation in Japan with respect to observations of precipitation and water level. Then, the storage function model approach is reviewed, including an extension to urban basins, as well as recent experiments with AI-based emulation in Japanese basins. Subsequently, the authors review the prospects of detailed hydrodynamic modeling involving high-resolution, vector-based Geographical Information System (GIS) data for the optimal description of the urban environment with applications in Tokyo. The authors conclude the paper with some future prospects related to urban flood risk modeling and assessment in Japan.

In the paper "Real-Time Urban Flood Forecasting Systems for Southeast Asia—A Review of Present Modelling and Its Future Prospects" [2], the authors reviewed state-of-the-art models of real-time forecasting systems in countries in Southeast Asia, such as Thailand, for urban flash floods. A real-time system basically consists of rainfall forecasting, drainage system modeling, and inundation area mapping. The authors summarized the recent radar data utilization methods for rainfall forecasting, physical-process-based hydraulic models for flood inundation prediction, and data-driven artificial intelligence (AI) models for the real-time forecasting systems. The authors also dealt with available technologies for modeling digital surface models (DSMs) for the finer urban terrain of drainage systems. The review indicated that an obstacle to using process-based hydraulic models was the limited computational resources and shorter lead time for real-time forecasting in many urban areas of tropical Southeast Asia.

The review paper "Frequency Analysis of Hydrological Data for Urban Floods—Review of Traditional Methods and Recent Developments, Especially an Introduction of Japanese Proper Methods" [3] investigates in detail the frequency analysis of hydrological data for urban floods, targeting the Japanese methods in particular. First, the authors introduced well-used Japanese frequency analysis methods, because some techniques that are slightly different from the international standard have been used in Japan for many years. This review emphasized discussions of the parameter estimation of stochastic models and the selection of optimal statistical models, which include the evaluation of goodness-of-fit techniques of statistical models. Based on these results, the authors criticized the Japanese standard procedures recommended by the central government, and indicated that consistency between parameter estimation and the evaluation of goodness-of-fit was necessary. From this perspective, the authors recommended using the maximum likelihood method and AIC. The authors also recommended, when using SLSC method, to apply not only SLSC itself but also SLSC's non-exceedance probability.

In the review paper "Application of Porous Concrete Infiltration Techniques to Street Stormwater Inlets That Simultaneously Mitigate against Non-Point Heavy Metal Pollution and Stormwater Runoff Reduction in Urban Areas: Catchment-Scale Evaluation of the Potential of Discrete and Small-Scale Techniques" [4], first, the literature related to the expansion of pervious areas was introduced, because the expansion of pervious areas was an essential and common concept in mitigating nonpoint pollution runoff in urban areas. Then, the potential application of porous concrete as a medium for constructing the bottom and side walls of street stormwater inlets was investigated. The effectiveness of the medium in reducing (i) the stormwater runoff volume and (ii) the heavy metal pollution runoff loads was assessed. In the paper, sensitivity tests were performed by changing the exfiltration rates. The results indicate that porous concrete used at only the bottom and side walls of the street stormwater inlets was suitable for reducing the runoff volume and removing any heavy metals from stormwater at a catchment scale.

In the paper "Groundwater Quality and Potential Pollution in the Southern Shimabara Peninsula, Japan" [5], the authors aimed to assess the groundwater quality in the southern regions of the Shimabara Peninsula in Nagasaki Prefecture, Japan, for a comprehensive understanding of the overall situation against the background that the peninsula is known for serious groundwater contamination caused by nitrate pollution. To achieve this goal, groundwater samples were collected at 56 locations in Minami-Shimabara City from 28 July to 4 August 2021. The authors showed using a Piper-trilinear diagram that almost 80% of the samples were classified as the alkaline earth carbonate type. From the Stiff diagrams, they showed that most of the locations exhibited a Ca-HCO_3 water type, while the Na-HCO_3 and Mg-HCO_3 types were also observed in coastal areas. Finally, from the principal component analysis, the authors revealed that the first component corresponded to dissolved constituents and denitrification, and the second component indicated the effects of ion exchange and low nitrate pollution.

The paper "PFAS in the Drinking Water Source: Analysis of the Contamination Levels, Origin and Emission Rates" [6] delves into the prevailing groundwater pollution situation in southern Sweden against the background that waterborne pollution caused by polyfluoroalkyl substances (PFAS) has been reported in numerous countries globally, emerging as a novel concern that is capturing attention. The objective of this study was to enhance understanding regarding the historical contamination of water sources due to PFAS and to explore interconnected facets of PFAS-containing aqueous film-forming foam (PFAS-AFFF) application in fire training exercises and equipment trials. To achieve this goal, the authors encompassed the analysis of contamination extents and PFAS compositions, the evaluation of potential PFAS and PFAS-AFFF emission scenarios, and the assessment of contaminant transport conditions.

The paper "Decision Support for Lake Restoration: A Case Study in Swedish Freshwater Bodies" [7] presents techniques aimed at providing decision support for lake restoration through a combination of multi-criteria analysis and decision analysis. The main objective is to identify effective and efficient measures for restoring lakes. The study focuses on evaluating six commonly used lake restoration methods for reducing internal phosphorus loads in two selected lakes, using criteria such as cost, longevity, and effectiveness. The findings indicate that aluminum treatment emerges as the most favorable option due to its superior effectiveness and cost efficiency. The authors suggested that these methodologies could be utilized not only in specific countries but also in the restoration of lakes and ponds worldwide.

The paper "A Detailed Analysis on Hydrodynamic Response of a Highly Stratified Lake to Spatio-Temporally Varying Wind Field" [8] explores the hydrodynamic reactions of a highly stratified lake or reservoir to various inhomogeneous wind conditions through the application of numerical models and integrated analysis. This approach was taken because wind was commonly acknowledged as a vital factor driving transport and mixing processes in stratified, enclosed systems. The authors demonstrated that under the influence of non-uniform wind conditions, often characterized by weak-to-moderate wind with high spatial variances, the lake's hydrodynamic responses differed from those under uniform wind conditions. On the other hand, low spatial variances, often associated with strong wind, resulted in hydrodynamic responses identical to those of uniform wind. Thus, the authors recommended using non-uniform wind in model simulation for achieving realistic results, improving water management in lakes and reservoirs.

The paper "Spatial Distribution and Source Identification of Water Quality Parameters of an Industrial Seaport Riverbank Area in Bangladesh" [9] employed a range of water quality indices, including the Metal Index (MI), Comprehensive Pollution Index (CPI), and Weighted Arithmetic Water Quality Index (WQI), to enhance understanding of pollution dispersion and the underlying processes influencing river water quality. Additionally, multivariate statistical techniques were utilized to assess pollutant loads and sources within the Pasur River system in Bangladesh. The authors indicated that contaminant origins encompass both geogenic and anthropogenic factors, involving untreated or inadequately

treated wastewater from industries and the discharge of urban domestic waste. The effectiveness of the water quality assessment and pollution source identification methodologies introduced by the authors was demonstrated, with potential applicability on a global scale.

In the paper "Topographical Characteristics of Frequent Urban Pluvial Flooding Areas in Osaka and Nagoya Cities, Japan" [10], frequent urban pluvial flooding areas using 20 years of urban pluvial flooding area records during 1993–2012 were identified and analyzed using the principal component analysis of their topographical characteristics in Osaka and Nagoya Cities, Japan. The authors showed that the topographical characteristics of the frequent urban pluvial flooding areas in both cities were different. In Osaka City, not only the topographical characteristics, but also the influence of anthropogenic factors and stormwater drainage improvements were influential. On the other hand, in Nagoya City, the mere presence of dominant structures dammed up the inundated water and caused urban pluvial flooding. The authors quantitatively showed the paradigm shift of urban pluvial flooding factors from topographical characteristics to anthropogenic characteristics by the statistical analysis of newly defined urban pluvial flooding frequency areas.

The paper "Study on a Water-Level-Forecast Method Based on a Time Series Analysis of Urban River Basins—A Case Study of Shibuya River Basin in Tokyo" [11] investigated a vector autoregressive model to develop a water level forecast system that uses observed rainfall and water level. The model was targeted to ensure information conducive to evacuation approximately 20 min in advance without the need to build a physical model. The authors showed that the method based on time series analysis achieved a stable forecast, and indicated that the method can be applied as a water level forecast method for basins with an extremely fast flood arrival times and limited observation data.

In the paper "An Expanded Interpretive Structural Modeling Analysis of the Barriers to Integrated Flood Risk Management Adaptation in Metro Manila" [12], the authors proposed an expanded ISM (Ex-ISM) method to comprehensively analyze the interrelationships between the barriers to integrated flood risk management (IFRM) adaptation in Metro Manila, Philippines. The Ex-ISM enhanced conventional ISM in that the symbolism was modified to explicitly show the contextual interrelationships; then, the hierarchy assignment step was simplified, and a diagram was used to show all of the inter-relationships that allowed a comprehensive analysis. The authors showed that the results obtained using the Ex-ISM method did not deviate from those yielded by the conventional ISM method, but the Ex-ISM method allowed an easy assignment of hierarchy. The authors also showed that the Ex-ISM method was able to draw a diagram incorporating not only the direct but also the indirect interrelationships to provide a comprehensive analysis of the relationships between barriers.

The paper "Willingness to Pay for Improved Urban Domestic Water Supply System: The Case of Hanoi, Vietnam" [13] investigated water users' willingness to pay (WTP) for the improvement of Hanoi's domestic water supply. This was because in Hanoi, the capital of Vietnam, the municipal government is facing a number of difficulties in providing sufficient water in a sustainable manner due to not only the increasing urban population and the serious pollution of water resources, but also a lack of resources to invest in the supply system. In this paper, a contingent valuation process based on a survey of 402 respondents was used to explore citizens' willingness to pay for the improvement of their urban water supply. The authors revealed that Hanoi's urban communities were generally satisfied with the quantity of their water supply, but tended to be dissatisfied with its quality. The developed WTP regression model based on the survey findings showed that the average WTP was 1.4% of the average household income, taken as the affordability level of monthly water payments.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Kawamura, A.; Amaguchi, H.; Olsson, J.; Tanouch, H. Urban Flood Runoff Modeling in Japan: Recent Developments and Future Prospects. *Water* **2023**, *15*, 2733. [CrossRef]
2. Chitwatkulsiri, D.; Miyamoto, H. Real-Time Urban Flood Forecasting Systems for Southeast Asia—A Review of Present Modelling and Its Future Prospects. *Water* **2023**, *15*, 178. [CrossRef]
3. Mizuki, C.; Kuzuha, Y. Frequency Analysis of Hydrological Data for Urban Floods—Review of Traditional Methods and Recent Developments, Especially an Introduction of Japanese Proper Methods. *Water* **2023**, *15*, 2490. [CrossRef]
4. Harada, S. Application of Porous Concrete Infiltration Techniques to Street Stormwater Inlets That Simultaneously Mitigate against Non-Point Heavy Metal Pollution and Stormwater Runoff Reduction in Urban Areas: Catchment-Scale Evaluation of the Potential of Discrete and Small-Scale Techniques. *Water* **2023**, *15*, 1998. [CrossRef]
5. Nakagawa, K.; Amano, H.; Yu, Z.; Berndtsson, R. Groundwater Quality and Potential Pollution in the Southern Shimabara Peninsula, Japan. *Water* **2022**, *14*, 4106. [CrossRef]
6. Mussabek, D.; Söderman, A.; Imura, T.; Persson, K.M.; Nakagawa, K.; Ahrens, L.; Berndtsson, R. PFAS in the Drinking Water Source: Analysis of the Contamination Levels, Origin and Emission Rates. *Water* **2023**, *15*, 137. [CrossRef]
7. Sellergren, M.; Li, J.; Drakare, S.; Thöns, S. Decision Support for Lake Restoration: A Case Study in Swedish Freshwater Bodies. *Water* **2023**, *15*, 668. [CrossRef]
8. Le, H.N.; Shintani, T.; Nakayama, K. A Detailed Analysis on Hydrodynamic Response of a Highly Stratified Lake to Spatio-Temporally Varying Wind Field. *Water* **2023**, *15*, 565. [CrossRef]
9. Islam, M.S.; Nakagawa, K.; Abdullah-Al-Mamun, M.; Khan, A.S.; Goni, M.A.; Berndtsson, R. Spatial Distribution and Source Identification of Water Quality Parameters of an Industrial Seaport Riverbank Area in Bangladesh. *Water* **2022**, *14*, 1356. [CrossRef]
10. Komori, D.; Nakaguchi, K.; Inomata, R.; Oyatsu, Y.; Tachikawa, R.; Kazama, S. Topographical Characteristics of Frequent Urban Pluvial Flooding Areas in Osaka and Nagoya Cities, Japan. *Water* **2022**, *14*, 2795. [CrossRef]
11. Koyama, N.; Sakai, M.; Yamada, T. Study on a Water-Level-Forecast Method Based on a Time Series Analysis of Urban River Basins—A Case Study of Shibuya River Basin in Tokyo. *Water* **2023**, *15*, 161. [CrossRef]
12. Mercado, J.M.R.; Kawamura, A.; Medina, R. An Expanded Interpretive Structural Modeling Analysis of the Barriers to Integrated Flood Risk Management Adaptation in Metro Manila. *Water* **2023**, *15*, 1029. [CrossRef]
13. Bui, N.T.; Darby, S.; Vu, T.Q.; Mercado, J.M.R.; Bui, T.T.P.; Kantamaneni, K.; Nguyen, T.T.H.; Truong, T.N.; Hoang, H.T.; Bui, D.D. Willingness to Pay for Improved Urban Domestic Water Supply System: The Case of Hanoi, Vietnam. *Water* **2022**, *14*, 2161. [CrossRef]