

# ADAPTATION PATHWAYS OF WASTEWATER TREATMENT PLANTS TO SEA LEVEL RISE

Cao Vu Quynh Anh, GPSS-GLI, 47-176840

Advisor: Professor Mino Takashi

Co-Advisor: Professor Miguel Esteban

## ABSTRACT

Sea level rise (SLR) has been widely acknowledged as one of the most significant challenges that human beings will have to face in the course of the 21st century. Currently, the global mean sea level is rising at a rate of 3.2 mm per year. However, the rate of SLR is accelerating, shown in the increases in the upper range of SLR projections in the literature. Past studies have projected that global mean sea levels could be up to between 1m to 3m higher than at present. Such changes in sea level could seriously affect Wastewater Treatment Plants (WWTPs), a type of infrastructure that is critical to support human life, which is usually located in low-lying areas near the coastline to utilize the gravity for sewage transportation and to discharge the effluent into large water bodies.

Several studies have investigated the vulnerability of WWTPs to SLR, which indicated that many such installations around the world are at high risk. Also, under the same SLR scenario, the number of population that is exposed to the risk of direct flooding is projected to be many times smaller than the number of population that is exposed to the loss of sanitary service. However, there is a limited number of studies that focuses on the vulnerability and adaptation

of WWTPs to SLR. Existing literature heavily focused on identifying the exposure of WWTPs to SLR using the elevation of the whole WWTP, which ignores the complexity of different levels of its components. Past studies only theoretically discussed the range of SLR impacts on WWTPs using a modeling approach combining with local SLR. There is generally a lack of detailed and comprehensive discussion on how SLR can affect the operation or maintenance of WWTPs.

Thus, the present thesis aims to deliver a comprehensive analysis of the dynamic of SLR related issues on WWTPs near the coastline and how these can adapt to sea level rise by using land subsidence as a proxy. The author investigated three significant WWTPs in the Tohoku region in northern Japan, which experienced severe land subsidence up to 1.14 m in Ishinomaki city after the *2011 Tohoku Earthquake*. The authors conducted in-depth interviews with staff from the WWTPs in the area, with the aim to elucidate the effects that land subsidence had on their operations, and how they could adapt to an increase in land subsidence or SLR.

The results suggest that under SLR of + 0.53 m, the case study WWTPs were considered to be able to operate normally without undertaking any significant adaptation actions, even though the discharge culvert was frequently occupied with seawater and there was an increasing amount of groundwater entering the sewage pipes. Global warming projections based on current climatic policy suggested SLR by the end of this century is very likely to be higher than 0.53 m. Therefore, coastal WWTPs may have to start planning for SLR adaptation from around the

middle of this century.

The author identified critical levels from components of the WWTPs that influence the vulnerability and adaptation strategies of WWTPs to SLR. These crucial levels lead to three types of SLR – induced floods that are coastal flooding, discharge flooding, and groundwater inundation. The impacts of these types of flooding on the WWTPs and possible countermeasures were also discussed in detail. WWTPs in the coastal areas should identify their vulnerability and plan for adaptation according to these three types of SLR – induced flooding. Finally, the author proposed a general process of constructing SLR scenario dependent adaptation pathways for WWTPs in low-lying coastal areas as a long-term and flexible adaptation guideline, with a sequence of possible countermeasures and timeline of actions that should take place. The methods were applied for the case study WWTPs, with the land subsidence being reflective of future SLR. The countermeasure sequences and timing for adaptation actions to be in place varies depending on the topography and design of each WWTP. The author also discussed the applications of the proposed adaptation pathways to the different context of Tokyo and Ho Chi Minh City. Different socio-economic contexts in these cities lead to different ways of applying the proposed adaptation pathways.

Key words: Wastewater treatment plants, Sea level rise, Adaptation, Land subsidence,

Adaptation pathways