Smart Salinity Management in Low-lying Deltaic Areas: A Model Predictive Control Scheme Applied to a Test Canal

Aydin, Boran; Abraham, Edo; Rutten, Martine; Delsman, Joost ; Oude Essink, Gualbert H.P.

Publication date
2017

Published in
Geophysical Research Abstracts (online)

Smart Salinity Management in Low-lying Polders: A Model Predictive Control Scheme Applied to a Test Case

Boran Ekin Aydin [(1)*], Martine Rutten [(1)], Gualbert H.P. Oude Essink [(2,3)], Joost Delsman [(2)], Edo Abraham [(1)]

(1): Delft University of Technology, Section of Water Resources Management, Stevinweg 1, 2628 CN, Delft, The Netherlands

(2): Unit Subsurface and Groundwater Systems, Deltares, P.O. Box 85467, 3508 AL, Utrecht, The Netherlands

(3): Department of Physical Geography, Utrecht University, P.O. Box 80115, 3508 TC, Utrecht, The Netherlands

This presentation participates in OSPP

Outstanding Student Poster & PICO Contest

Introduction

Saline groundwater exfiltration to surface water increases the surface water salinization and degrades the surface water quality in low-lying deltaic areas. The use of surface water will be less appropriate for agricultural, industrial and drinking water production due to salinization, and therefore, **freshwater** diverted from river is used for **flushing** canals and ditches in these areas.

Motivation

Due to expecting negative effects of climate change, sea level increase and decreasing freshwater availability, current water management strategies (fixed flushing throughout the dry season) for flushing control in low lying polders have to be revised. In our research we explore smarter strategies to explore:

Is it possible to flush the ditches of a polder using less water while keeping the quality and quantity constraints at set points?

How much freshwater can be saved by a smarter control?

Current practise of flushing is using the available capacity with a fixed discharge. In our test case presented here we assume the maximum capacity of the flushing discharge is 0.15 m^3/s and the necessary amount of freshwater for the test period we demonstrate in this study is presented below with 10 buckets.

Total freshwater used is 270.000 m^3 throughout the simulation period presented in this study.

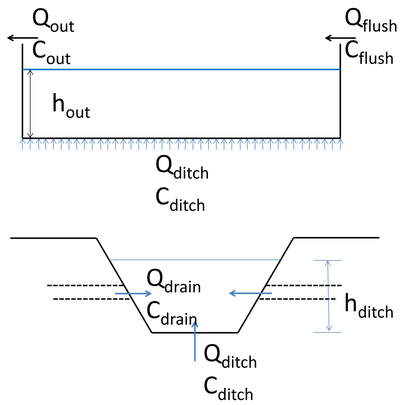
RSGEM

Rapid Saline Groundwater Exfiltration Model is a water balance model used for determining the saline groundwater exfiltration discharges and salinity concentrations which are used as disturbances by the controller.

Model Predictive Control

MPC is an optimization based control strategy which uses a process model to predict the future process outputs within a specified prediction horizon. Constraints, delays and uncertainties of the states and the inputs can be explicitly implemented to the objective function.

Test Canal and Control Objectives

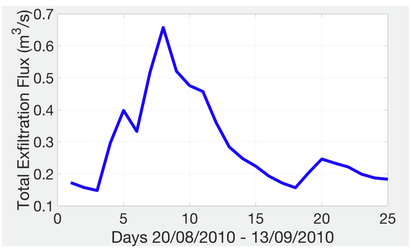


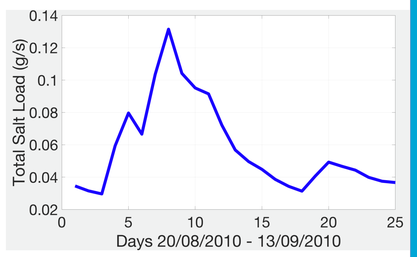
Objective:
Downstream water level h_{out} = -0.4 m
Average Concentration C_{av} < 0.5 g/m^3

Disturbance:
Saline Groundwater Exfiltration (RSGEM)

Control:
Manipulating the change of : Q_{out} & Q_{flush}

Test Scenario



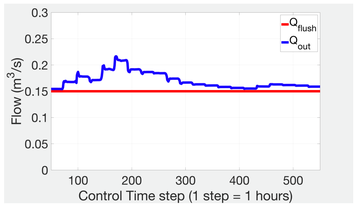


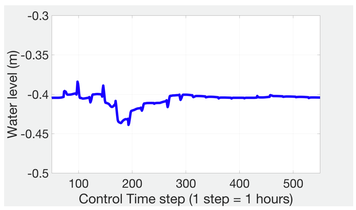
After running RSGEM for a longer simulation, 25 days with high saline groundwater exfiltration variation is selected like a real scenario. For this scenario two schemes are tested.

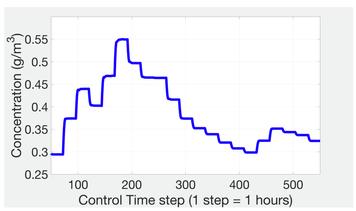
i) Fixed Flushing
ii) Flushing with MPC (+ minimization of flushing discharge)

Results

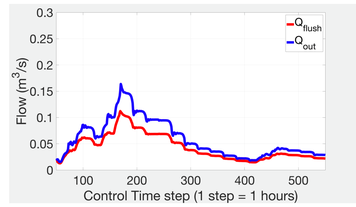
i) Fixed Flushing

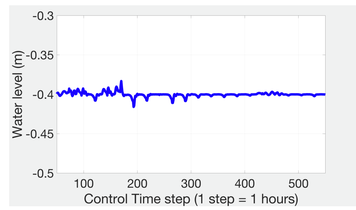


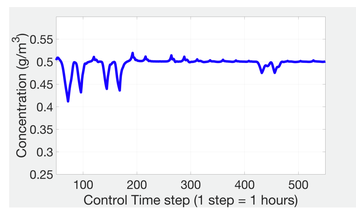




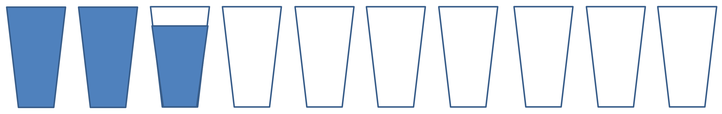
ii) Flushing with MPC







Freshwater used for flushing with MPC



Total freshwater **used** for flushing is 78.123 m^3 (>70 % saved)

It is possible to flush with less water keeping the set points

Conclusion

The MPC scheme developed in this study can be used for salinity control of a polder ditch effectively. MPC uses the available information about the disturbances thus the flushing is done only when it is necessary. Therefore, the smart MPC scheme saves more than 70 % freshwater compared to the current flushing strategy.

Acknowledgements:

This research is financed by the Netherlands Organisation for Scientific Research, which is partly funded by the Ministry of Economic Affairs, and co-financed by the Netherlands Ministry of Infrastructure and Environment and partners of the Dutch Water Nexus consortium.

*Contact : **B.E.Aydin@tudelft.nl**