

Water injection for dredging sediment in reservoirs – insights from preliminary experiments

Buffon, Patricia; Valero, Daniel; Uijttewaal, Wim; Franca, Mario

Publication date

2021

Document Version

Final published version

Citation (APA)

Buffon, P., Valero, D., Uijttewaal, W., & Franca, M. (2021). *Water injection for dredging sediment in reservoirs – insights from preliminary experiments*. 56-57. Abstract from NCR DAYS 2021. <https://kbase.ncr-web.org/outputs/rivers-in-an-uncertain-future/>

Important note

To cite this publication, please use the final published version (if applicable). Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights. We will remove access to the work immediately and investigate your claim.

Green Open Access added to TU Delft Institutional Repository

'You share, we take care!' - Taverne project

<https://www.openaccess.nl/en/you-share-we-take-care>

Otherwise as indicated in the copyright section: the publisher is the copyright holder of this work and the author uses the Dutch legislation to make this work public.

Book of abstracts

Rivers in an uncertain future

NCR days 2021 | Enschede, February 11-12



Jord J. Warmink, Anouk Bomers,
Vasileios Kitsikoudis, R. Pepijn van
Denderen & Fredrik Huthoff (eds.)

NCR publication: 46-2021

Netherlands
Centre for
River studies **NCR**

NCR Days 2021

Rivers in an uncertain future

Jord J. Warmink, Anouk Bomers, Vasileios Kitsikoudis, R. Pepijn
van Denderen & Fredrik Huthoff (eds.)

Organising partner:

UNIVERSITY OF TWENTE.

Co-sponsored by:



Organising partner

University of Twente
P.O. 217
7500 AE Enschede
The Netherlands

telephone: +31 53 489 35 46
e-mail: secretariat-mfs-et@utwente.nl
www: <https://www.utwente.nl>

Contact NCR

dr. ir. K.D. Berends (programme Secretary)
Netherlands Centre for River Studies
c/o Deltares
P.O. 177
2600 MH Delft
The Netherlands

telephone: +31 6 21 28 74 61
e-mail: secretary@ncr-web.org
www: <https://www.ncr-web.org>

Cite as: Warmink, J.J., Bomers, A., Kitsikoudis, V., van Denderen, R.P., Huthoff, F. (2021), *Rivers in an uncertain future: NCR Days proceedings*. Netherlands Centre for River Studies, publication 46-2021

Photo credits cover: IJssel river from Bureau Beeldtaal Filmmakers (2018)

Copyright © 2021 Netherlands Centre for River Studies

All rights reserved. No parts of this document may be reproduced in any form by print, photo print, photo copy, microfilm or any other means, without permission of the publisher: Netherlands Centre for River Studies.

Water injection for dredging sediment in reservoirs – insights from preliminary experiments

Patricia Buffon^{a,b,*}, Daniel Valero^a, Wim Uijttewaal^b, Mário Franca^{a,b}

^aIHE Delft, Water Resources and Ecosystems Department, P.O. Box 3015, 2601 DA, Delft, the Netherlands

^bTU Delft, Department of Hydraulic Engineering, P.O. Box 5048, 2628 CN, Delft, the Netherlands

Keywords — Sediment dynamics, Turbidity currents, Sustainable infrastructure

Introduction

River dams have been largely implemented to store water for energy production, irrigation, flood control, and human and animal water supply; albeit some environmental implications. A negative consequence of damming rivers is the associated loss of connectivity. Several concerns can be raised in terms of sediment entrapment, among others: the continuous reduction of reservoirs' storage capacity, the altered morphodynamics and the impact on ecosystems of the river reach. Therefore, the ultimate goal of sediment management frameworks for river water reservoirs is granting sediment continuity through the dams. Nevertheless, choosing the most suitable strategy is complex, and a comprehensive knowledge about techniques and the environment is necessary to successfully achieve this goal.

This ongoing experimental research focuses on turbidity currents triggered by a water jet. The proposed experimental framework is an idealized conceptual model of Water Injection Dredging (WID), which can potentially be applied in water reservoirs as a sediment management technique. Other current sediment management techniques are described in [Anandale, Morris and Karki \(2016\)](#), and the history and application of WID is discussed by the World Association for Waterborne Transport Infrastructure (PIANC) in [PIANC Report n° 120 \(2013\)](#).

Problem definition

Scouring may happen when injecting water into a partially compacted mobile bed. Particles can be suspended and finally transported downstream by a buoyancy-driven flow, which is commonly known as a turbidity current. Flow processes occurring during application of WID are presented in Figure 1.

In this study, these processes are spatially divided in water (i) injection, (ii) impact zone, (iii)

near field, and (iv) far field. The inlet velocity of the water jet defines the initial input of energy that can trigger the aforementioned processes. The jet impact in the scouring hole will lead to a resuspension of sediment that may be conceptualised as the upstream boundary condition of the triggered turbidity currents (near field). These processes together will define the transport of mass, momentum, and turbulence into the far field. Ultimately, these will determine the feasibility of the technique in a specific site. An example of this modelling approach application is described in [Winterwerp et al \(2002\)](#). A set of preliminary experiments were performed to refine the experimental design, and are presented below.

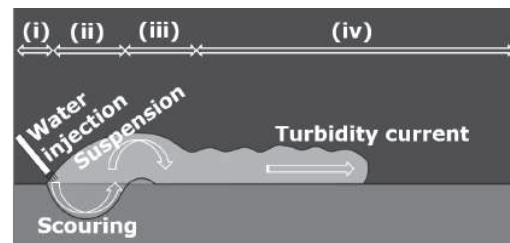


Figure 1: Sketch and problem definition. (i) injection, (ii) impact zone, (iii) near field, and (iv) far field.

Methodology

The experimental setup consisted of:

- A flume 4 m long, 2 m high, and 22 cm width equipped with a sediment damping tank;
- A 3D-printed diffuser device positioned at 45° reproducing a 2D water jet, with the discharge recorded upstream by a flow-meter;
- A lighter-weighted sediment ($D_{50} = 0.548$ mm and $\rho = 1243$ kg/m³) was used to build the mobile bed of – roughly horizontal – slope .

The flume before the beginning of the experiment, the diffuser, and sediment are shown in Figure 2.

*Corresponding author
 Email address: p.buffon@tudelft.nl (Patricia Buffon)
 URL: www.un-ihe.org/patricia-buffon (Patricia Buffon)



Figure 2: Experimental setup: (a), the 2D and 3D-printed water jet (b), and sediment (c).

Preliminary results

Three exploratory experiments are presented below (for a short video of these experiments, see Buffon, 2020).

- Experiment 1 (Figure 3a): in the first experiment, a pulse in the water discharge was released (approximately 9 l/s), triggering a non-desired situation in which a large quantity of sediment was abruptly suspended;
- Experiment 2 (Figure 3b): insufficient discharge was applied (approximately 2 l/s), also leading to a non-desired situation in which the sediment was suspended in a controlled way, but it was not efficiently transported in the downstream direction by the turbidity current;
- Experiment 3 (Figure 3c): in the third experiment, an intermediate discharge was achieved (approximately 4 l/s), triggering the desired situation that will be further investigated. In this case a cloud of sediment was suspended, and plunged in a turbidity current that transported sediment in the downstream direction.

Future work

Adaptations have been conducted in the flume, and a series of new experiments (similar to Figure 3c) will follow, attempting to quantify key hydrodynamic processes and optimum conditions to apply the technique.



Figure 3: Set of preliminary experiments: (a) Experiment 1 - peak of discharge; (b) Experiment 2 - low discharge; (c) Experiment 3 - intermediate discharge.

Acknowledgements

The first author acknowledges CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, a Foundation within the Ministry of Education in Brazil) for funding her Ph.D. Program (grant number 88881.174820/2018-01), the Hydraulic Engineering laboratory of TU Delft, and the River Basin Development chair group of IHE Delft for providing additional resources to develop the experimental work.

References

- Annandale, George W.; Morris, Gregory L.; and Karki, Pravin. 2016. Extending the Life of Reservoirs: Sustainable Sediment Management for Dams and Run-of-River Hydropower. Directions in Development. Washington, DC: World Bank. doi: 10.1596/978-1-4648-0838-8
- Buffon, Patricia. 2020. Turbidity currents triggered by a water jet. Available at: <https://www.youtube.com/watch?v=UeIzG7p43uU>. Last access: 07/01/2021
- Winterwerp, J. C.; Wang, Z. B.; van Kester, J. A. Th. M. and Verweij, J. F. 2002. Far-field impact of water injection dredging in the Crouch River. Proceedings of the Institution of Civil Engineers - Water and Maritime Engineering 2002 154:4, 285-296. doi.org/10.1680/wame.2002.154.4.285
- World Association for Waterborne Transport Infrastructure (PIANC), Report n° 120, Maritime Navigation Commission. 2013. Injection Dredging. Bruxelles, BE: PIANC Secrétariat Général. ISBN: 978-2-87223-205-5