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Irving, Meghan; Sloff, Kees

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Rivers in an uncertain future

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University of Twente	telephone:	+31 53 489 35 46
P.O. 217	e-mail:	secretariat-mfs-et@utwente.nl
7500 AE Enschede	www:	https://www.utwente.nl
The Netherlands		

Contact NCR

dr. ir. K.D. Berends (programme Secretary)	telephone:	+31 6 21 28 74 61
Netherlands Centre for River Studies	e-mail:	secretary@ncr-web.org
c/o Deltares	www:	https://www.ncr-web.org
P.O. 177		
2600 MH Delft		
The Netherlands		

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Morphological Impacts of Porcupine River Training Structures

Meghan Irving[a,*], Kees Sloff[a,b]
[a]TU Delft, Faculty of CEG, Building 23, Stevinweg 1, 2628 CN Delft, the Netherlands
[b]Deltares, P.O. Box 177, 2600 MH Delft, the Netherlands

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Introduction

Flexible river training structures such as tetrahedron frames ('porcupines') can be attractive for control of braided river channel networks in regions where permanent control structures (e.g. groynes) are too expensive or potentially inefficient, such as areas with highly dynamic flow regimes and morphology. Porcupine fields (see Fig. 1) provide hydraulic resistance, generating energy loss through turbulence that may reduce velocities and promote sediment deposition (*Shang et al.*, 2013).

Porcupine systems can be used for bed or bank protection, and were implemented in a 2019 channel-control pilot project on the Ayeyarwady River in Myanmar. Incorporating porcupine resistance into numerical models has not been systematically evaluated. First, we must understand the processes that need to be captured for accurate predictions of impacts to flow and sediment transport, which is the focus of this work. Improved models can aid in future porcupine system design.

Figure 1: Porcupine field in secondary channel of Ayeyarwady River, Myanmar. Photo courtesy of H. Fredrikze, Royal HaskoningDHV.

Methods

Predicted impacts were examined using literature review and data from a 2018 porcupine flume experiment (*Nientker*, 2018), and then evaluated against pilot project observations. The pilot project was implemented in the Ayeyarwady River near Mandalay. In this location the river consists of a primary channel and four secondary channels (see Fig. 2).

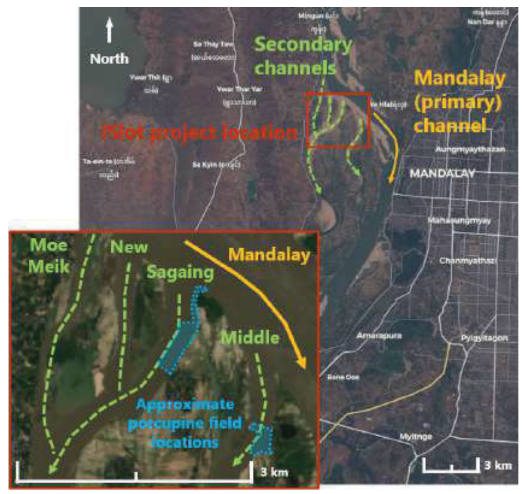

Figure 2: Ayeyarwady River pilot project location. Aerial imagery: Landsat 11/03/2020 (overview), 18/09/2020 (inset); (apps.sentinel-hub.com)

The main objective is to improve navigational stability by maintaining the current channel discharge distributions and hence a least available depth of 2 m in Mandalay channel. To encourage this, 2 m tall concrete porcupines were placed in a staggered configuration in secondary channels to increase local roughness (*Kreeke et al.*, 2018). Survey measurements were taken before and after the first wet season to examine morphological changes.

Results

Predicted Hydrodynamic and Morphological Impacts

The velocity and turbulence profiles through a field of resistance elements varies as density increases from 'sparse' to 'dense'. Dense fields generally reduce velocities and shear stresses inducing sedimentation. Sparse fields may experience erosion or deposition depending on the exact velocities and shear stresses. The leading, trailing and lateral field edges can have a different response than a central

*Corresponding author
Email address: meghan.irving@gmail.com (Meghan Irving)

(fully-developed) flow area for dense fields. Increased shear stresses and erosion may be observed at the leading or lateral edges, while deposition is likely in the center and trailing edge. This effect may be absent in sparse fields where edge velocity gradients are weak. In addition, channel placement dictates initial flow velocities in or along the field (e.g. higher velocities in an outer versus inner bend).

Pilot Study Observations

The pilot porcupines likely exhibit transitional or sparse behavior of the flow field, where significant scour at leading and lateral edges was not evident; however, porcupines located at the leading edge and especially in high-energy areas (e.g. outer bend) did show signs of scour and sinking into the bed (see Fig. 3). Porcupines were also partially buried through deposition, while largely maintaining their installation elevation.

Buried (shorter) porcupines offer less flow resistance and velocity reduction. Therefore upstream porcupines sinking can cause downstream porcupines to sink as they receive higher flow velocities. Loss of elevation may reduce the field's long-term effectiveness.

Fig. 3 also suggests that transverse resistance gradients from equi-height porcupines installed at varying cross-sectional elevations (generally higher at the inner bend) have helped push the flow (and thalweg) towards the outer bend.

Note that limited site data prevents us from entirely separating porcupine-induced changes from external influences.

Conclusion

Numerical modeling of porcupine systems must take into account changes in resistance due to porcupine burial over time, through sinking or deposition. They should accurately capture predicted behaviors according to field density including variations at leading and lateral edges to make informed design choices. In addition, estimating the strength of transverse gradients may be important if protecting the outer bend is a design goal. Further studies are needed to validate and expand these results for a wider range of field configurations and flow conditions.

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References

Shang, Q., Xu, H., Li, G. (2013) Overview of research on the influence of permeable structures. Applied Mechanics and Materials 405-408, pp. 2115–2122. issn: 16609336.

Nientker, G. (2018) Porcupines for river training: A study on the near-field effects of porcupines. Tech. rep. Delft University of Technology.

Kreeke, P. van de, Schuurman, F., Commandeur, A., Laboyrie, H., Kesteren, J. van, Nieuwenhuis, O. (2018) Report AIRBM - Component 3, Engineering, Design, Capacity Building and Construction Supervision for Sub-Project 1. Detailed Design Report.

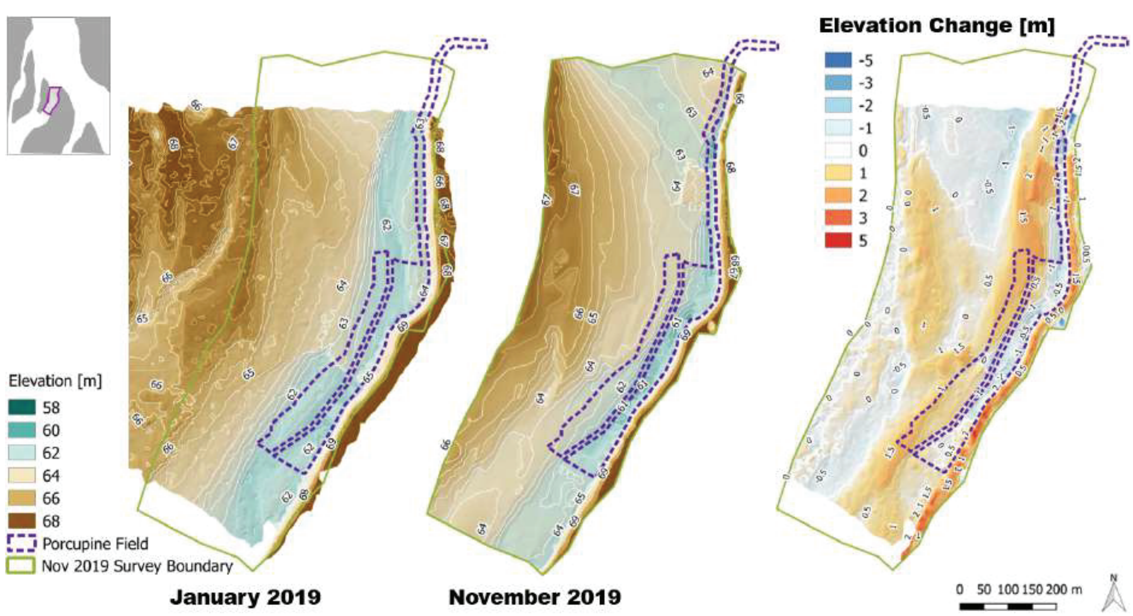

Figure 3: Morphological change in Sagaing Channel (November elevation minus January elevation).