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Performance evaluation of newly developed porcupine systems for efficient erosion control in alluvial rivers

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Abstract: A common problem faced during floods is scouring of the riverbed and bank, subsequently leading to a change in the course of the river along with losses to both land and property. Porcupine systems have been developed as a preventive measure which traps the sediments, thereby controlling scouring. In big perennial rivers like Ganga, Brahmaputra and Kosi, porcupine systems have been effectively deployed as a cost-effective measure for river training. This study investigates the sediment trap efficiencies of newly developed porcupine systems through experimental analysis. Various layouts of porcupines have been investigated to gain an insight into the sediment deposition pattern under a particular set of river conditions involving discharge, water depth, and sediment concentration. The velocity at upstream, mid and downstream has been measured with the help of Acoustic Doppler Velocimeter (ADV). A set of dimensionless performance indices for porcupine systems has been formulated, and the corresponding changes in trap efficiency relative to these indices have been analyzed. It was observed that the models with two compartments and higher amount of sediment injection showed better trap efficiencies as compared to those with three compartments. Moreover, the contour plots of sediment deposition are also presented which display the effective sediment deposit along and across the channel.

Key words: Perennial river; porcupine; sediment deposition; trap efficiency; sedimentation contour plots.

1. INTRODUCTION

River erosion is the process in which a river gradually cuts into its bed and banks, both downward and sideways. This leads to the loss of land and farmland, disrupts ecological balance, and can harm infrastructure such as bridges, buildings, and other structures located close to the river (Barman and Kalita, 2018). Therefore, riverbank protection has become crucial; particularly for meandering rivers, those undergo intense erosion during the monsoon season (Kalita, 2017). Protection of the river banks is normally accomplished by a variety of riverbank protection works including a marginal embankment or levees, guide banks, guide bunds, groynes or spurs, submerged vanes, cut offs, pitching of banks, pitched islands, sills, closing dykes, and longitudinal dykes. Sediments move in different modes in the rivers. The quantity of sediments entering the channel is an important factor, which influences the flow in the channel, cross-section of the channel and a true regime of the channel (Garde and Raju, 2000).

Alluvial rivers typically exhibit meandering or braided forms (Kakati et. al., 2022). In India, different riverbank protection measures have been taken over the years. Reinforced Cement Concrete (RCC) Jack Jetty has become a cost-effective river training measure in Indian rivers (Shriwastava and Sharma, 2014). Authors concluded that the presence of submerged jacks leads to a significant decrease in flow velocity, and the extent of this reduction varies with several factors - e.g., larger jacks tend to reduce velocity more effectively than smaller ones. There is significant reduction in flow velocity due to the presence of submerged jacks, which depends on variety of situations such as, reduction in velocity with bigger jacks than smaller ones. Comprehensive laboratory investigations at IIT Roorkee on the RCC Jack Jetty system in conjunction with bamboo-submerged vanes were undertaken, with the results further corroborated by pilot field trials near Nakhwa Village along the Ganga River (Sharma and Nayak, 2015). In the right and left bank of the Jamuna River, guide bunds, revetment, groynes/spurs have been constructed of which revetment type structures are found to be more stable than groynes type structure (Sarkar et.al., 2011). Casting and laying of permeable RCC porcupine screens/spurs/dampeners at various locations have been done at Majuli Island of Assam to prevent erosion (Brahmaputra Board, 2012).

Permeable structures in the form of RCC porcupine screens/spurs/dampeners are a cost- effective alternative to the impermeable bank protection works for the rivers carrying considerable amount of silt. RCC porcupine is a prismatic type permeable structure, comprises of six members made of RCC, which are joined with the help of iron nuts and bolts (Gayan and Talukdar, 2018). Each member is 2-4 m in length, depending upon the requirements. At the time of concreting of members, holes are kept in the RCC poles for the bolts. Generally, RCC poles of 3 m length are used having a cross-section of 15 cm × 15 cm. Reinforcement is given using 4 numbers of MS bars of 6 mm diameter with stirrups at 15 cm c/c. Larger porcupines may also be used with greater cross-section and heavier reinforcement as per the requirements. The bolts typically have a diameter of 12–15 mm. Check nuts are provided for better grip. Washers are required at both ends for better grip with the RCC members. RCC porcupines should be connected together by wire rope and properly placed on the ground to avoid any disturbance caused by the intensity of flow (Aamir and Sharma, 2015). Permeable structures such as RCC porcupines can perform several functions: they help direct the river along a preferred alignment, lessen the force of flow at critical erosion points, generate slower currents that encourage silt deposition around and downstream of the structures, and safeguard the riverbank by lowering the flow velocity near the bank. Porcupine structures have proved to be cost-effective (Handique et. al., 2024). Many experiments have been performed in the Outdoor River Engineering Laboratory of the Department of Water Resource Department & Management, IIT Roorkee, aiming to study the pattern of deposition of sediment caused by various configurations of porcupine field (Aamir and Sharma, 2014). Various scaled-down modified Deltoid structures can effectively reduce flow velocity and enhance sediment deposition in river channels, offering a promising, low-cost approach for erosion control and riverbank stabilization (Barman and Talukdar, 2025).

The present study investigates the effect of different porcupine field configurations in sediment deposition patterns, aiming to make a detailed comparison of the sediment trapping efficiency of various porcupine field models. The models are further characterized by parameters/indices, which govern the effectiveness of the sedimentation process. Further, a comparative analysis between different porcupine field models is carried out to evaluate their effectiveness in trapping sediment.

2. MATERIALS AND METHODS

2.1 Geometry of RCC prototype porcupines

RCC porcupine is a prismatic type permeable structure, comprising six members made of RCC, which are joined with the help of iron nuts and bolts. Figure 1 shows a three-dimensional sketch of typical RCC porcupine. Length of each member is 2 m to 3 m and cross-section is 15 cm × 15 cm. Reinforcement is given using 4 nos. of Mild Steel (MS) bars of 6 mm diameter, with stirrups at 15 cm c/c. These porcupines can be laid along and across the flow to induce gradual obstruction to the flow, reduce velocity locally and induce the siltation. Figure 1 shows a typical RCC porcupine screen.

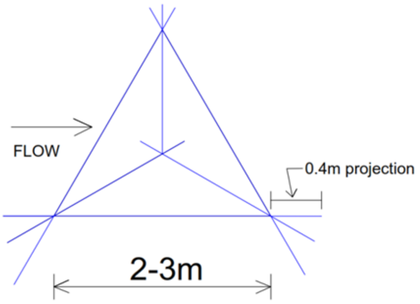


Figure 1. Three- dimensional sketch of a typical RCC Porcupine unit

3. EXPERIMENTAL INVESTIGATION

3.1 Porcupine model

The porcupine models used in this study are prepared by reducing scale to match the dimensions of the laboratory channel. The models are prepared with MS Rods, circular, having diameter of 6 mm and 120 mm in length which are anchored together with nails. Projection length of 30 mm for members of the model is kept for embedding them into the simulated riverbed in the experimental channel. Photographs of such typical model are shown in Figure 2.

Figure 2. Model of porcupine made of MS Rod

3.2 Bed and bank material

The bed and bank materials used in the laboratory channel are collected from the River Brahmaputra, Pandu Port of Maligaon, Guwahati, Assam. After collecting the material samples, they are air dried for evaluating the particle size distribution so that the relative percentages of fine and medium-grained sand as well as the fines present in the sample could be estimated. The simulated riverbed that was used in the laboratory channel (having depth of 0.49 m) was prepared by keeping the same relative percentages of fine and medium sand that exist in the actual sample of riverbed material collected from the site.

3.3 Channel description

All the experiments for this study were carried out in the Hydraulics Laboratory Channel or Flume of Assam Engineering College, Guwahati. A schematic view of the experimental setup is provided in Figure 3. The channel is having dimensions of 19.14 m long, 0.96 m wide and 1.275 m deep. A constant sand bed of 0.49 m thickness is also provided throughout the length of the channel, for all the experiments. Three pumps of 7.5 HP, 10 HP and 15 HP are used to feed water into the channel. The water from the pump is collected in a tank and then passed through a combined arrangement of energy dissipater and sets of wire mesh for stilling before letting it to enter into the channel through an inlet. The minimum depth of flow was kept constant inside the channel (equal to 15 cm) with the help of a rectangular weir fitted at the downstream end of it. The water at the outlet opening was collected in a rectangular tank. The flow in to the channel was regulated with the help of a discharge valve fitted at the inlet.

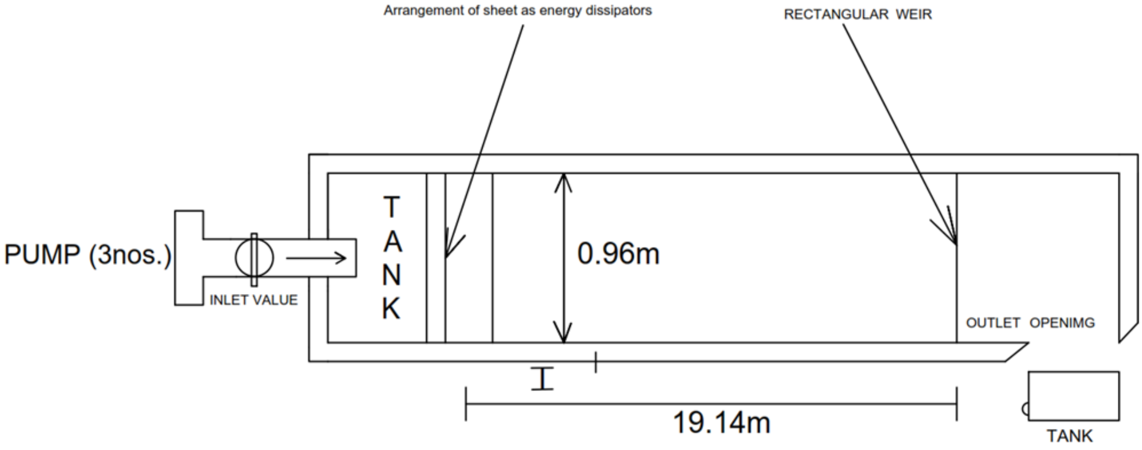


Figure 3. Layout of experimental channel

3.4 Experimental procedure

First, the bed of the channel was levelled, and the flow was gradually introduced by releasing the discharge valve slowly until a point at which the bed materials just tend to lift representing incipient motion condition. The valve was then readjusted back a little so that the velocity of flow remains a little less than the critical velocity (that corresponds to incipient motion condition). Before starting of experimentation with the porcupine field models, this clear water run was continued for half an hour. Then the motor was shut and the rectangular weir was removed which allowed the water to drain out gradually from the channel without disturbing the sand bed. The position of the discharge valve (that regulates the quantity of flow into the channel) was thus fixed and was kept constant for the rest of all experiments. Sand bed levels were measured with the help of point gauge as shown in Figure 4. The typical notations for defining various parameters, described in the succeeding sections are referred following the descriptions shown in Figures 5-6.

After placement of the first trial model of the porcupine field, the sediment bed of flume was again levelled around the field and the flow was introduced in the channel. The discharge was maintained consistent with that used in the clear-water experiment. Once the flow came into steady state condition, a fixed quantity of sediment was injected into the channel, 2 m upstream of the porcupine field, for 45 minutes. Then the motor was shut down and the rectangular weir was removed which allowed the water to drain out gradually from the channel. After the water was drained completely, sand bed levels were again measured with the help of point gauge. The same procedure was followed for the rest of the model porcupine fields studied in this work.

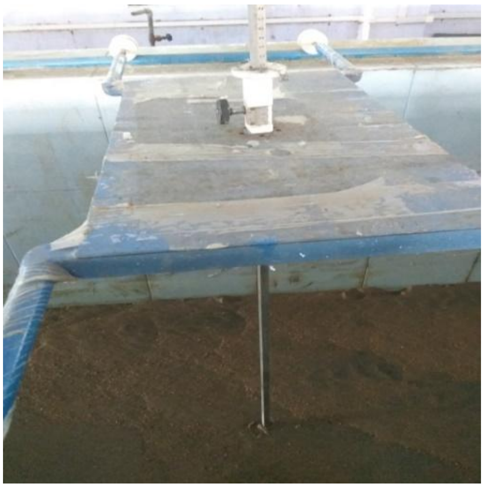


Figure 4. Point Gauge with trolley

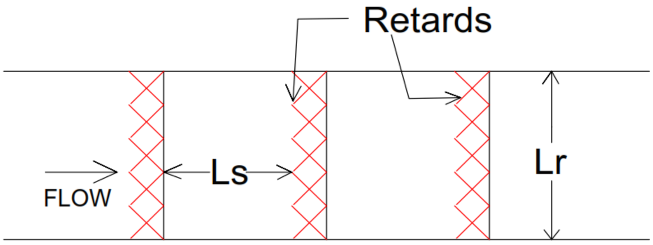


Figure 5. Typical layout of porcupine field

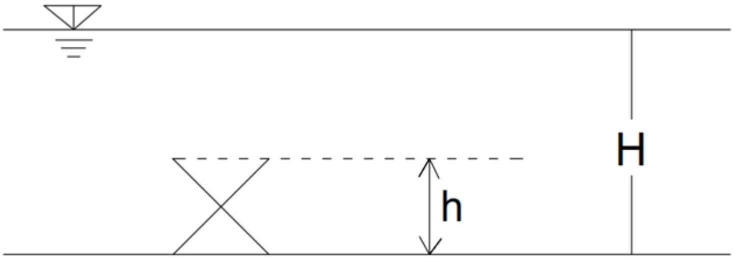


Figure 6. Sketch of porcupine model submerged in water

All the experiments are performed with sediments having the average diameter (D_{50}) of 0.43 mm, specific gravity of 2.58 and porosity of 34% for bed material and average diameter (D_{50}) of 0.25 mm, specific gravity of 2.78 and porosity of 35% for bank material respectively.

3.5 Nomenclature of model porcupine system

Total eight trials of model porcupine systems, as presented in Table 1, have been utilized for analyzing the trap efficiency for the above mentioned channel description. The nomenclature of the model porcupine system depicts the total number of compartments, gap between porcupine along channel length and the amount of sand injected. For example- porcupine model C2G15I3 describes that the particular model has two compartments, the gap between two adjacent porcupines is 15 cm along the channel length and a total of 3 kg sand is injected at the upstream of the cannel as shown in Figure 3 (injection point, I).

3.6 Indices

Several indices were formulated in this study to systematically differentiate among the various porcupine field models. The definitions of these indices are presented below:

(a) Porcupine Field Density Index (PFDI) = $\frac{L_r}{L_s}$
where, L_r = Length of one retard and L_s = Spacing between the two retards

(b) Porcupine Compartment Density Index (PCDI) = $\frac{L_r}{L_c}$
where, L_c = Total length of compartment

(c) Porcupine Field Length Factor (PFLF) = $\frac{L_s}{L_c}$

(d) PFSI (Porcupine Field Submergence Index) = $\frac{Depth\ of\ water\ over\ porcupine}{Total\ depth\ of\ water} = \frac{(H-h)}{H}$
where, H = total depth of water and h = height of porcupine model

(e) PFVI (Porcupine Field Velocity Index) = $\frac{(Upstream\ velocity-Mid\ velcity)}{(Mid\ velocity-Downstream\ velocity)}$

4. INSTRUMENTATION

4.1 Measurement of velocity

The velocity was measured with the help of an Acoustic Doppler Velocimeter (ADV) (refer Figure 7). The Vectrino Velocimeter measures water speed using the Doppler Effect by transmitting a short pulse of sound, listening to its echo and measuring the change in pitch or frequency of the echo. The Vectrino measures velocity components parallel to its three beams, or in beam components. It reports data in Beam or XYZ coordinate systems. The XYZ coordinates are relative to the probe and independent of whether the Vectrino points up or down. In XYZ coordinates, a positive velocity in the X-direction goes in the direction of the X-axis arrow. The velocity was measured at three points for each trial i.e., at the upstream, mid and downstream.

Figure 7. Acoustic Doppler Velocimeter (ADV)

5. RESULT AND DISCUSSION

Using the dimensional parameters as listed in Table 1, trial porcupine field models were prepared and laid on the channel with the simulated riverbed. Relevant observations were made to study the sediment deposition of these trial field models as per the methodology laid down. Length of each porcupine field was started from a distance of 6 m from the upstream end of the simulated bed in the channel and the width started from the bank of the channel. After each experimental run, the bed profiles were measured in the form of 0.30 m x 0.48 m grid with point gauge along three imaginary lines (A, B & C) on the channel bed across the flow, as shown in Figure 8.

Table 1. Nomenclature of the model porcupine system

No. of porcupine along transverse direction		No. of compartment	Gap b/w porcupine along channel (cm)	Sand Injected (kg)	Model Nomenclature
Subchannel 1	Subchannel 2				
1	1	2	15	3	C2G15I3
1	1	2	15	6	C2G15I6
1	1	3	15	3	C3G15I3
1	1	3	15	6	C3G15I6
1	1	2	30	3	C2G30I3
1	1	2	30	6	C2G30I6
1	1	3	30	3	C3G30I3
1	1	3	30	6	C3G30I6

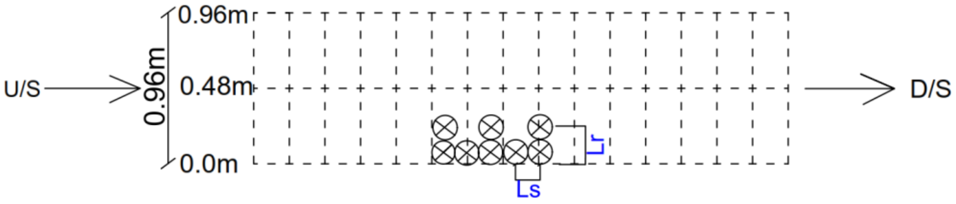


Figure 8. Typical layout of channel grid

5.1 Estimation of sediment deposition

Sediment deposition was evaluated for all eight system configurations by positioning the porcupine models in various layouts i.e., by changing the length and spacing of the retards, by changing the number and length of the compartments and also the amount of sand injected, which is shown in the Table 2.

Table 2. Range of dimensional parameters for the trial porcupine field models

Model	L_r (cm)	L_s (cm)	No. of compartment	Weight of sand injected (kg)	Length of compartment (L_c) (cm)	PFLF $(\frac{L_s}{L_c})$	PCDI $(\frac{L_r}{L_c})$	PFDI $(\frac{L_s}{L_c})$
C2G15I3	24	15	2	3	30	0.5	0.8	1.6
C2G15I6	24	15	2	6	30	0.5	0.8	1.6
C3G15I3	24	15	3	3	45	0.33	0.53	1.6
C3G15I6	24	15	3	6	45	0.33	0.53	1.6
C2G30I3	24	30	2	3	60	0.5	0.4	0.8
C2G30I6	24	30	2	6	60	0.5	0.4	0.8
C3G30I3	24	30	3	3	90	0.33	0.27	0.8
C3G30I6	24	30	3	6	90	0.33	0.27	0.8

5.2 Contour plots of sediment laden bed

The sediment deposition in the porcupine field with every dimensional variation is shown by contour plots drawn with the help of SURFER@13 software. These plots clearly show the deposition of sand around the porcupine fields. Length of the porcupine field is indicated starting from the point nearest to the upstream end of channel and width is indicated starting from the wall of the channel. The colour legend shows sediment deposition in m (Figure 9).

From Figure 9 (a–h), it is evident that sediment deposition is higher near the location of the porcupine models than at the far end, as further discussed in Section 5.3.

5.3 Measurement of sediment deposition

From the graph (Figure 10), it can be concluded that there is more sediment deposition at the near end where the porcupine models are placed than the far end. At some points of the far end, scouring can also be seen. In all trials, the graph exhibits a steady rise from 6.0 m to 9.0 m. The peak sediment deposition has been observed when the length of retard was 24 cm; spacing 30 cm with 3 compartments and 3 kg of sediment has been injected at 6.6 m from the right end. The minimum sediment deposition has been observed when the length of retard was 24 cm; spacing 15 cm with 2 compartments and 3 kg of sediment has been injected.

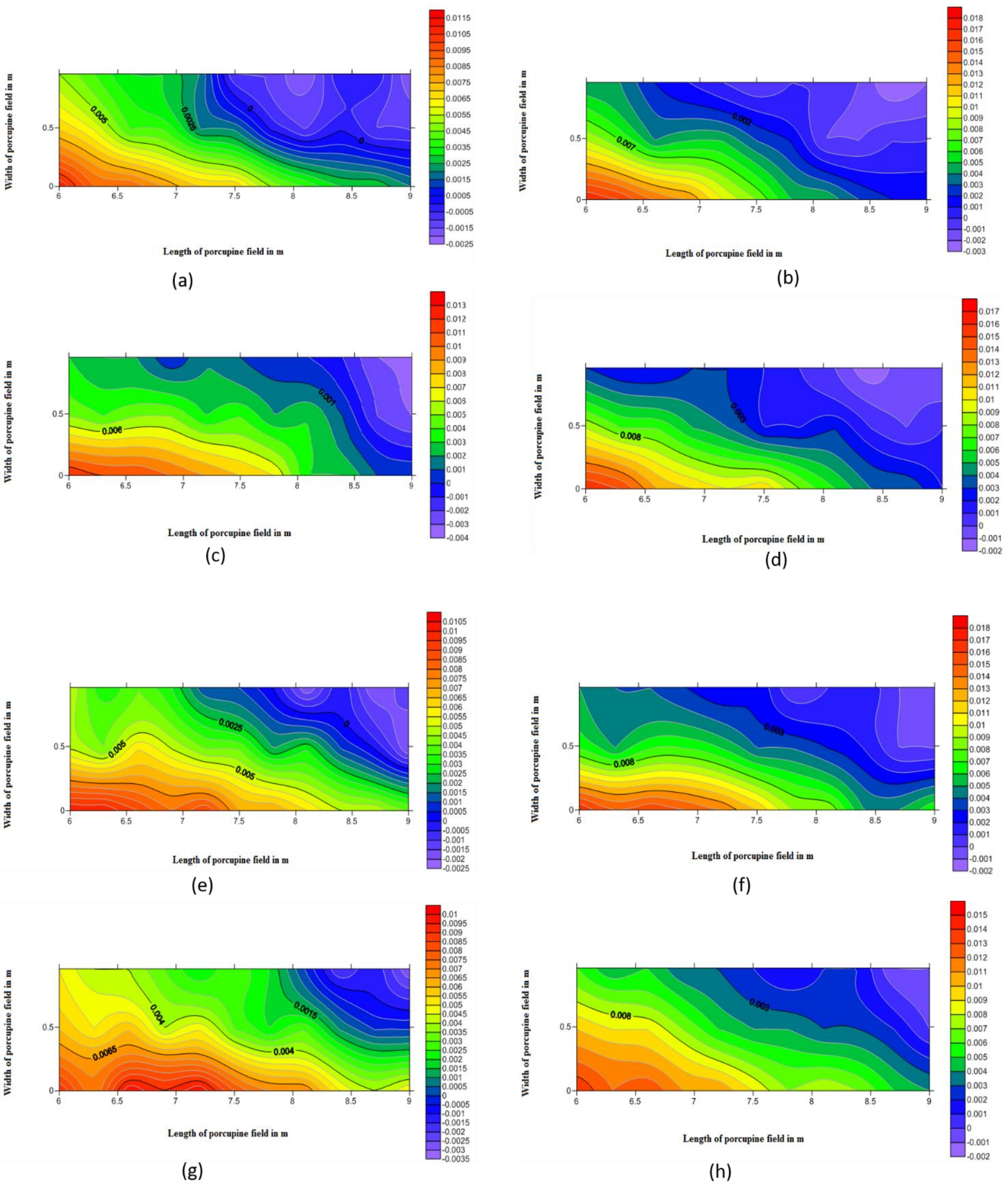


Figure 9.Contour plots for configurations; (a) C2G15I3 with PFDI= 1.6, PCDI= 0.8 and PFLF= 0.5, (b) C2G15I6 with PFDI= 1.6, PCDI= 0.8 and PFLF= 0.5, (c) C3G15I3 with PFDI= 1.6, PCDI= 0.53 and PFLF= 0.33, (d) C3G15I6 with PFDI= 1.6, PCDI= 0.53 and PFLF= 0.33, (e) C2G30I3 with PFDI= 0.8, PCDI= 0.4 and PFLF= 0.5, (f) C2G30I6 with PFDI= 0.8, PCDI= 0.4 and PFLF= 0.5, (g) C3G30I3 with PFDI= 0.8, PCDI= 0.27 and PFLF= 0.33, (h) C3G30I6 with PFDI= 0.8, PCDI= 0.27 and PFLF= 0.33

Figure 11 indicates that models with lower sediment injection yield a smaller total amount of sediment deposition compared to models with higher sediment injection. Further, the model with 2 nos. of compartments showed higher amount of sediment deposition as compared to the models with 3 compartments, when amount of sediment injection is 6 kg. For lower sediment injection, it is observed that the total amount of sediment deposition is almost in the same range for both type of models, i.e., having 2 and 3 nos. of compartments. However, the model with 2 compartments and gap between two adjacent retards 15 cm shows lowest sediment deposit as compared to that for other models.

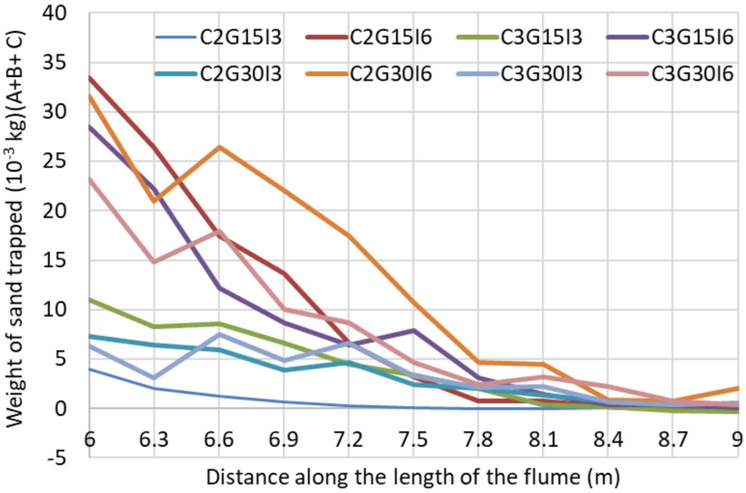


Figure 10. Weight of sand trapped along the length of flume at regular interval

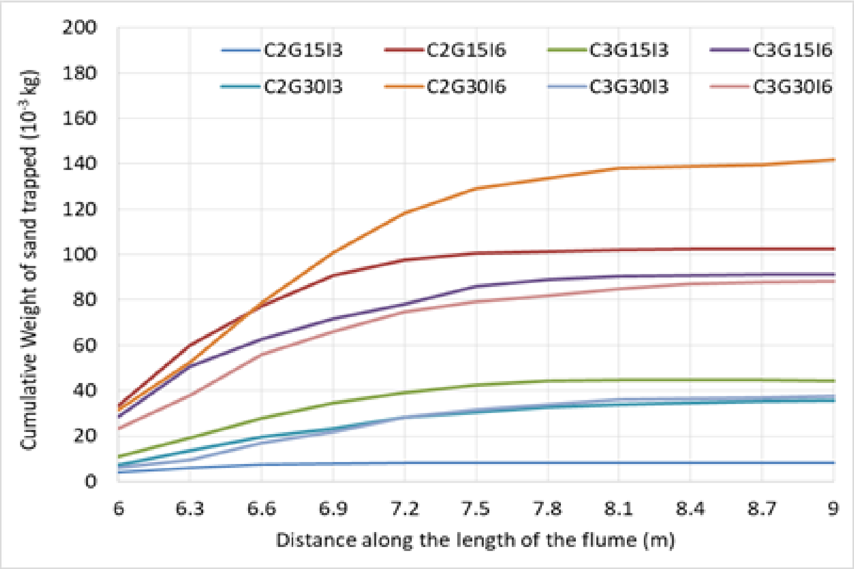


Figure 11. Cumulative weight of sand trapped along the length of flume

5.4 Calculation of trap efficiency

Based on the data collected, different indices have been calculated for different sediment injection namely 300 ppm and 600 ppm. The total weights of the sand deposited along the length of the flume are calculated for different input of sand injection and trap efficiency has been calculated as follows:

$$Trap\ efficiency\ (\%) = \frac{Weight\ of\ sand\ deposited}{Weight\ of\ sand\ injected} \times 100 \quad (1)$$

PFDI are kept as 1.6 and 0.8, whereas, PCDI and PFLF, velocity index and sediment concentration varies as shown in Table 3.

Table 3. Trap Efficiency for each model porcupine system at constant depth of 15 cm

Model	PCDI $(\frac{L_r}{L_c})$	PFLF $(\frac{L_s}{L_c})$	PFDI (L_s)	Vel. Index	Sediment Conc. q_s (ppm)	Sand deposited (kg)	Sand injected (kg)	Trap Eff. (%)
C2G15I3	0.8	0.5	1.6	2.68	300	0.0304	3	1.01
C2G15I6	0.8	0.5	1.6	2.35	600	0.0994	6	1.65
C3G15I3	0.53	0.33	1.6	1.19	300	0.0444	3	1.48
C3G15I6	0.53	0.33	1.6	2.64	700	0.1023	6	1.70
C2G30I3	0.4	0.5	0.8	3.76	300	0.0358	3	1.19
C2G30I6	0.4	0.5	0.8	4.51	600	0.0883	6	1.47
C3G30I3	0.27	0.33	0.8	1.20	300	0.0376	3	1.25
C3G30I6	0.27	0.33	0.8	3.16	700	0.0911	6	1.52

5.5 Comparison of trap efficiency with different indices

The variation of trap efficiency with PFDI has been plotted varying the sediment concentration, PFLF, PFSI and amount of sediment injected. When the sediment injection is lower, the sediment deposition is also lower, whereas higher sediment injection results in more deposition. Additionally, with 6 kg of sediment injection, the model with 2 compartments shows greater sediment deposition than the models with 3 compartments.

It has been observed from the result summarised in Table 4 and graph displayed in Figure 12 (a) that the trap efficiency is higher when q_s = 700 ppm than q_s = 600 ppm which means with the increase in the sediment concentration, the trap efficiency increases, when PFSI = 0.20. The rate of trap efficiency with respect to PFDI is higher for higher values of sediment concentration. In addition, it has been observed that with the increase in PFDI, the trap efficiency increases. From Figure 12 (a), it is observed that there is more deposition of sediment for more sediment injection and vice-versa. This means that trap efficiency increases with increase in sediment concentration, i.e. trap efficiency is directly proportional to sediment concentration.

Table 4. Variation of Trap efficiency with PFDI for q_s = 600 ppm and q_s= 700 ppm, keeping PFSI = 0.20

PFDI	Trap Efficiency (%) for q_s = 600 ppm	Trap Efficiency (%) for q_s = 700 ppm
0.8	1.47	1.52
1.6	1.65	1.7

It has been observed from the result summarised in Table 5 and graph displayed in Figure 12 (b) that the trap efficiency is higher when PFLF = 0.33 than PFLF = 0.5 which means with the decrease in the PFLF, the trap efficiency increases, when 6 kg of sediment is injected. The rate of trap efficiency with respect to PFDI is higher for lower values of PFLF. In addition, it has been observed that with the increase in PFDI, the trap efficiency increases.

Table 5. Variation of Trap efficiency with PFDI for PFLF = 0.5 and PFLF = 0.33, when 6 kg of sediment was injected

PFDI	Trap Efficiency (%) for PFLF = 0.5	Trap Efficiency (%) for PFLF = 0.33
0.8	1.47	1.52
1.6	1.65	1.7

It has been observed from the result summarised in Table 6 and graph displayed in Figure 12 (c) that the trap efficiency is higher when PFLF = 0.33 than PFLF = 0.5 which means with the decrease in the PFLF, the trap efficiency increases, when 3 kg of sediment is injected. The rate of trap efficiency with respect to PFDI is higher for lower values of PFLF. In addition, it has been observed that with the increase in PFDI, the trap efficiency increases. From Figure 12 (b-c), it is observed that trap efficiency decreases with increase in PFLF i.e., trap efficiency is inversely proportional to PFLF. The trap efficiency is more when 6 kg of sediment was injected compared to 3 kg sediment, i.e., trap efficiency increases with the increase in sediment concentration.

Table 6. Variation of Trap efficiency with PFDI for PFLF = 0.5 and PFLF = 0.33, when 3 kg of sediment was injected

PFDI	Trap Efficiency (%) for PFLF = 0.5	Trap Efficiency (%)for PFLF = 0.33
0.8	1.19	1.25
1.6	1.47	1.48

It has been observed from the result summarised in Table 7 and graph displayed in Figure 12 (d) that the trap efficiency is higher when 6 kg of sediment is injected than 3 kg sediment which means with the increase in the sediment concentration, the trap efficiency increases for PFLF = 0.5. The rate of trap efficiency with respect to PFDI is higher for higher values of sediment. In addition, it has been observed that with the increase in PFDI, the trap efficiency increases.

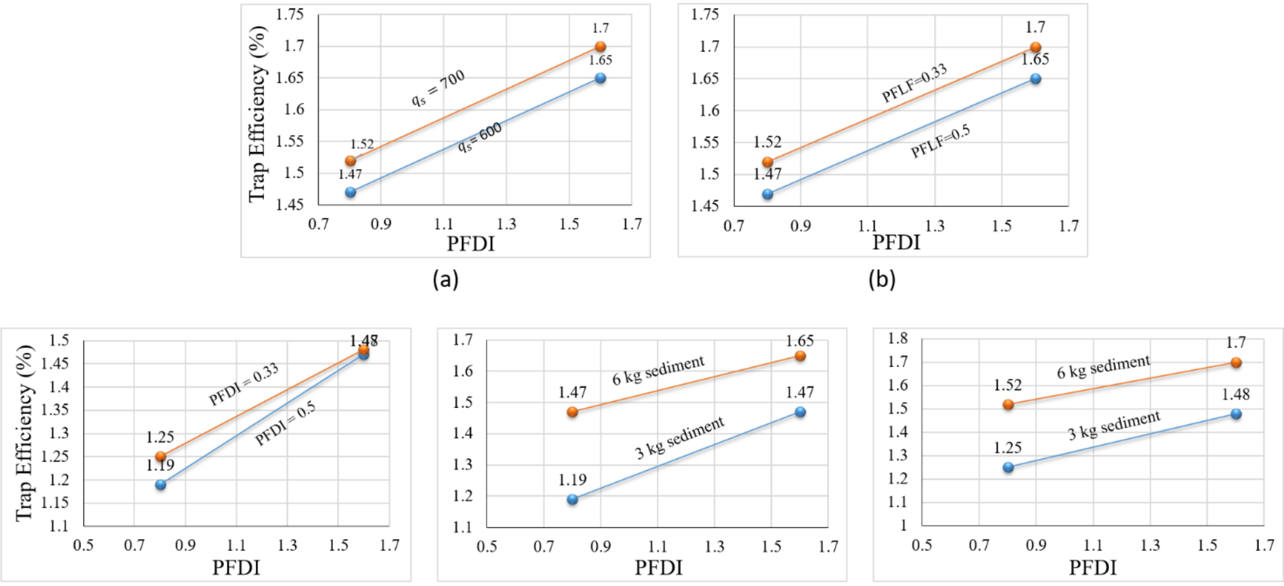
Table 7. Variation of Trap efficiency with PFDI for PFLF = 0.5, when 3 kg and 6 kg of sediment was injected

PFDI	Trap Efficiency (%), when 3 kg sediment was injected	Trap Efficiency (%) when 6 kg sediment was injected
0.8	1.19	1.47
1.6	1.47	1.65

It has been observed from the result summarised in Table 8 and graph displayed in Figure 12 (e) that the trap efficiency is higher when 6 kg of sediment is injected than 3 kg sediment which means with the increase in the sediment concentration, the trap efficiency increases for PFLF = 0.33. The rate of trap efficiency with respect to PFDI is higher for higher values of sediment. In addition, it has been observed that with the increase in PFDI, the trap efficiency increases. From Figure 12 (d-e), it is observed that trap efficiency increases with increase in amount of sediment injected i.e., trap efficiency is directly proportional to amount of sediment injected. The trap efficiency is more when PFLF = 0.33 compared to PFLF = 0.5, i.e., trap efficiency decreases with the increase in PFLF.

Table 8. PFDI versus Trap efficiency for PFLF = 0.33, when 3 kg and 6 kg of sediment was injected

PFDI	Trap Efficiency (%) when 3 kg sediment was injected	Trap Efficiency (%) when 6 kg sediment was injected
0.8	1.25	1.52
1.6	1.48	1.7



(a) (b)

(c) (d) (e)

Figure 12. Variation of Trap efficiency with; (a) PFDI when PFSI = 0.20, (b) PFDI when 6 kg of sediment is injected, (c) PFDI when 3 kg of sediment is injected, (d) PFDI when PFLF = 0.5, (e) PFDI when PFLF = 0.33

6. CONCLUSIONS

The findings of this research indicate that porcupine structures, independent of their specific geometric configurations, reliably encourage sediment deposition by diminishing flow velocity. This confirms their wider relevance as practical river-training interventions. The study further suggests that mild steel-rod porcupine units, being lightweight and modular, represent a cost-effective and feasible option for riverbed and bank stabilization, particularly in areas where traditional engineering measures are difficult to construct. Their straightforward fabrication and installation—requiring minimal labour and no specialized skills—also make them suitable for broader deployment in remote or resource-limited regions.

In addition, the results establish fundamental performance trends for porcupine systems. Their sediment-trapping capability increases with higher sediment input, demonstrating the responsive nature of these permeable structures in rivers with substantial sediment loads. Conversely, the decline in trap efficiency with greater Porcupine Field Length Factor (PFLF) offers a generalized design insight that can help refine porcupine arrangements for different channel conditions. Moreover, the findings show that trap efficiency declines with increasing PFVI, while PFVI reduces as sediment concentration rises, highlighting the interconnected influence of flow velocity and sediment load on system performance. Overall, the outcomes advance the understanding of permeable river-training devices and underscore the potential of porcupine systems as adaptable and low-cost tools for sediment control and stabilization of riverbed as well as riverbank in alluvial rivers.

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Competing interests

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Author contributions

Anwesha Gayan: Material preparation, data collection, analysis and interpretation of results, and manuscript preparation. *Dr. Bipul Talukdar*: Interpretation of result and overall supervision.

REFERENCES

Aamir, M. and Sharma, N., 2014. Sediment trap efficiency of porcupine systems for riverbank protection. In Proceedings of 19th International Conference on Hydraulics, Water Resources, Coastal and Environmental Engineering (ISH-HYDRO 2014), 18-20 December, 2014, pp 688-698, Bhopal, India.

Aamir, M. and Sharma, N., 2015. Riverbank protection with Porcupine systems: development of rational design methodology. ISH Journal of Hydraulic Engineering, 21(3): 317-332. https://doi.org/10.1080/09715010.2015.1029544

Barman, R. and Kalita, G., 2018. River Bank Protection with Porcupine and Groynes System.

Barman, R. and Talukdar, B., 2025. Experimental investigation of deltoid structures for improved sediment deposition. ISH Journal of Hydraulic Engineering, 31(4): 673–685. https://doi.org/10.1080/09715010.2025.2514578

Board, B., 2012. Protection of Majuli Island from Floods and erosion. Guwahati, May.

Garde, R.J. and Raju, K.R., 2000. Mechanics of sediment transportation and alluvial stream problems. Taylor & Francis.

Gayan A. and Talukdar T., 2018. Porcupine as Pro-siltation Measure in Alluvial Rivers. In proceedings of Civil Engineering for Sustainable Development-Opportunities and Challenges (CESDOC), 18-19 December, 2018, pp. 253-257.

Handique, A., Sarma, A.K., Ahmed, J.A., Medhi, S., Konwar, D. and Bhattacharjya, R.K., 2024. Evaluating the impact of porcupine systems in the flow field of the river: a hydrodynamic model study. ISH Journal of Hydraulic Engineering, 30(4): 454-463. https://doi.org/10.1080/09715010.2024.2364827

Kakati, R., Chembolu, V. and Dutta, S., 2022. Experimental and numerical investigation of hybrid river training works using OpenFOAM. Water Resources Management, 36(8): 2847-2863. https://doi.org/10.1007/s11269-022-03181-6

Kalita, S., 2017. A Comprehensive Study on the Sediment Trapping Efficiencies of Various Riparian and Aquatic Vegetations on Open Channel flow Environment. In HYDRO-2017, In Proceedings of 22nd International conference on Hydraulics, Water Resources and Coastal Engineering. LD College of Engineering, Ahmedabad, 21-23 December, 2017.

Sarker, M.H., Akter, J. and Ruknul, M., 2011, May. River bank protection measures in the Brahmaputra-Jamuna River: Bangladesh experience. In International seminar on River, society and sustainable development, Dibrugarh University, India (Vol. 121, pp. 1-14), 26-29 May, 2011.

Sharma N. and Anupama, N., 2015. Paper 173-RCC Jack Jetty and Bamboo Submerged Vanes Application for Navigation Fairway in Ganga River of India. “SMART RIVERS 2015” Buenos Aires, Argentina, 7-11 September 2015.

Shriwastava, A. and Sharma, N., 2014. Investigation of RCC Jack Jetty as a cost effective river training structure. In International Conference on Agricultural, Environmental and Biological Sciences, AEBS-2014. Phuket, Thailand (pp. 42-46), 24-25 April, 2014.