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Emperical Correllation of Hydraullic Characteristics of Ikpa River Akwa Ibom State Nigeria

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ABSTRACT: *The study examined the hydraulic properties of the of IKPA river and and its impact on sediment transport. Measurements such as depths of the river, Top width, discharges were measured along the stretch of the river. The cross section of the river was divided with ranging poles with maximum distance of 4m apart. The maximum velocity of the river was 0.94m/s while the minimum velocity of 0m/s was recorded in the cross-section of the rivers. The maximum velocity of the river was recorded at the second vertical and the minimum velocity was recorded at the banks of the river and also on the bed of the river. The regression analysis of the velocity profile against depth at different stages showed a quadratic relationship between the velocity and depth of the river with R^2 value of 0.962 which occurred at the 3rd vertical, of stage 2.2m. The highest discharge recorded at the stages of the river was 9.79m^3/s which occurred at stage 3.28m. Regression analysis of the average depth against the discharge showed a power function relation which a maximum R^2 value of 0.90. Results showed that the maximum discharge of the river recorded was 33.71m3/s at the velocity of 0.67m/s and at the depth of 1.73m from the bed of the river.*

KEYWORDS: discharge, verticals, stages, river, regression analysis, velocity.

INTRRODUCTION

River studies are multidisciplinary, but the two most prominent areas are hydrology and hydraulics. Hydrology treats the occurrence, distribution, movement, and properties of the waters of the earth and their relationship with the environment within each phase of the eater cycle (USGS, 2012). Hydraulics applies engineering science to the practical problems of collecting, storing, measuring transporting, controlling, and using water and other fluids (Salterfield, 2010). River studies find application in water supply management, coastal protection, evaluation of the stability of channel bed and marine structures, river training, and flood control.

The term hydraulic characteristics of rivers refers to the processes of water and sediment movement in a natural channel and the physical factors related to them. Such parameters include flow depth and type, flow velocity, wetted perimeter, water surface width, channel roughness and slope, channel alignment, and catchment area. From river studies, the discharge through a section of a river has been found to be related to the water level, while the net mass rate at which sediments leave and enter the flow over the bed at a cross section, referred to as entrainment, is said to be related to a ratio of shear force exerted by the water on the grains to gravity force. This ratio is called entrainment function or Shield's parameter, after Shield who originated it (Reeve and others, 2004).

Methods of field measurement are as varied as there are prediction models. An eminent scholar in the field of sediment transport was Hans Albert Einstein, son of the founder of the Theory of Relativity, Albert Einstein (Olsen, 2007). It is reported that when Hans told his father that his research was on sediment transport, senior Einstein replied that he also thought of it when he was young, but he considered it too difficult.

In Nigeria, studies on the hydraulic characteristics of rivers have been done by NEDECO on River Niger and Benue in 1959 (Jansen and others, 1979) and on the south west Nigeria Omi River (Adegbola and Olaniyan, 2012). Outside Nigeria, work has been done on numerous rivers across the world such as the East Fork River in the United States (Leopold and Emmet, 1976), Amurang River Estuary in Malaysia (Tendean and others, 2012), and Tapi River in India (Yadav and Samtani, 2008), among others. This work applies some existing models to study the hydraulic characteristics of Ikpa River in south eastern Nigeria.

MATERIALS AND METHODS

Study Area

The study area is along a reach of Ikpa River in south eastern Nigeria. The river has its source in lbiono Ibom Local Government Area of Akwa Ibom State and passes through the state capital and four other local government areas before discharging into the Cross River at Oron close to the Cross River estuary with the Atlantic Ocean. Onuoha and others (2010) published results of studies on the biodiversity of the Ikpa River drainage basin. They gave the channel length of the river as 52.5 kilometers and the catchment area as 516.5 square kilometers out of which 76.5 square kilometers or 15% of the area is subjected to annual flooding. However, Udose'n (2009) who wrote on effects of gully erosion in coastal areas of South Eastern Nigeria estimated the drainage area as 413 square kilometers. Ojha and others (2008) noted that the water divide may not always be the same for surface and groundwater. So there might be some degree of error in all estimates.

Data Collection

This study was undertaken to determine the hydraulics characteristics of the south eastern Nigeria river, Ikpa. The hydraulics features and the required data to be gathered for analysis will include:

a. Discharge - The required data for this include flow depths, flow velocities, geometry of cross sections and slope of the energy line for determining Manning's coefficient.
b. Depth - This requires the use of echo sounder to obtain the depth
c. Velocity - velocity meter was used to obtain velocity across the cross-section of the river
d. Viscosity which requires Reynolds's number, water density, velocity and grain size.

The data obtained through the field measurements such variables as drag coefficient, Manning's coefficient, in shear stress, shear velocity, Nikuradse grain roughness, k_s, roughness length Z_o, wavelengths and heights, material and water unit weight ,was determined. The data obtained from the level instrument will be reduced and plotted to scale with python software. With the software, the subsection areas and wetted perimeters will be determined.

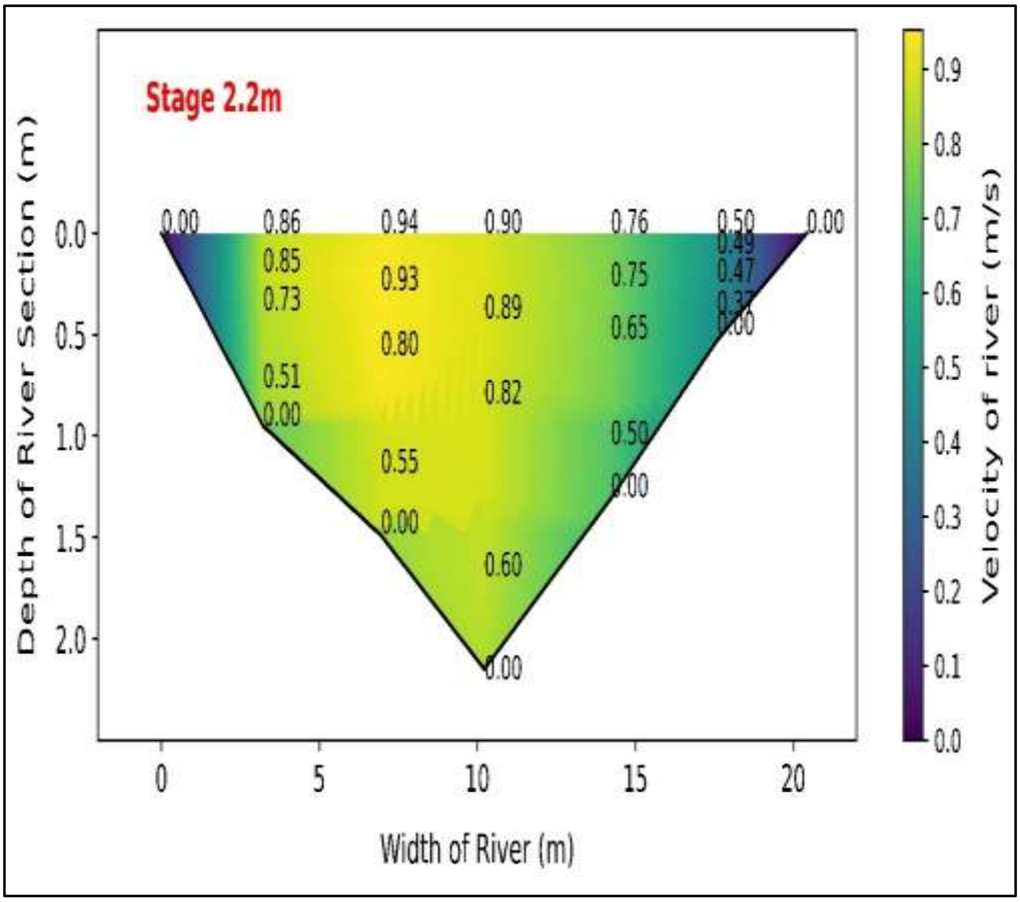
The mean of the eight velocity readings taken at each point on a vertical were plotted on a depth against velocity graph. Spreadsheet Regression analysis will then be used to plot the best fit curve for each vertical. The mean velocity at each subsection and the area is used to obtain the flow and the values for all subsections are added to obtain the overall discharge across the cross section. The mean velocity at a subsection is the average of the values at 0.2 of flow depth and 0.8 of depth.

RESULTS AND DISCUSSION

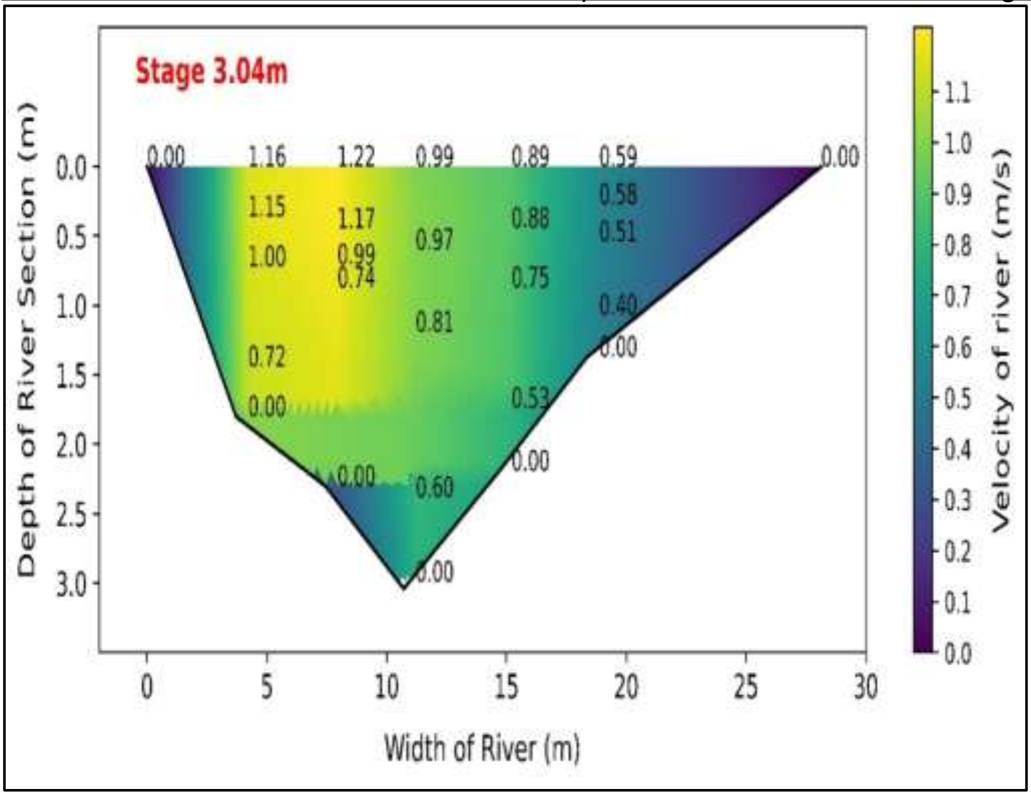
Results

The results shows the velocity profile distribution, regression of the velocity and the depth of the river and the discharge pattern in a cross-section of the river at stages 2.2, 3.04, 2.43, 2.0 and 3.28m

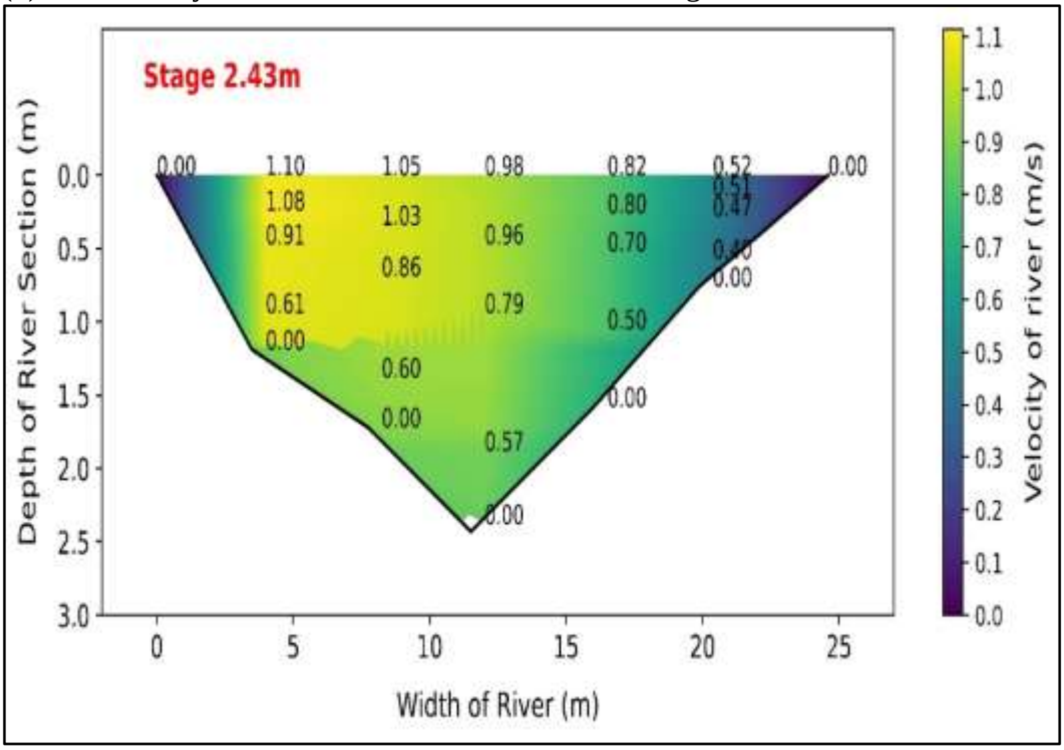
3.1.1 Velocity Profile Distribution



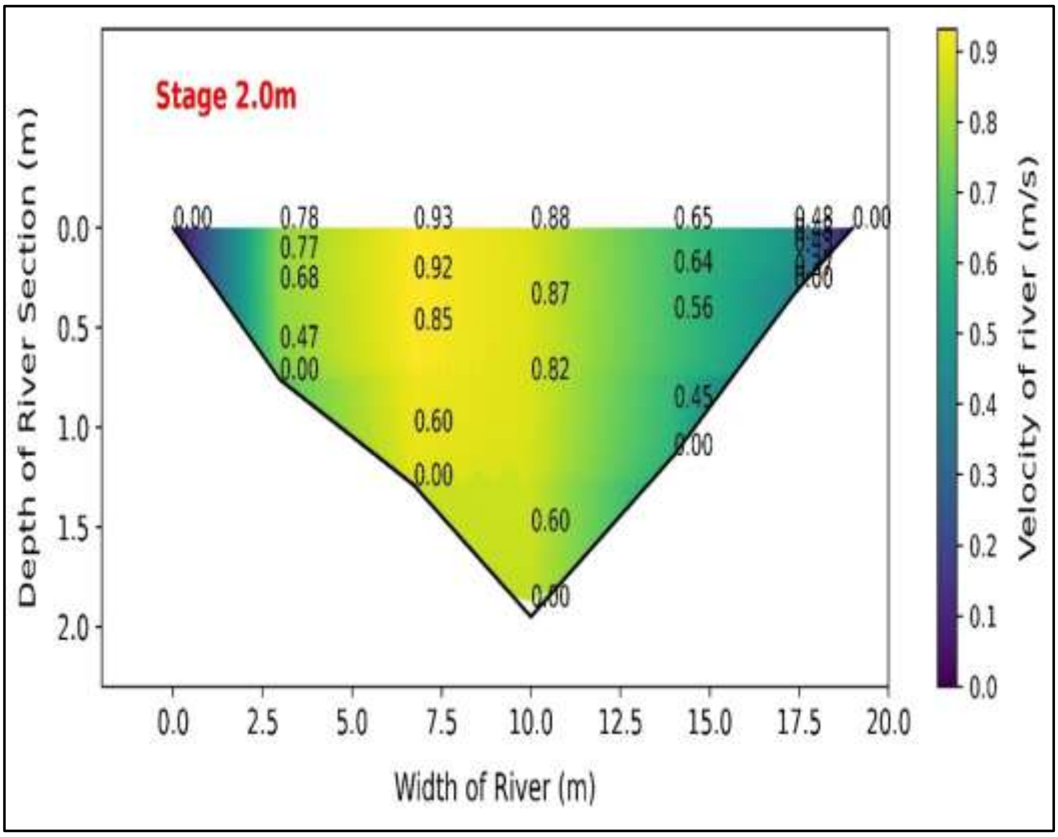
(a) Velocity distribution in the river section at stage 2.2m



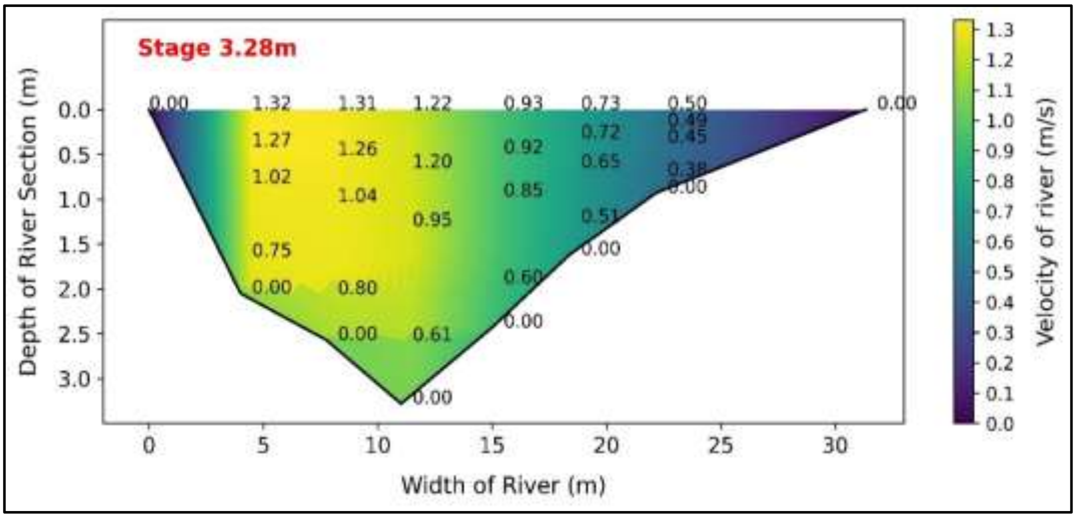
(b) Velocity distribution in the river section at stage 3.04m



(c) Velocity distribution in the river section at stage 2.43m



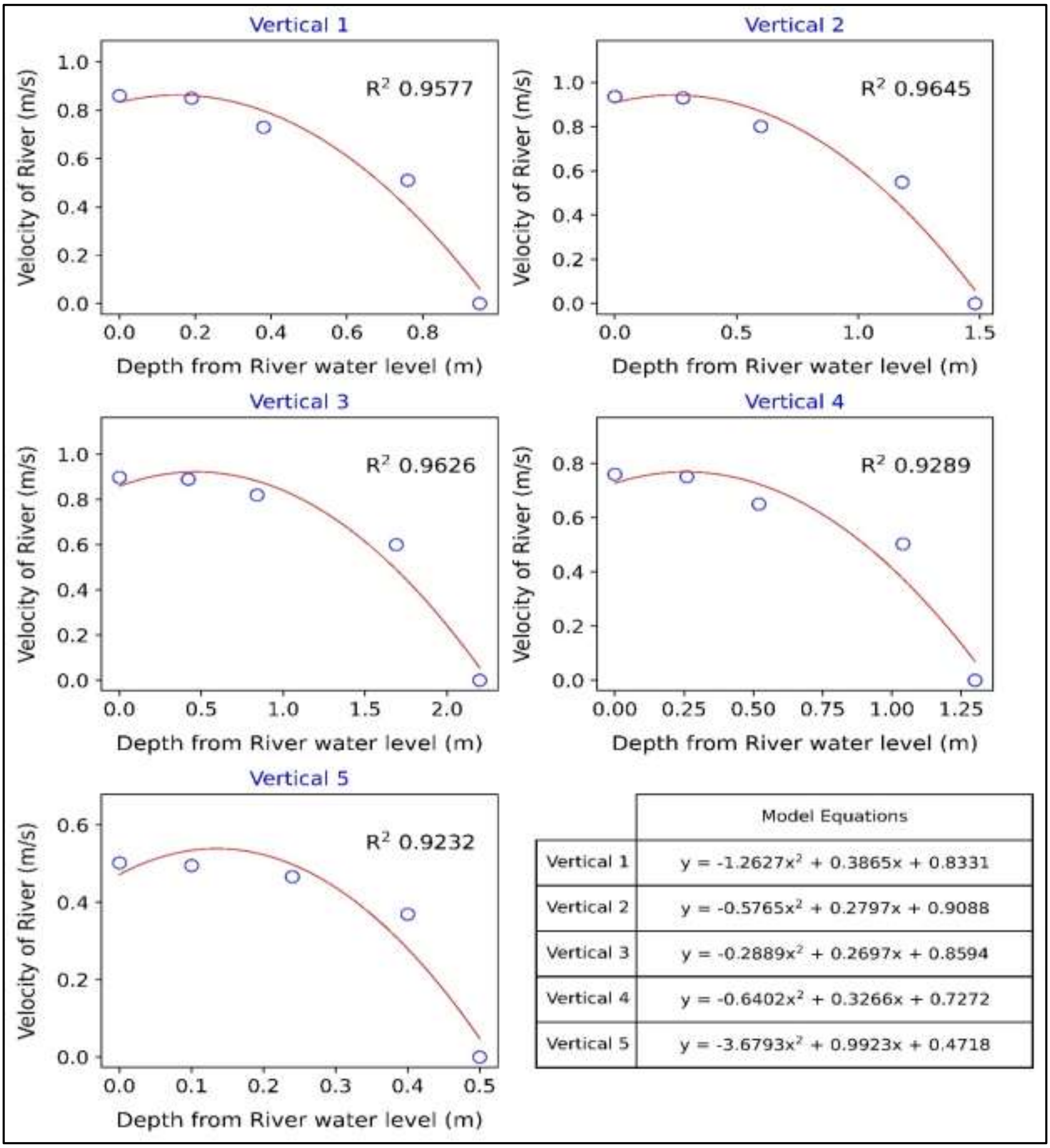
(d) Velocity distribution in the river section at stage 2.0m



(e) Velocity distribution in the river section at stage 3.28m

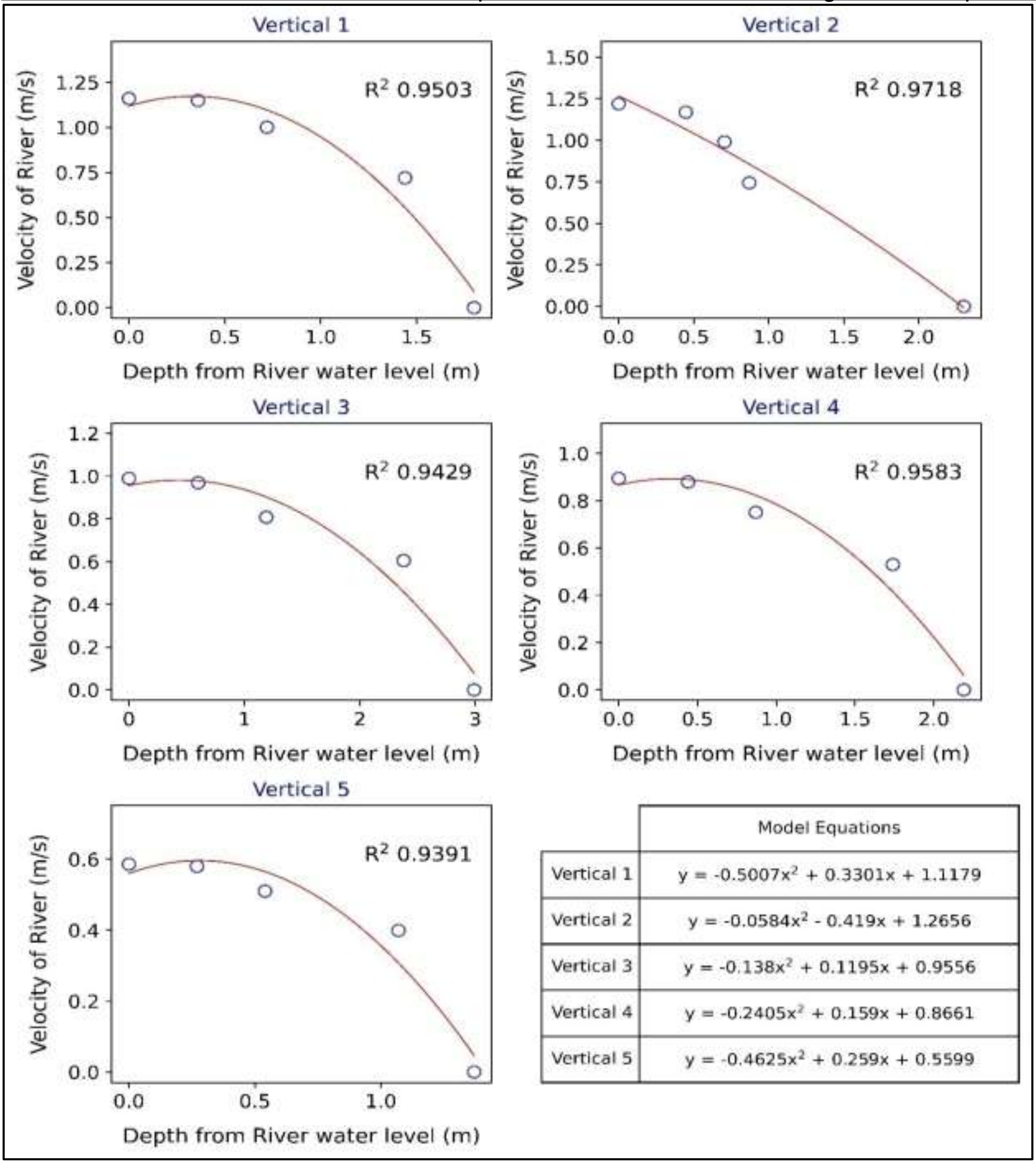
Figure 3.1: Velocity distribution in the river section at respective stages

Regression of the Velocity and the Depth of the River



	Model Equations
Vertical 1	$y = -1.2627x^2 + 0.3865x + 0.8331$
Vertical 2	$y = -0.5765x^2 + 0.2797x + 0.9088$
Vertical 3	$y = -0.2889x^2 + 0.2697x + 0.8594$
Vertical 4	$y = -0.6402x^2 + 0.3266x + 0.7272$
Vertical 5	$y = -3.6793x^2 + 0.9923x + 0.4718$

(a) *Regression of the velocity and the depth of the river at stage 2.2m*



(b) *Regression of the velocity and the depth of the river at stage 3.04*

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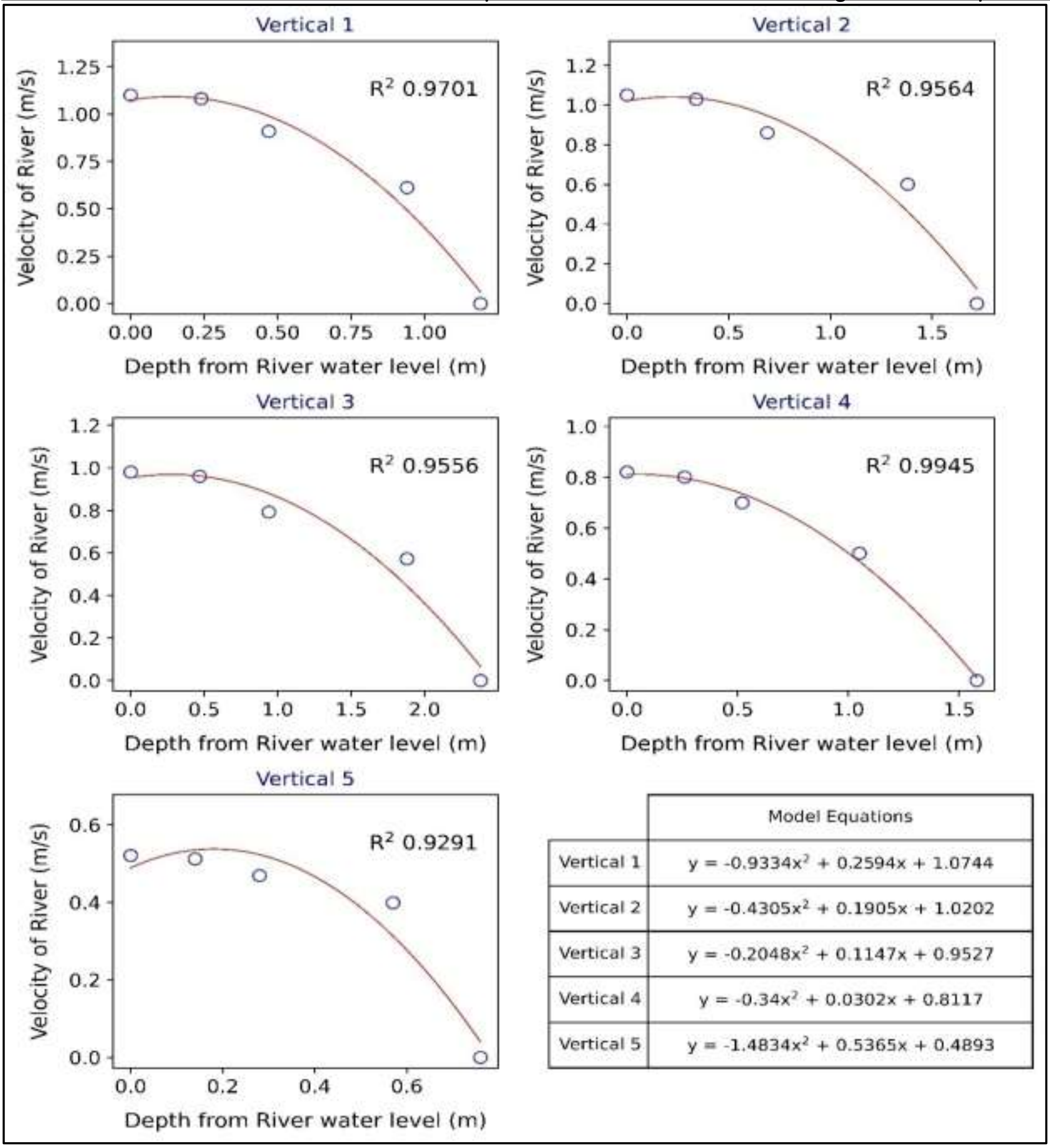
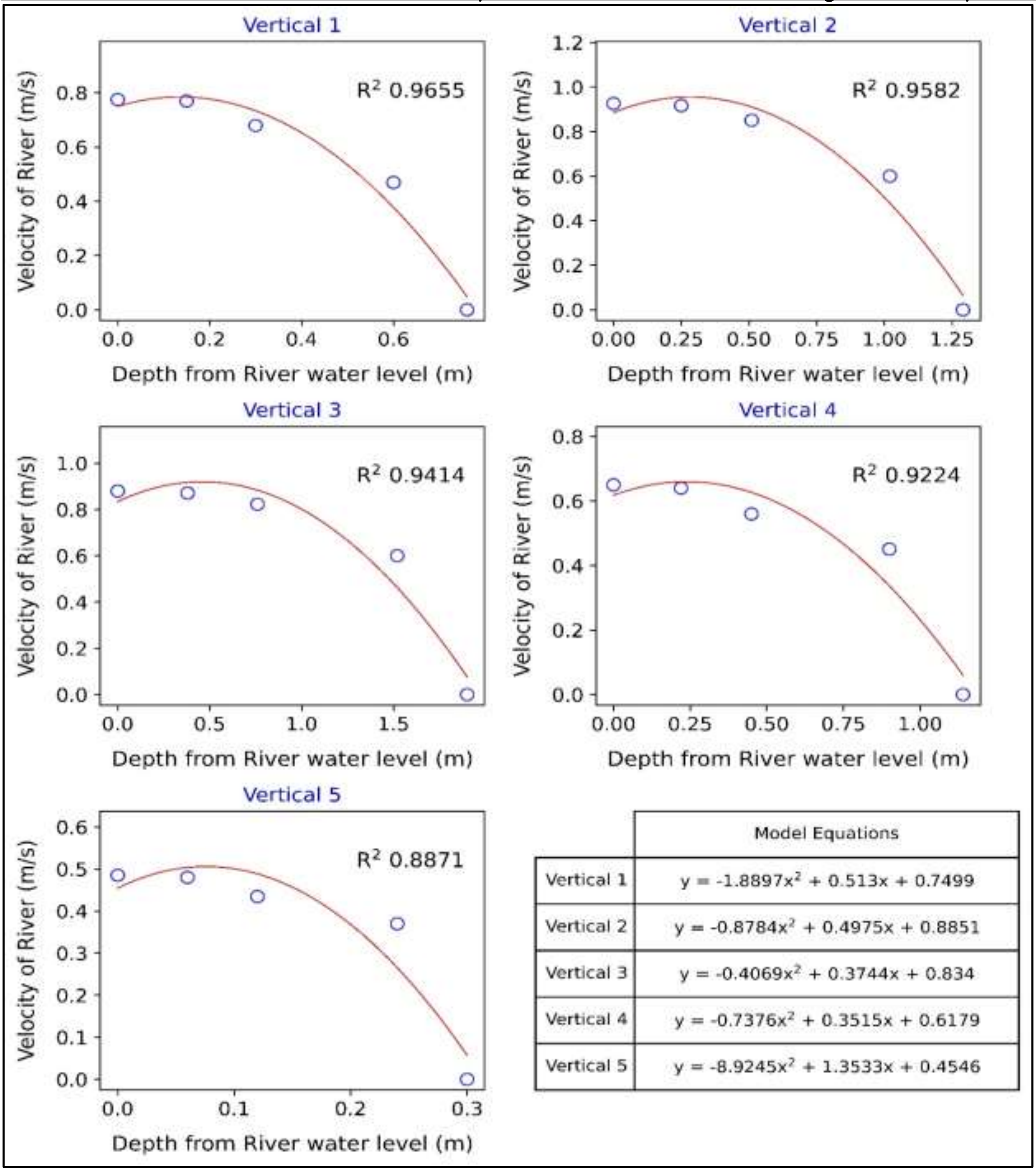
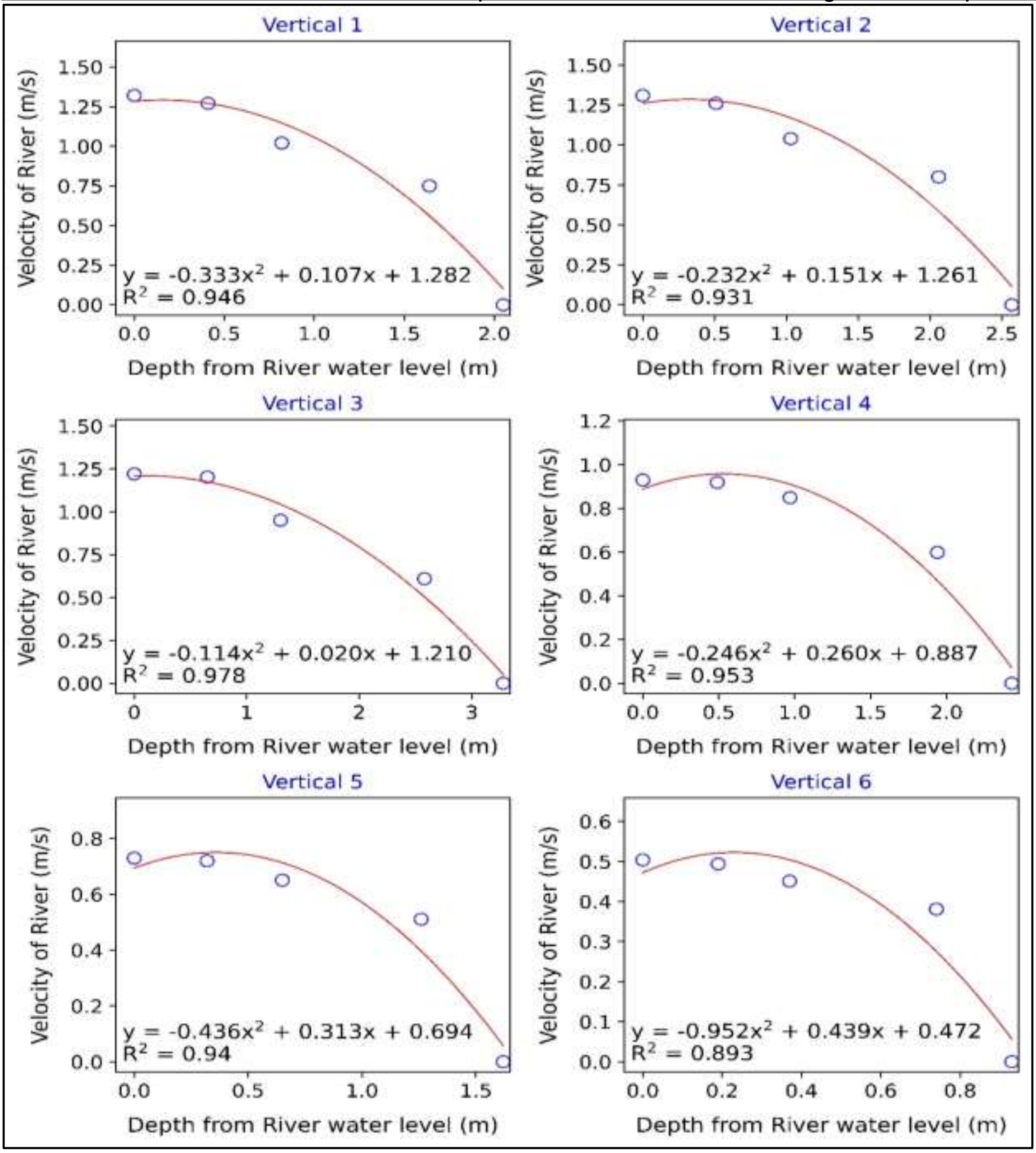


(c) *Regression of the velocity and the depth of the river at stage 2.43m*



	Model Equations
Vertical 1	$y = -1.8897x^2 + 0.513x + 0.7499$
Vertical 2	$y = -0.8784x^2 + 0.4975x + 0.8851$
Vertical 3	$y = -0.4069x^2 + 0.3744x + 0.834$
Vertical 4	$y = -0.7376x^2 + 0.3515x + 0.6179$
Vertical 5	$y = -8.9245x^2 + 1.3533x + 0.4546$

(d) *Regression of the velocity and the depth of the river at stage 2.0m*

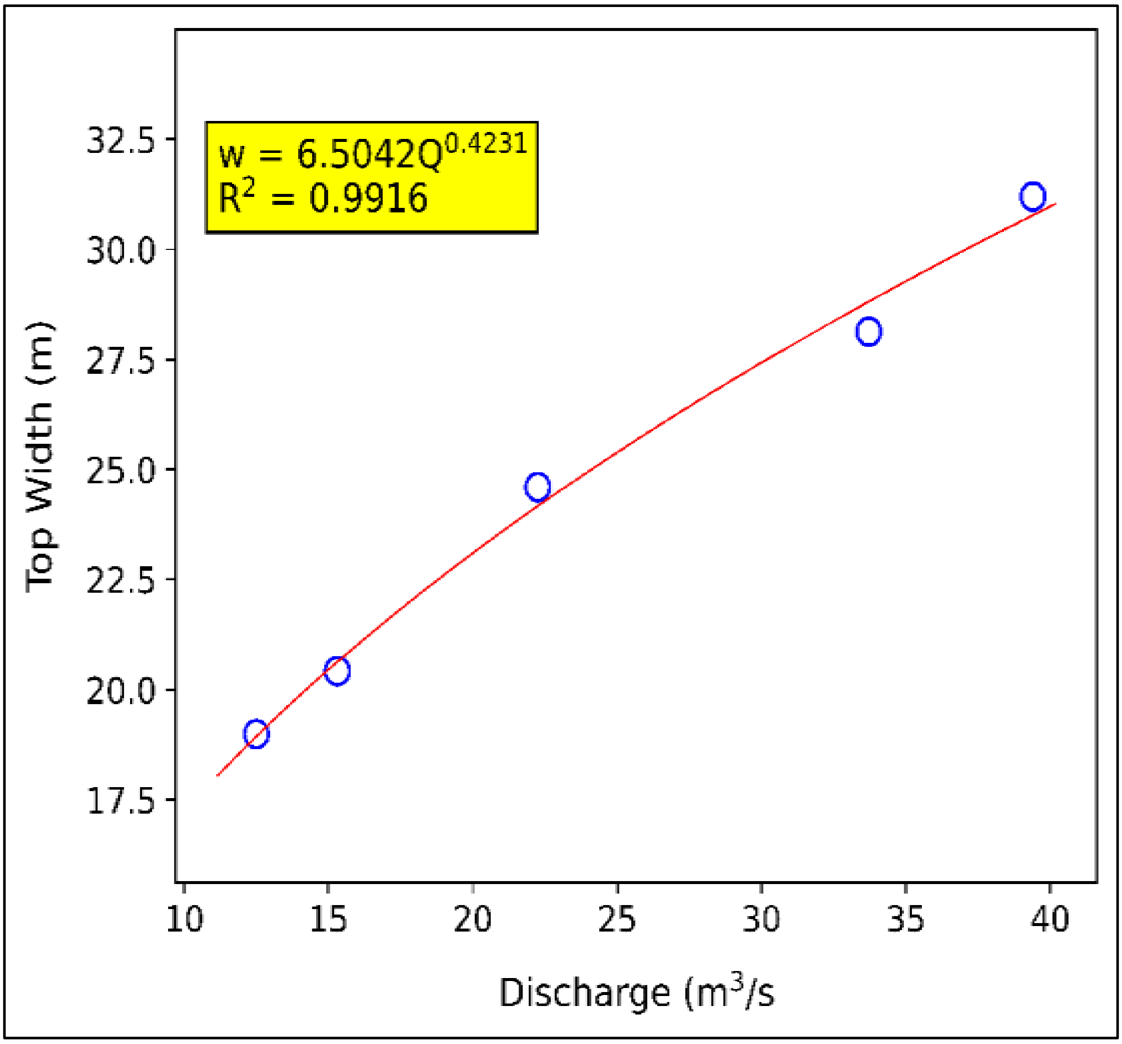


(e) *Regression of the velocity and the depth of the river at stage 3.28m*

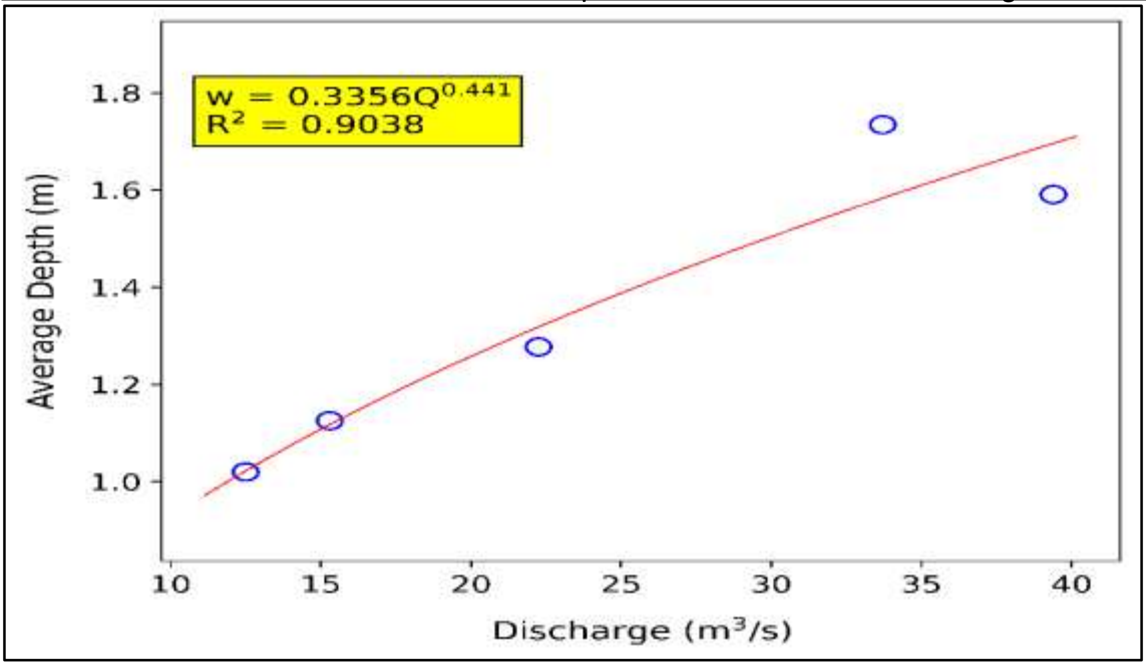
Figure 3.2: Regression Analysis of the Velocity profile against the depth

Table 3.1: Hydraulic Geometry of the River

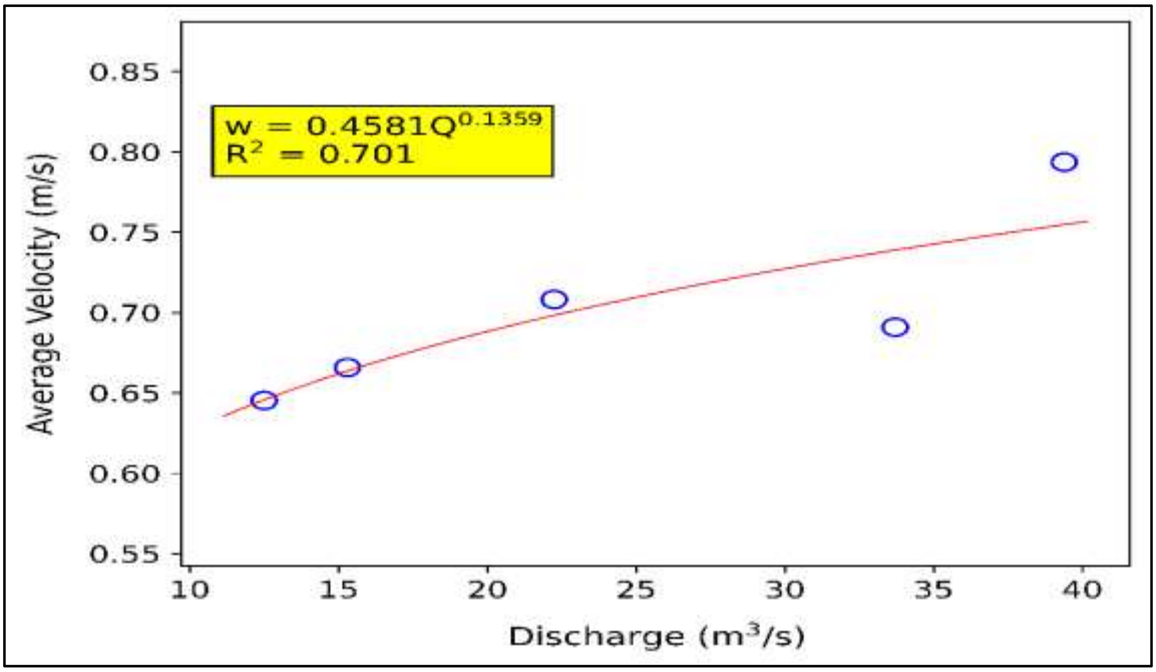
Discharge (m3/s)	Top Width (m)	Area (m2)	Avg. Velocity (m/s)	Avg. Depth (m)	Bed Load (kg/s)
15.30	20.42	22.98	0.67	1.13	0.09
33.71	28.13	48.79	0.69	1.73	0.29
22.25	24.60	31.42	0.71	1.28	0.16
12.50	18.99	19.37	0.65	1.02	0.04
39.39	31.20	49.63	0.79	1.59	0.36



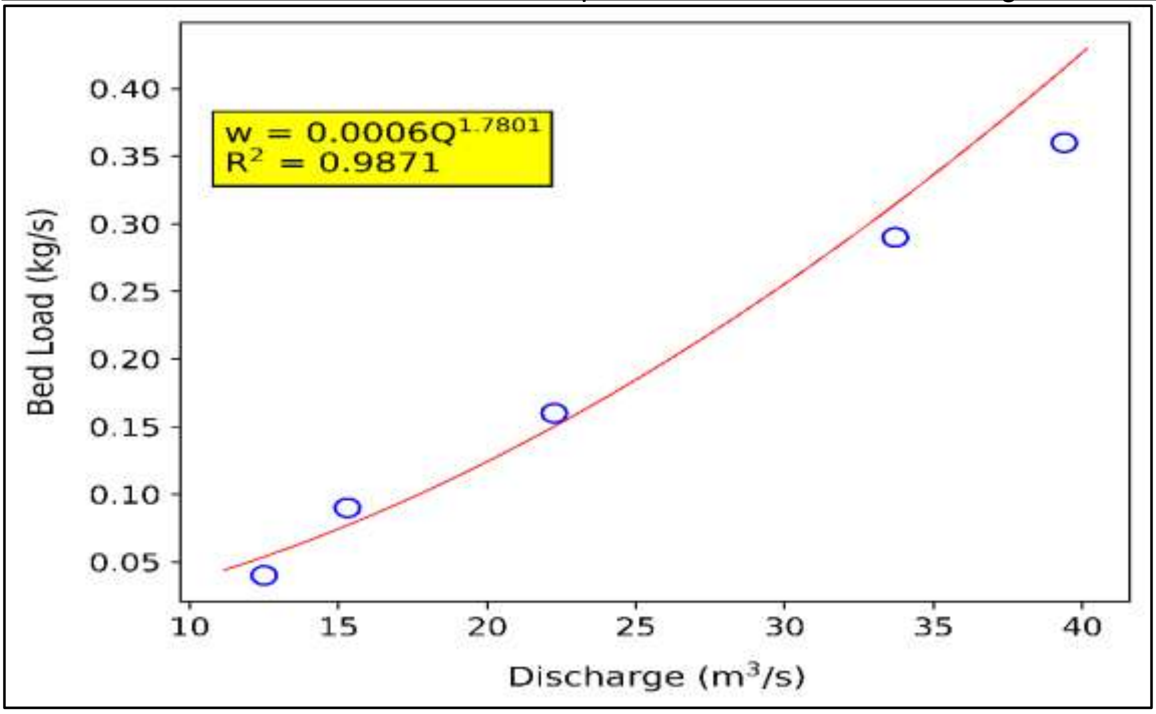
(a) Model of the top width against the discharge of the river



(b) Model of the average depth against the discharge of the river



(c) Model of the average velocity against the discharge of the river



(d) Model of the bed load against the discharge of the river

Figure 3.3 Modeling the Hydraulic Geometry against the Discharge of the River

3.1.3 Modeling the stage against the Discharge of the Rivers

Table 4.2: Discharge of the river at various stages

Stage (m)	Discharge (m3/s)
2.2	15.30
3.04	33.71
2.43	22.25
2.00	12.50
3.28	39.39

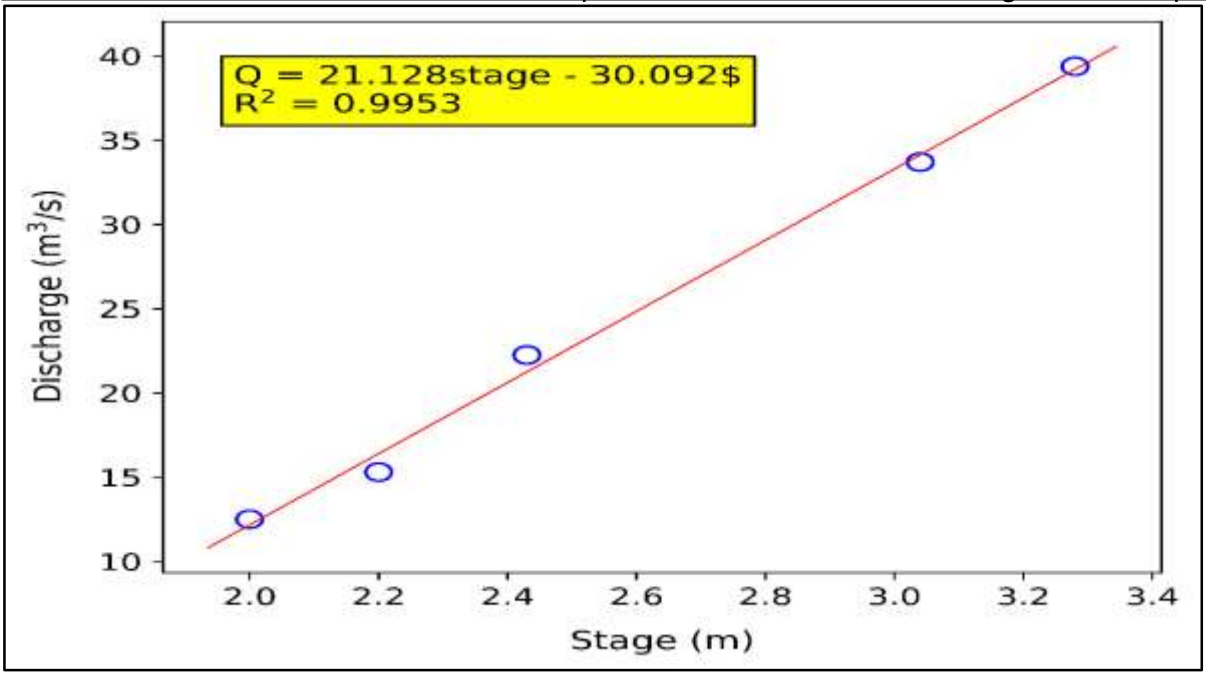


Figure 4.4: *Model of the discharge against stage of the river.*

3.2 Discussions

Figure 4.1 shows the velocity profile distribution at a cross-section of the river at the observed stages. The maximum velocity of the river at stage 2.2m was 0.94m/s while the minimum velocity of 0m/s was recorded in the cross-section of the rivers. The maximum velocity of the river was recorded at the second vertical and the minimum velocity was recorded at the banks of the river and also on the bed of the river. The result from Figure 4.2 showed a correlation coefficient of 0.995 at vertical 4 of stage 2.43m indicating an exponential increase in velocity with the depth of the river while in Figure 4.3 and 4.4, the maximum discharge of the river was recorded close to the bank of the river at stage 3.28m.

CONCLUSION

From the results of the study of the hydraulic characteristics of Ikpa River in south eastern Nigeria, the flow through the channel at the study area is hydraulically rough and the flow resistance was not only as a result of grain roughness, but combined the effect of bed forms and grains friction. Finally, the hydraulic characteristics of the river form an inter-reliant system as evident in the relationship between flow width, depth and velocity with discharge and the way they react in unity to changes in discharge thereby shaping the cross section.

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