LONG TERM TREND OF RIPARIAN VEGETATION DYNAMICS IN DOWNSTREAM REACH OF THE TENRYU RIVER

Nagoya University, Student Member,○Deen Islam
Nagoya University, Regular Member, Yuji Toda
Nagoya University, Fellow Member, Tetsuro Tsujimoto

INTRODUCTION

Understanding the hydraulics of riparian vegetation is important to river flow, sediment transport and river morphology. From the flood control view, riparian vegetation is an important factor as it retards flood discharge capacity and increase the river stage during flood. In Japanese rivers, many dams were constructed from the 1950's to the 1980's in order to control flooding, to generate hydro-electric power and other efficient use of water resources. Due to that the channel in the downstream of the dam has reduced the regenerative capacity and the sediment supply to the downstream decreased which results bed degradation, expansion of vegetation cover, plant species transition and the ecosystem degradation. Among them, the change of vegetation cover is more detrimental which has been focused in this research article.

VEGETATION COVER CHANGE

The flood over 6000 m^3/s has often happened to 1976, percentage of vegetation cover is under 10% and about 50~70% of all the vegetation area exchange with invasion and destruction. In 1981, flood flow of 5500 m^3/s are one time with other below 3000 m^3/s and therefore the vegetation has expanded largely. In 1990 the herb limits are large to the period 1996 increase the highest. When it enters into 2000 age, percentage of vegetation cover has stabilized as the whole, but transition to the woody plant occurs from the herb, the woody plant limits have increased from about 8% to 13% (Fig 1).

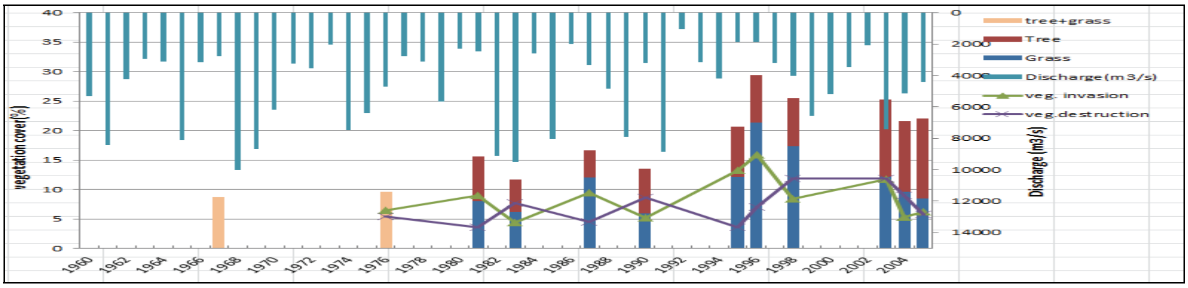


Fig. 1 Yearly maximum discharge of average daily flow (m^3/sec) from 1960 to 2004(up). Tree and grass type vegetation shows in a same bar whereas vegetation invasion or destruction shows by line diagram

In 1981, vegetation largely invades with 14 km, and 19~20 km from river mouth (Fig 2a) and 19~21 km from river mouth has more destruction in 1983 (Fig 2b). In 1995, 12~17 km shows large invasion (Fig. 2c) and it continues until 1996 (Fig 2d). After that in 1998(Fig 2e), destruction has more prominent feature with 15~20 km from river mouth shows more destructions. No big flood observed in the year of 1996~1998 but vegetation destruction has occurred with the section where the vegetation invaded the preceding year largely. But small scale flood below 3000 m^3/s occurred several times in that period. Therefore, flood frequency produces the effect on the vegetation destruction and invasion. In the average of all period (Fig. 2f), invasion is large with 12~20 km and the destruction is large in 16~20 km. On the other hand, 9~11 km both are small but together these values are large which means that exchange of vegetation is active.

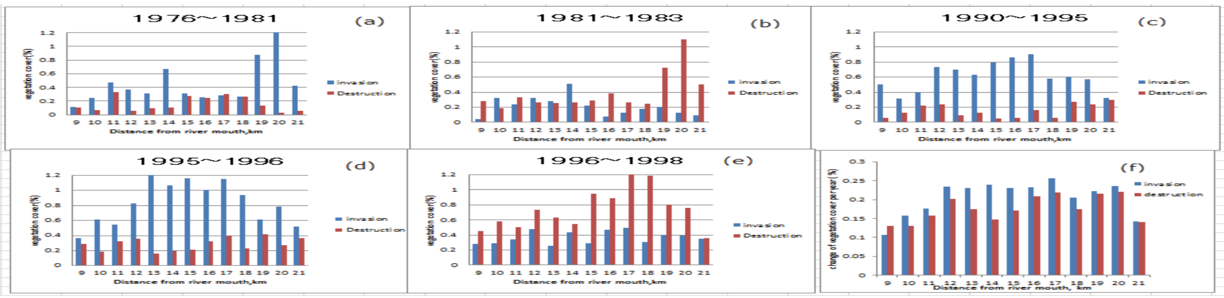
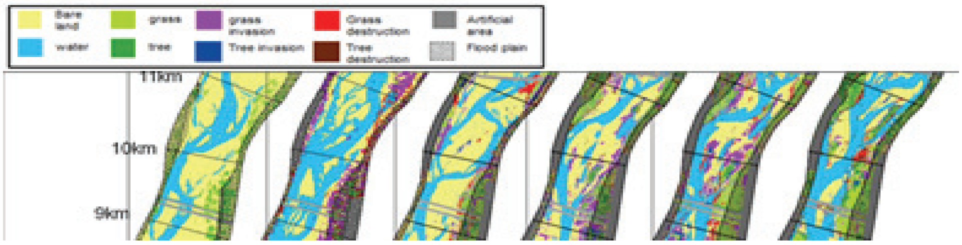


Fig. 2 Spatial distribution of vegetation invasion and destruction ratio in every km starting from 9 km to 21 km of Tenryu river mouth

Hydraulic Engg. Lab,Nagoya Univeristy,Furo-cho,Chikusa-ku,Nagoya 464-8603,email:deenislam@civil.nagoya-u.ac.jp

In the sixties before dam construction the river bed is characterized by sand bar and less vegetation. After dam construction to the eighties more vegetation is invaded and flood plain has expanded (Fig.3).

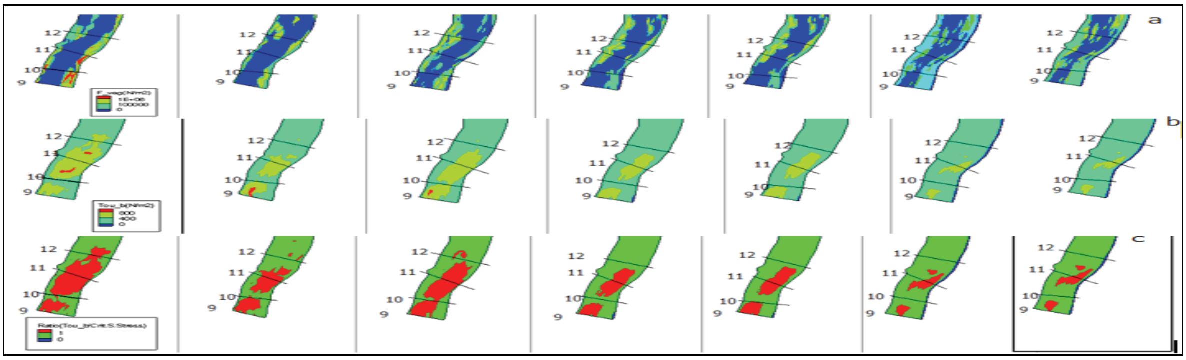


1967 1976 1981 1995 1996 2003

Fig. 3 Temporal change of vegetation and flood plain in Tenryu river downstream from 9 km to 11 km of river mouth

TWO DIMENSIONAL FLOW ANALYSIS

Two dimensional flood flow analysis using a curvilinear coordinate system have been used. The Manning's roughness law is used to determine the bottom friction (Toda et. al 2005). The drag force is determined by Ikeda and Izuami (1990).



1961 1974 1982 1991 1999 2003 2007

Fig. 4 Drag force due to vegetation (a), bed shear stress (b) and ratio of bed shear stress and critical shear stress with grain diameter, d_{90} (c) for different flood flow of 9 to 12 km from the river mouth

Fig. 4a indicates very high value of drag force variation and thus is difficult to express the washout condition of vegetation. The range of critical shear stress for Japanese vegetation lies between 58-110 N/m^2 (Tanaka and Yagisawa, 2009) which can be identified from Fig 4b. As the velocity and shear stress decrease inside a vegetated area (Kouwen and Unny, 1973), the apparent critical shear stress for washing out plants increases. The depth-averaged equation does not consider the difference between the flow velocity over the plants and through the vegetated zone. The difference increases as the flow passes through the vegetation. In Fig. 4c the ratio >1 indicates that the designed particle size is likely to be moved. Thus the river bed is active in this section which is responsible for vegetation destruction.

CONCLUSION

Tenryu Kawasita drainage basin was the rivers which almost do not have the vegetation in the downstream section to the seventies, but, first vegetation enlargement happened to the eighties, enlargement of the vegetation limits advanced due to the fact that the herb whose growth rate is fast in the nineties expands at a stroke. Among the parameters bed shear stress, drag of vegetation and ratio of bed shear stress and critical shear stress, the ratio of bed shear stress and critical shear stress with particle diameter (d_{90}) is found to predict the washout condition of vegetation accurately then others.

REFERENCES

Ikeda, S., Izumi, N., and Ito, R.: Effects of pile dikes on flow retardation and sediment transport. Journal of Hydraulic Engg., 117-11,1991, pp. 1459–1478.

Kouwen, N., and Unny, T.: Flexible roughness in open channels, Journal of Hydraulics division, 99, 1973, pp.713-728.

Tanaka, N., and Yagisawa, J.: Effects of tree characteristics and substrate condition on critical breaking moment of trees due to heavy flooding, Landscape and Ecological Engineering, 5-1, 2009, pp.59-70.

Toda,Y., Ikeda, S., Kumagai, K., and Asano, T.: Effects of Flood Flow on Flood Plain Soil and Riparian Vegetation in a Gravel River. Journal of Hydraulic Engg, 131-11, 2005, pp. 950-960.