Book of Extended Abstracts
41st IAHR World Congress
22-27 June 2025
Singapore

CHARACTERISTICS OF SEDIMENT TRANSPORT IN HAN-GANG RIVER, KOREA

Doeon Kim[1], Changseong Kim[2], Sung-Uk Choi[3]

[1,3] Yonsei University, Republic of Korea
email : ehdjs1215@yonsei.ac.krr
email : schoi@yonsei.ac.kr

[2] Korea Institute of Hydrological Survey, Republic of Korea
email: csckim@kihs.re.kr

ABSTRACT

Korean rivers are relatively steep and have a high ratio of maximum and minimum discharges. Moreover, high flows are concentrated in the summer, the rainy season. This makes the prediction of sediment transport in Korean rivers very complicated. This study presents the characteristics of the total sediment load in the Han-gang River, Korea. The total sediment load data collected in the period of 2006-2019 by Korea Institute of Hydrological Survey are used. First, the relationships between the total sediment load and discharge are presented by year. Then the formula that best-fits to the data, is proposed to predict the total sediment load among existing formulas. This study will be useful for predicting the sediment transport in rivers, which will be more important due to climate change.

Keywords: sediment transport; bed sediment; total sediment load; discharge versus total sediment load

Introduction

In Korea, two-thirds of the annual rainfall occurs in the rainy season. Except during the rainy season, sediment transport in Korean rivers is known to be ignorable. That is, a significant amount of sediment transport in rivers in Korea occurs especially during floods, and the mode of sediment transport during floods is suspended sediment (Seo et al., 1996). This is mainly due to the rainfall pattern and the geomorphological characteristics of rivers in Korea.

In general, sediment transport in rivers leads to morphodynamic change, including morphological change (or bed elevation change in 1d sense) and change in bed sediment. Sediment transport results in aggradation or degradation, affecting the carrying capacity of rivers, the safety of instream installations, and the health of physical habitats for aquatic animals. It also affects aquatic plants, that is, the recruitment and succession of riparian vegetation, which, in turn, provides drag force to the river flow. Therefore, accurate prediction of sediment load in rivers is crucial to effective river management.

Choi and Lee (2015a) calculated the total sediment load in rivers using the Lateral Distribution Method. They used the Meyer-Peter and Muller formula and Rouse distribution for the bedload and suspended load transports, respectively. The proposed method was applied to Danube River in Slovakia and the Han-gang River in Korea, which are gravel-bed and sand-bed rivers, respectively. Choi and Lee (2015b) used the Lateral Distribution Method to estimate the total sediment load in the Han-gang River, Geum-gang River, and Nakdong-gang River in Korea. For the total load formula, Engelund-Hansen’s, Ackers-White’s, Yang’s, Brownlie’s, and Karim’s formulas were used. They discussed the applicability of the proposed method by comparing the results with those from conventional one-dimensional calculations. Using field measurement data, Jang and Ji (2021) investigated the characteristics of sediment load in South Korean Rivers. They found that the sediment transports in tributaries are more extensive than those in the main streams.

Previous studies on the characteristics of sediment load in rivers in Korea are rare. This is due to the topographic and climatic characteristics of Korea. That is, Korean rivers are relatively steep and have a high ratio of maximum and minimum flows. In addition, high flows are concentrated in the rainy season from June to August. The purpose of the present study is to investigate the characteristics of sediment transport in the Han-gang River, Korea based on the data collected in 2006-2019.

Study Site and Data

The Han-gang River has the largest watershed area of 26,018 km^2 in Korea, with a channel length of 514.8 km and a mean watershed width of 48.20 km. The study site, Yeoju Station, is located just downstream of Chungju Dam, which is approximately 150 km from the river mouth. The study site is a sand-bed river with D_{50} = 1.0 mm. The flow at the Yeoju Station is directly affected by the discharge from the dam. The average bed slope of the Yeoju Station is 0.000215. The design flood at the Yeoju Station is 20,130 m^3/s, which is a 100-year flood.

Korea Institute of Hydrological Survey (KIHS) has started the measurement of sediment load in major rivers in Korea since 2006. Bed sediment and concentration of suspended sediment were sampled using BM-54 and D-74 (or P-61), respectively. Bed sediment samples were collected before and after each flood. Discharge measurements were also conducted using various methods, including microwave water surface current meter, Acoustic Doppler Current Profiler (ADCP), Acoustic Doppler Velocity Meter (ADVM), and Ultrasonic Velocity Meter (UVM).

Characteristics of Sediment Transport

KIHS (2006-2019) provides both suspended load and total sediment load. The total sediment load is estimated from the suspended load using the modified Einstein procedure. It is generally known that the suspended sediment load accounts for 75-95% of the total sediment load in a sand-bed river. However, the ratio of the suspended load to the total sediment load appeared to be less than 70% in 38% of 65 data. This means that the modified Einstein procedure over-estimated the bedload significantly. These data were excluded from the analysis.

The change in the distribution of bed sediment was given before and after the flood. It was found that fine sediment increased after the flood due to sediment deposition in the falling stage of the flood.

By fitting the data, the relationship between the discharge and total sediment load was obtained in the form of $Q_s = \alpha Q^{\beta}$ by year (here, Q_s and Q denote the total sediment load and discharge, respectively). Fig.1 shows an example of the discharge versus total sediment load for 2019 data. The regressed constant and exponent are α = 0.000024 and β = 2.7277, respectively, with R^2 = 0.94. It can be seen that the data are well fit to the relationship. For the data collected in 2006-2019, values of α and β are in the respective ranges of 0.00004 - 0.6, and 1.79 – 2.72. Values of R^2 lie in the range of 0.79 – 0.94. This indicates that this type of relationship is not reliable due to too high variability of parameters over the year.

Next, five total sediment load formulas were applied to the total sediment load data. The formulas include Engelund-Hansen’s formula, Acker-White’s formula, Yang’s formula, Brownlies’s formula, and Karim’s formula. Such metrics as discrepancy ratio, geometric mean, and geometric standard deviation were computed.

It was found that Engelund-Hansen's formula best predicts the total sediment load at Yeoju Station in Han-gang River, followed by Yang's formula (See Fig. 2).

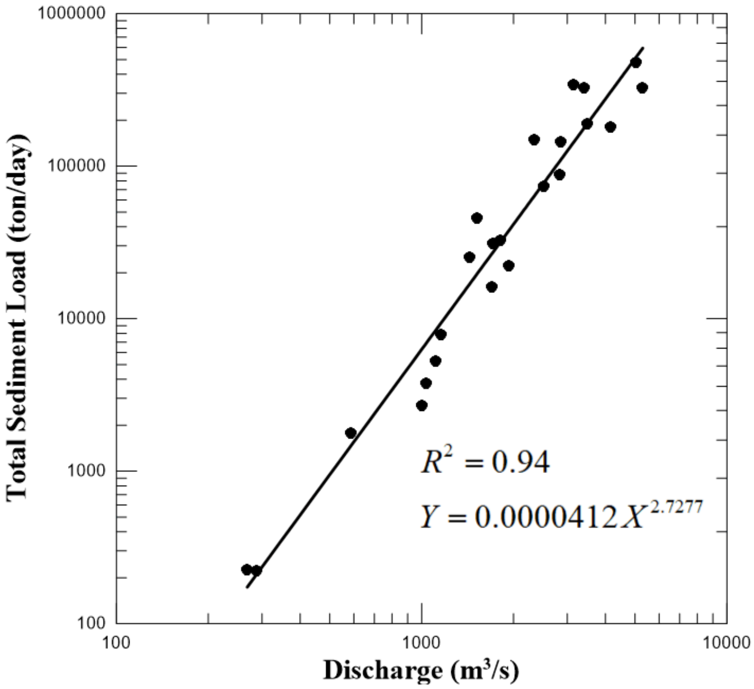

Fig. 1. Total sediment load versus discharge relationship at Yeoju Station in 2019

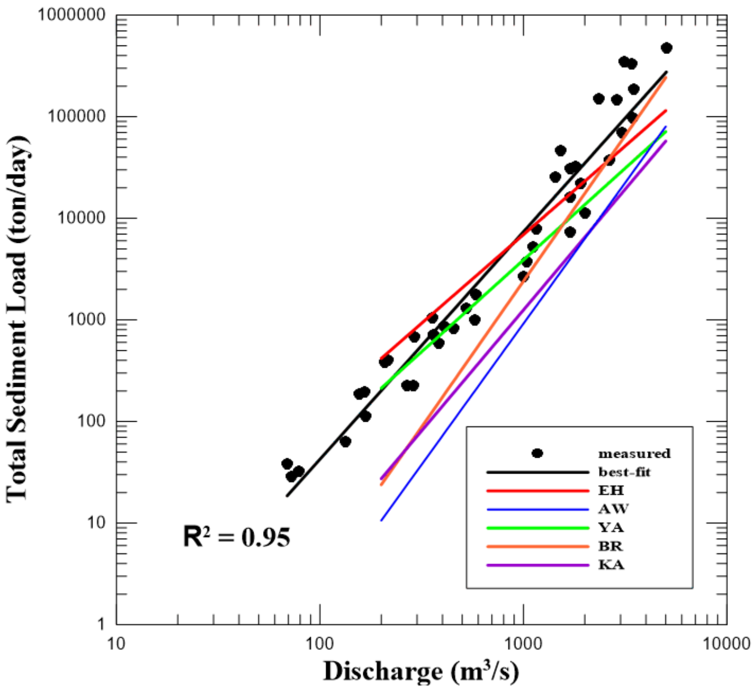

Fig. 2. Application of sediment transport formulas

.

Conclusions

This study investigated the characteristics of the total sediment load at Yeoju Station in the Han-gang River, Korea. The total sediment load data in KIHS (2006-2019) were used in the study. First, the relationships between the total sediment load and discharge were obtained via regression. It was found that the relationship of $Q_s = \alpha Q^{\beta}$ fits the data successfully. However, best fits of the constant and exponent vary significantly by year, indicating that this type of relationship is not so reliable. Then, five total sediment load formulas were applied to the data. Such metrics as discrepancy ratio, geometric mean, and geometric standard deviation were compared, revealing that Engelund-Hansen's formula, followed by Yang's formula, best predicts the total sediment load at Yeoju Station in Han-gang River.

Acknowledgements

This work was supported by Korea Environment Industry & Technology Institute(KEITI) through「Research and Development on the Technology for Securing the Water Resources Stability in Response to Future Change(RS-2024-00335281)」Program, funded by Korea Ministry of Environment(MOE).

References

Choi S-U, Lee J (2015a) Prediction of Total Sediment Load in Sand-Bed Rivers in Korea Using Lateral Distribution Method, JAWRA Journal of the American Water Resources Association, 51(1), 214-225.
Choi S-U, Lee J (2015b) Assessment of total sediment load in rivers using lateral distribution method, JHER Journal of Hydro-environment Research, 9, 381-387.
Jang E-K, Ji U (2021) Sediment load characteristics in South Korean Rivers and assessment of sediment transport formulas, KSCE Journal of Civil Engineering, 25, 4646-4660.
Korea Institute of Hydrological Survey (2006-2019) Hydrological Annual Report in 2006 – 2019. Ministry of Environment.
Seo S, Kim H, Woo H (1997) A Study on Estimation by Depth Integrating Method of Sediment Discharge, Journal of the Korean Society of Agricultural Engineers, v.38 no.1, 90 – 97.