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FLUVIAL MORPHOLOGY AND STRUCTURE, AND WATER QUANTITY AT THE SHINJEON RIVER, HAPCHEON-GUN, KOREA

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ABSTRACT

Flowing water is the main agent responsible for the creation of physical habitat in a river environment (FAO 1998). This study was carried out on the Shinjeon River located at Shinjeon-ri, Hapcheon-gun Province in Korea. Index degrees of river morphology and structure according to the river morphology were analyzed. As a result of an analysis about environmental factors for water quality in each surveyed sites, the most effective groups were, pH, DO, BOD, COD, SS, T-N, and T-P. Transversal & longitudinal sandbars were seven or more (score = 1). Materials of river levee at low channel width were shown artificial soil-levee (natural vegetation, lawn). The law water's edge vegetation was naturally formed a variety of vegetation communities. The mean of pH was 7.286 across stations, varying from 7.130 to 7.451. At middle section, number of flexion was four or more in this region. Bed materials were composed of sand, silt, and clay (50% >). Land uses in riparian zones within river levee were arable land, urban, residential mixed. At low section, transversal & longitudinal sandbars were seven or more (score = 1). The value for index of degree of river naturality according to the environment factors was a mean of 4.0. The mean of pH was 7.085. The average value of DO was 5.025 ㎎/L. The average value of BOD and COD were 4.288 mg/L and 2.275 mg/L, respectively.

Keywords: Shinjeon River, river morphology, water quality.

INTRODUCTION

Since the word fluvial means produced by rivers, the term, ‘fluvial morphology’ can be defined as a science dealing with forms as those produced by river action (Rosgen, 1996). Hence fluvial morphology means the science of landforms as produced by river action. It can also be called river morphology. Fluvial morphology is of great interest to hydraulic engineers, geologists, geo-morphologists, geographers and environmental engineers, since many of the complex problems they have to deal with are due to the form of the streams created by the erosion, transportation and deposition of sediment carried by them (Abbe & Montgomery, 2003).

A river system is composed of the main stream and many tributaries. Channel processes reflected in river morphology are erosion, transportation and sedimentation. The materials brought to the lower reaches in a channel are sediment load. The load can also be divided into bed-material load, which is that part of the load whose sizes are represented in the bed in non-negligible percentages, and wash load, which is that part of the load whose sizes are not present in the bed in appreciable percentages. The wash load, which is always the finest fraction of the load (mainly clay or finest silt size), is carried through a long segment of a river without any exchange of sediment between the bed and the flow.

Many aspects of fluvial processes and morphology may be measured to help assess a watershed's condition; however, individual measurements are difficult to interpret unless they are placed within the watershed's temporal and spatial context.

Classification provides a way to simplify assessment of complex watersheds by grouping components into sets with common qualities. Many types of river classifications have been developed (Kondolf et al., 2003) depending on the nature and scale of the problem and specific character of the watershed system. Fluvial geomorphological processes and channel forms are determined by three main factors: discharge and sediment yield, which are the main drivers, and valley characteristics, which establish the boundary conditions (Newson, 2002). The classification of rivers are complicated by both longitudinal and lateral linkages, by changes that occur in the physical features over time, and by boundaries between apparent patches that are often indistinct. Broadly, two types of river classifications exist in literature: (1) physical and (2) biotic. Most classifications are based on characteristics of biota (Huet, 1954; Hawkins et al., 1993) or fluvial process (Gregory, 1997), but a few are based on other characteristics like levee formations (Culbertson et al., 1967) and floodplain types (Nanson & Croke, 1992).

Flowing water is the main agent responsible for the creation of physical habitat in a river environment (FAO, 1998). Both river morphology and geomorphology are descriptive sciences based mainly on careful observation and interpretation of natural phenomena. The Shinjeon River is located at Hapcheon-gun, Gyeongsangnam-do in South Korea. The length of the Shinjeon River is 3.7 km long, flows across the countryside. The objective of this paper is to review the river health on the creation of fluvial morphology and provide illustrations of different examples taken mainly from the Shinjeon River but also from three geographical regions.

METHODOLOGY

Surveyed Regions

This study was carried out on the Shinjeon River (upper region: 35°381′217″N/128°189′579″E, low region: 35°409′344″N/128°122′393″E), located at Hapcheon-gun, Gyeongsangnam-do province in Korea (Fig. 1). Geographical ranges of the Shinjeon River were a total length of 3.7 kilometers from the both mountains (835 m and 897 m) to the confluence of the Yangcheon River. The relatively low level land can be developed either as agricultural fields or sites for habitation or business. Flood plains of this river are usually very fertile agricultural areas and out sides of this river consist of a mosaic of agricultural fields and farming houses. It is estimated that 80-90% of the Shinjeon-River water has be used for irrigation. The river in the upper basin is often narrowly confined between bedrock cliffs, older river terraces, or landslide deposits, leaving little land available for settlement or farming. Flood plains of this river are usually very fertile agricultural areas and out sides of this river consist of a mosaic of agricultural fields and farming houses. Mean annual temperature ranges from -0.5 (January) to 25.4 °C (August) with 13.0°C, and mean annual precipitation ranges from 15.2 (December) to 294.5 mm (August) with 1275.6 mm.

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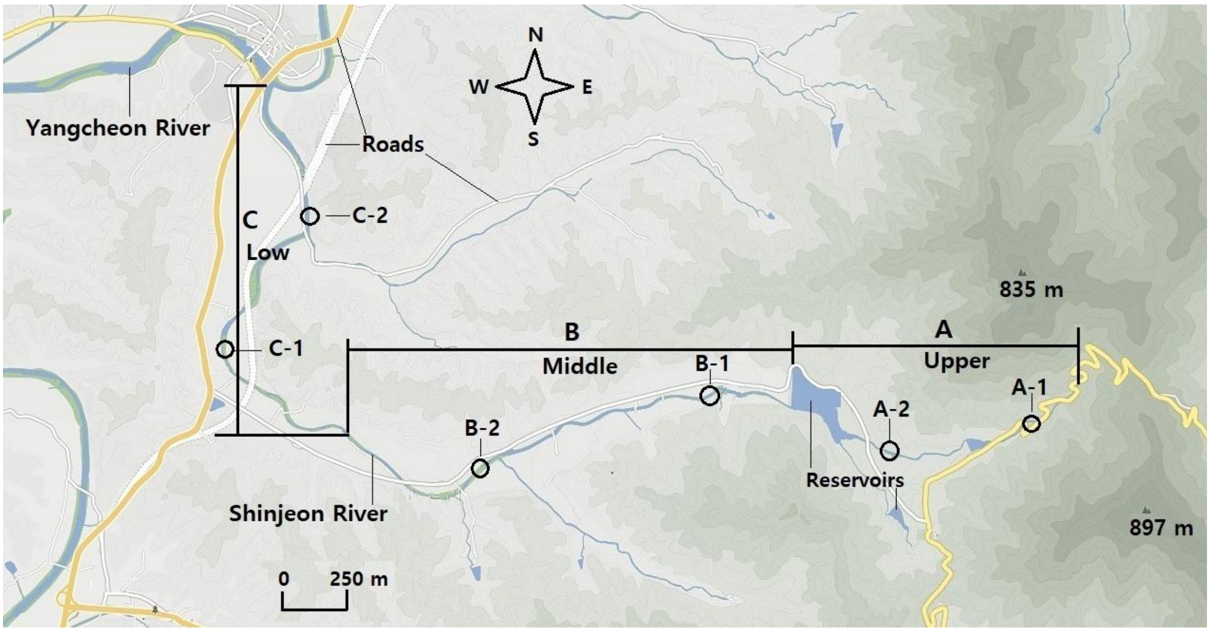

Figure 1. The eight stations (A-1 – C-2) and three sections at the Shinjeon River in Korea.

Index of degree of river structure

The three sections of Shinjeon River were divided by the geographic location with considering length of the river. Index of degree of river structure according to the river morphology was analyzed according to Table 1. Index of degree of river naturality according to the environment of river was also analyzed according to Table 2.

Water quality

The change in dissolved oxygen (DO) concentration is measured over a given period of time in water samples at a specified temperature. Dissolved oxygen (DO) meters are used to measure the amount of dissolved oxygen in a liquid (Thermo Scientific™ Orion™ Star A323 RDO / DO Portable Meter, USA). In environmental chemistry, the chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. Biological oxygen demand (BOD) is an indication of water contamination by organic materials and bacteria, especially from sewage water. BOD is similar in function to COD, in that both measure the amount of organic compounds in water. The methods for BOD and COD were used to a standard method of the American Public Health Association (APHA) and is approved by the U.S. Environmental Protection Agency (USEPA, 2002). Total phosphorus and nitrogen in river were evaluated the use of alkaline peroxodisulfate digestion with low pressure microwave, autoclave or hot water bath heating (Maher et al., 2002). Total suspended solids (SS) were determined by membrane filtration (0.1 um polycarbonate filters). A Shimadzu UV-210A double beam spectrophotometer (Japan) was used for absorbance measurements.

RESULTS

Upper region (A section)

The Shinjeon River situated on the southeastern end of Hapcheon-gun, Gyeongsangnam-do Province in Korea. The mean river width at this region is about 3.1 m. Number of flexion was three (score = 2) in this region (Table 3). Transversal & longitudinal sandbars were seven or more (score = 1). Diversity of flood velocity was wide and fast (score = 2). Bed materials were composed of sand, silt, and clay (score = 3). Diversity of channel width was moderate (score = 3). Materials of river shore at low channel width were state of stonework and artificial vegetation. Materials of river levee at low channel width were shown artificial soil-levee (natural vegetation, lawn). The law water's edge vegetation was naturally formed a variety of vegetation communities (Table 4). Flood way vegetation was naturally formed a variety of vegetation communities. Land use in riparian zones within river levee was arable land, urban, residential mixed. Land use in flood plains beyond river levee were Arable land or artificial vegetation. Transverse direction of artificial structures was three and mean reservoir of height was 0.3-0.4 m, and fish migration was difficulty. The ratio of sleep width/river width was 10-20%. The value for index of degree of river naturality according to the environment factors was a mean of 2.5. As a result of an analysis about environmental factors for water quality in each surveyed sites, the most effective groups were, pH, COD, DO, SS, T-N, and T-P excluding BOD. The mean of pH was 7.286 across stations, varying from 7.130 to 7.451 (Table 5). The average value of DO was 4.293 ㎎/L varying from 2.901 to 5.139. The average value of BOD was 2.942 ㎎/L varying from 2.556 to 3.122. The average value of COD were 1.448 mg/L. BOD and COD values of water sample from the Shinjeon River were found to be within the limit (Current National Recommended Water Quality Criteria). Mean value of suspended solids was 0.144 ㎎/L. T-N and T-P were 2.532 ㎎/L and 0.090 ㎎/L, respectively.

Middle region (B section)
The mean river width at the region is about 5.8 m. Number of flexion was four or more in this region (Table 3). Transversal & longitudinal sandbars were seven or more (score = 1). Diversity of flood velocity was wide and fast (score = 2). Bed materials were composed of sand, silt, and clay (50% >). Diversity of channel width was slight (score = 4). Materials of river shore at low channel width were state of stonework and artificial vegetation. Materials of river levee at low channel width were shown artificial soil-levee (natural vegetation, lawn). The vegetations of low water's edge were naturally formed various vegetation communities by natural erosion weeds, natural weeds, and artificial mixed composition (Table 4). The flood way vegetation was removed vegetation artificially. Land uses in riparian zones within river levee were arable land, urban, residential mixed. Land use in flood plains beyond river levee was about 1/2 park facilities, playground facilities. Transverse direction of artificial structures was fish move completely blocked. The ratio of sleep width/river width was 20% or more. The value for index of degree of river naturality according to the environment factors was a mean of 3.333. The mean of pH was 7.115 across stations, varying from 6.737 to 7.344 (Table 5). The average value of BOD was 3.395 mg/l. The average value of DO was 4.920 ㎎/L. The average value of COD was 1.758 mg/l. Mean SS was 0.172 ㎎/L. T-N and T-P were 2.482 ㎎/L and 0.182 ㎎/L, respectively.

Low region (C section)
The mean river width at the region was about 8.7 m. Number of flexion was four or more in this region (Table 3). Transversal & longitudinal sandbars were seven or more (score = 1). Diversity of flood velocity was moderate (score = 3). Bed materials were composed of silt and clay. Diversity of channel width was slight. Materials of river shore at low channel width were state of stonework and artificial vegetation. Materials of river levee at low channel width were shown artificial soil-levee (natural vegetation, lawn). The law water's edge vegetation were shown natural weeds, shrubs, and mixed (Table 4). Flood way vegetation was shown removed vegetation artificially. Land uses in riparian zones within river levee was

1/2 or more urban, residential. Land use in flood planes beyond river levee were impervious man-made structures, parking, etc. Transverse direction of artificial structures was fish move completely blocked. The ratio of sleep width/river width was 20% or more. The value for index of degree of river naturality according to the environment factors was a mean of 4.0. The mean of pH was 7.085 (Table 5). The average value of DO was 5.025 ㎎/L. The average value of BOD and COD were 4.288 mg/L and 2.275 mg/L, respectively. BOD and COD values of water sample from the Shinjeon River were found to be within the limit (Current National Recommended Water Quality Criteria). Mean value of suspended solids was 0.243 ㎎/L. T-N and T-P were 3.040 ㎎/L and 0.194 ㎎/L, respectively.

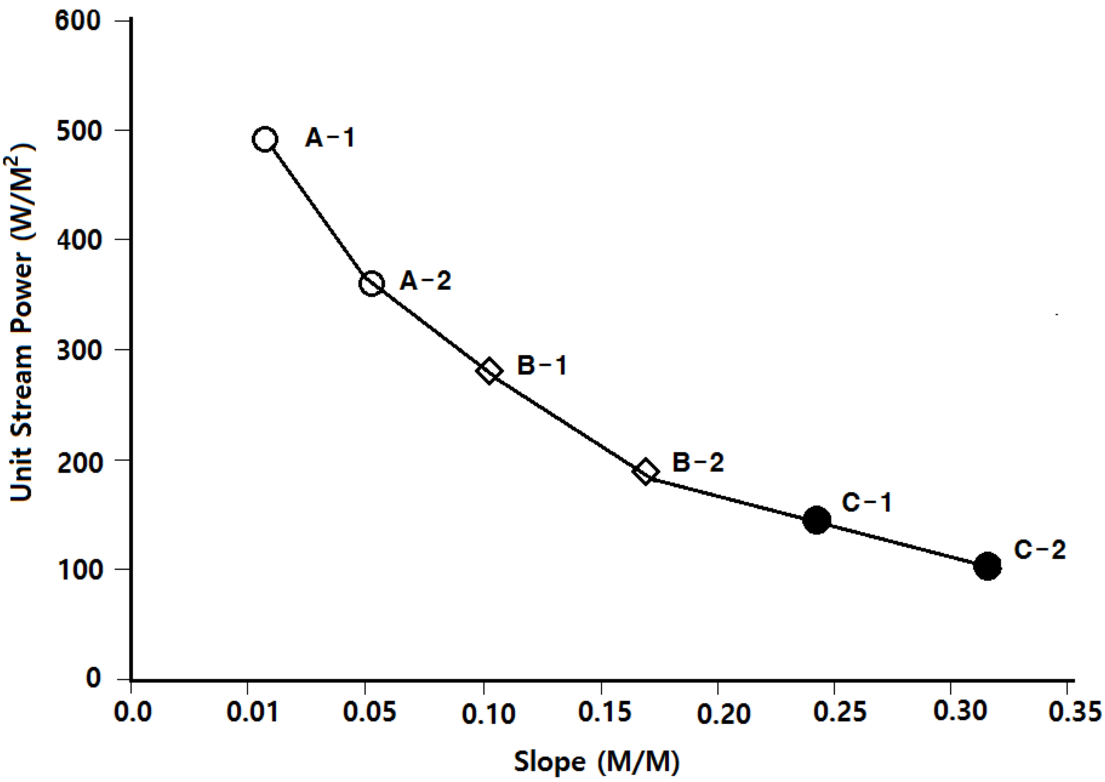

Figure 2. Relationship of unit river power to gradient in the Shinjeon River, Korea. Values for unit power are mean for the 20-year recurrence interval flood, across cross-sections of the 20-year floodplains. Data are based on Korea Meteorological Administration (KMA). A-1 – C-2 are the same as Fig. 1.

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Table 1. Index of degree of river structure according to the river morphology

Item	Estimated index and scores				
	1	2	3	4	5
No. of flexion	Over four	Three	Two	One	Absent
Transversal & longitudinal sandbars	Over 7	Five or six	Three or Four	One or two	Absent
Diversity of flow	Very fast	Fast	Moderate	Slight	Absent
Bed materials	Boulders	Boulders & gravel	Sand, silt, clay : 50% >	Silt, clay	Sand
Diversity of low channel width	Very large	large	Moderate	Slight	Absent
Materials of river shore at low channel width	State of nature without protecting materials	Natural materials + artificial vegetation	Stonework + artificial vegetation	Stonework or penetrating river shore	Concreted impervious
Materials of river levee at low channel width	State of nature without artificial levee	Artificial soil-levee (natural vegetation, lawn)	Stonework, natural type block with artificial vegetation	Stonework, penetrating levee with natural type block	Stonework, impervious levee with concrete

Table 2. Index of degree of river naturality according to the environment of a river

Item	Estimated index and scores				
	1	2	3	4	5
The law water's edge vegetation	Naturally formed a variety of vegetation communities	Naturally formed various vegetation communities by natural erosion (sediment exposure) were absent	Natural weeds, shrubs, and mixed	Artificial vegetation composition	Vegetation blocked by stonework etc.
Flood way vegetation	Naturally formed a variety of vegetation communities	Naturally formed various vegetation communities by natural erosion (sand bar) were absent	Both of natural vegetation and artificial vegetation	Artificial vegetation with Parks, lawns, and so on	Remove vegetation artificially
Land use in riparian zones within river levee	Bush or grassland as natural floodplain	Arable land (paddy fields, orchards)	Arable land, urban, residential mixed	About 1/2 urban, residential mixed	1/2 or more urban, residential
Land use in flood plains beyond river levee	State of nature without artificial vegetation, manmade structures	Arable land or artificial vegetation	Artificial vegetation or natural vegetation mixed	About 1/2 park facilities, playground facilities	Impervious man-made structures, parking, etc.
Transverse direction of artificial structures	Absent	Bypass reservoir or slope waterway reservoir	Fish migration reservoir	Reservoir of height 0.3-0.4 m, fish migration difficulty	Fish move completely blocked
Sleep width /river width ratio	20% or more	20 ~ 10%	10 ~ 5%	5 ~ 1 %	Less than 1%

Table 3. River structure of the Shinjeon River

Region	No. of flexion	Transversal & longitudinal sandbars	Diversity of flow	Bed materials	Diversity of low channel width	Materials of river shore at low channel width	Materials of river levee at low channel width	Mean
Upper	2	1	2	3	3	3	2	2.286
Middle	1	1	2	3	4	3	3	2.429
Low	1	1	3	4	4	3	3	2.714

Table 4. Index of degree of river naturality according to the environment of river at the Shinjeon River

Region	The law water's edge vegetation	Flood way vegetation	Land use in riparian zones within river levee	Land use in flood plains beyond river levee	Transverse direction of artificial structures	Sleep width /river width ratio	Mean
Upper	1	3	3	2	4	2	2.500
Middle	2	5	3	4	5	1	3.333
Low	3	5	5	5	5	1	4.000

Table 5. Water quality for four stations at the Shinjeon River in Korea. The values are mean of four seasons at each station and standard deviation

Item	Section A	Section B	Section C
pH	7.286±0.126	7.115±0.232	7.085±0.277
DO (mg/L)	4.293±0.854	4.920±0.812	5.025±0.625
BOD (mg/L)	2.942±0.228	3.395±0.726	4.288±0.398
COD (mg/L)	1.448±0.588	1.758±0.583	2.275±0.672
SS (mg/L)	0.144±0.018	0.172±0.014	2.243±0.062
T-N (mg/L)	2.532±0.670	2.482±0.170	3.040±0.257
T-P (mg/L)	0.091±0.054	0.182±0.076	0.194±0.035

DISCUSSION

Construction of flood control works such as embankments, reservoirs, channel straightening, meander cut-offs and channel improvement also tend to disturb the equilibrium of the stream and needs careful study. Change in drainage basin characteristics due to change in land use such as deforestation, reforestation, agricultural land development, road construction, urbanization, and building of dams and check-dams disturb the river equilibrium by changing runoff and sediment load and trigger changes in the channel characteristics.

River sediments comprise a spectrum of particle sizes such as boulder, cobble, pebble, granule, sand, silt, and clay (Lane, 1947). Among these, the largest particles commonly occur in upland channels where the terrain gradient is the highest, while finer entities are enriched progressively downstream due to sediment sorting based on size and specific gravity (Blatt et al., 1972).

Human interventions consequent to economic developments in the past few decades have imposed tremendous pressure on rivers. As a result, most of the rivers in the world, especially the small rivers, have been altered to levels, often beyond their natural resilience capability.

Values of BOD were 2.942 at the Section A, 3.395 at the B, and 4.288 at C (Table 5). Values of COD were 1.448 at the Section A, 1.758 at the B, and 2.275 at C. The portion of BOD and COD in the river increased exponentially along the upper-down gradient. BOD increases as micro-organisms accumulate to degrade organic material. In addition, suspended solids are important as pollutants in water system. pH, DO, SS, T-N, and T-P showed the same tendency. Decreasing of the pH levels caused by sulfur and nitrogen oxides deposition (as a result of the combustion of fossil fuels) into the rivers' catchments Although SS and phosphorus did not exceed the threshold, the amount of both values solids increased significantly. Phosphorus is caused by the use of fertilizer in the surrounding croplands. The agricultural sector with its fertilizers and manure enrichment of soil increases the concentrations of nutrients (nitrates, ammonium and phosphorus) in water that is associated with the river flow alteration (dams, reservoirs, etc.) boosting the propagation of algal blooms and hence water turbidity. Fertilizers and pesticides both have definite pros and cons associated with their use. Both types of chemical tend to increase yields, and thus make a significant difference in food production, particularly in countries that struggle periodically with famines. This increased acidification can result in a toxic environment that has a significant negative impact on the ecosystems of rivers (USEPA, 2002).

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