FLUVIAL MORPHOLOGY AND RIVER NATURALITY AT THE JUNGCHONCHEON STREAM, HAPCHEON-GUN PROVINCE IN KOREA

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ABSTRACT

A stream is a body of water with surface water flowing within the bed and banks of a channel. This study is to investigate the degree of river naturality according to the river morphology and river naturality on the Jungchoncheon Stream at Hapcheon-gun, Gyeongsangnam-do in Korea. Materials of river shore at low channel width at upper region were state of nature without protecting materials and materials of river levee at low channel width were state of nature without artificial levee. The value for index of degree of river structure according to the river morphology was a mean of 2.286 at upper region. The vegetation of low water's edge at middle region was naturally formed various vegetation communities by natural weeds, shrubs, and mixed. The flood way vegetation was removed vegetation artificially. The value for index of degree of river structure according to the river morphology was a mean of 2.429 at middle region. Transverse direction of artificial structures was one bypass reservoir and two slope waterway reservoirs at low region. 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 2.857 at low region.

Keywords: Channel, Jungchoncheon Stream, river morphology, river naturality.

INTRODUCTION

Biomes can be considered life zones, environments with similar climatic, topographic, and soil conditions, and roughly comparable biological communities. Most biomes are identified by the dominant plants of their communities, for example, grassland or littoral zone. Freshwater ecosystems cover relatively little total areas, but biologically they are very distinctive. Freshwater ecosystems are as varied as their individual sites because they are influenced not only by characteristics of local climate, soil, and resident communities, but also by the surrounding terrestrial ecosystems and anything that happens uphill or upstream from them (Cunningham and Cunningham, 2002). Increasing human population and growth of technology require human society to devote more and more attention to protection of adequate supplies of water (Rodrigues-Iturbe, 2000). Other effects include an imbalance in healthy natural ecosystems, harm to the food chain, and impaired populations of fish and other wildlife.

A stream is a body of water with surface water flowing within the bed and banks of a channel. Streams typically derive most of their water from precipitation in the form of rain and snow. River sources are usually small, and in the case of mountain streams, step and erosional Montgomery and Buffington, 1997). In temperate environments, small tend to be shaded by an interlocking, overhead tree canopy. Such conditions result in nutrients, well oxygenated streams that communities in the streams. The structure and functioning of

freshwater ecosystems are also tightly linked to the watersheds, or catchments, of which they are a part.

Streams exchange water, nutrients, and organisms with surrounding aquifers. The interstitial, water-filled space beneath river beds, where most active aquifer-river water exchange occurs, is termed the hyporheic zone, and is an important habitat for a number of aquatic organisms. The morphology of rivers, especially in plain view, varies enormously. The most common way to classify rivers is on the basis of their plan-view morphology. The geologic, climatic, and human conditions to which a watershed is subjected determine the dependent landscape variables of sediment supply, stream discharge, and vegetation (Buffington et al. 2003). Channel morphology is the result of the combined influence of the dependent landscape variables, and the channel responds to changes in these variables by adjustments in one or many of the dependent channel variables (Hogan and David, 2010).

Some rivers show a flow of water all the time, even long after the last rainstorm in the watershed. Such a river is called a perennial stream. Other rivers flow for only a short time after a rainstorm, and for the rest of time, usually most of the time, their beds are dry. Such a river is called an ephemeral stream. Jungchoncheon Stream is a perennial stream. The effectiveness and predictability of stream ecosystem in local region such as Jungchoncheon Stream will improve with an increased understanding of the processes by which ecosystems develop and are maintained (Lake et al., 2007).

An evaluation of the characteristics required for healthy functioning can begin with a description of the natural or flow patterns for streams or rivers (Baron & Poff, 2004). 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 Junchoncheon Stream but also from three geographical regions.

METHODOLOGY

Surveyed Regions

This study was carried out on the Jungchoncheon Stream (upper region: 35°370′436″N/128°166′999″E, low region: 35°381′528″N/128°143′407″E), located at Hapcheon-gun, Gyeongsangnam-do province in Korea (Fig. 1). The stream is located to the eastern region of the city of Hapcheon-gun. The length of the stream is 3.9 km long and flows across the countryside. Lowlands are usually no higher than 150 m, while uplands are somewhere around 200 m to 220 m. The stream starts at some high point. The high point can be a mountain, hill, or other elevated area. 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.

Index of degree of river structure

Various indicators may be used to assess river health though all indicators are not the best practical representation of issues impacting river health. The three regions of Jungchoncheon Stream were divided by the geographic location with considering length of the river and river morphology. Index of degree of river naturality according to the environment of river was also analyzed according to Table 1. River terminology was followed by Hutchinson (1975).

Environmental factors

Laboratories and equipment were used to measure a range of water quality parameters including pH, suspended solids (SS), dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). The change in DO concentration is measured over a given period of time in water samples at a specified temperature. The test for BOD is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter (Sawyer and McCarty, 1978). The method for BOD was used to a standard method of the American Public Health Association (APHA) and is approved by the U.S. Environmental Protection Agency (USEPA, 2002). COD is a widely known parameter used to measure water quality using the 910 colorimeter (YSI Incorporated, Ohio, USA). It is a measure of water pollution resulting from organic matter. 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).

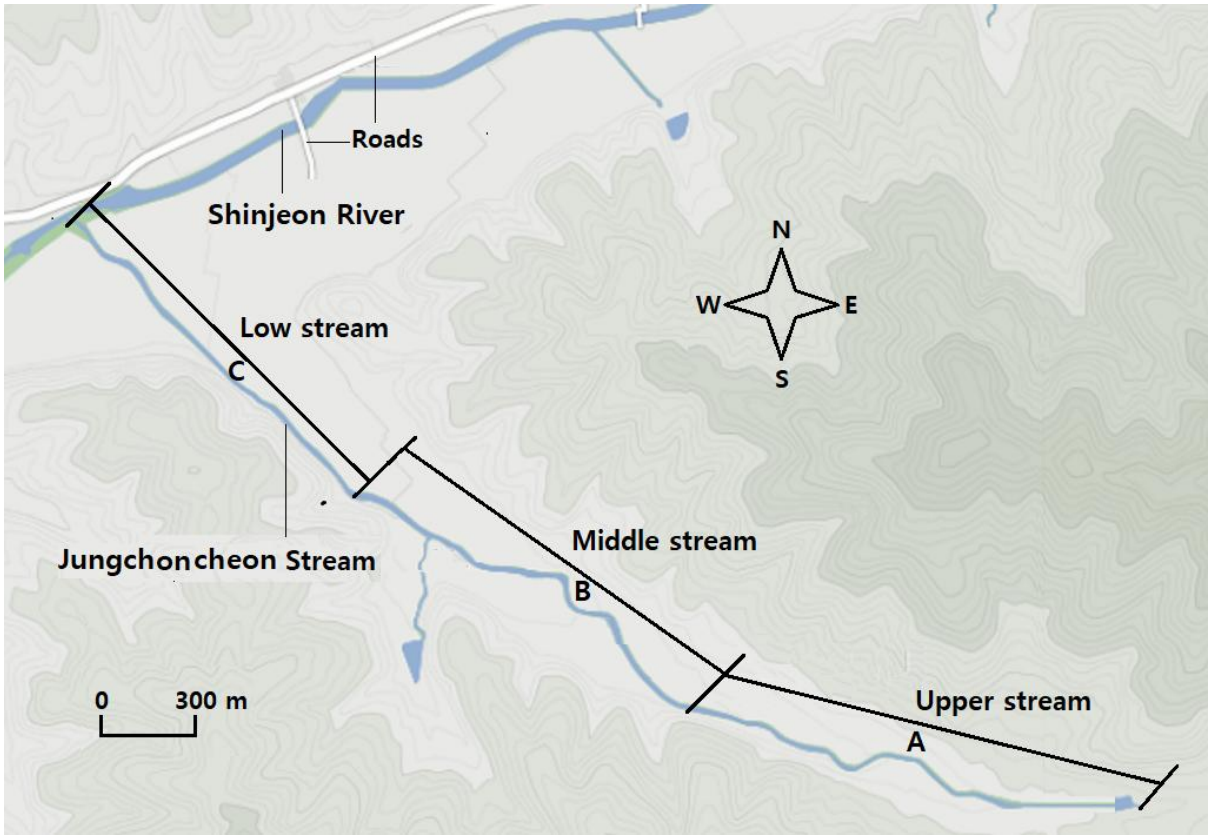

Figure 1: Location of the study area and the three detailed internodes at the Jungchoncheon Stream.

RESULTS

Region A

The mean river width at this region is about 2.3 m.

Number of flexion with more 60 degrees was one (score = 4) in this region (Table 3). Transversal & longitudinal sandbar was absent (score = 5). Diversity of flood velocity was wide and very fast (score = 1). Bed materials were composed of boulders and gravel (score = 2). Diversity of channel width was large (score = 2). Materials of river shore at low channel width were state of nature without protecting materials. Materials of river levee at low channel width were state of nature without artificial levee. The value for index of degree of

river structure according to the river morphology was a mean of 2.286.
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 artificial vegetation with parks, lawns, and so on (score = 4). Land use in riparian zones within river levee was bush or grassland as natural floodplain. Land use in flood plains beyond river levee were about 1/2 park facilities, playground facilities. Transverse direction of artificial structures was absent. 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 2.143.

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 7.18 across stations, varying from 7.01 to 7.36 (Table 5). The average value of DO was 4.82 mg/L varying from 4.33 to 5.14. The average value of BOD was 2.90 mg/L varying from 2.34 to 3.32. The average value of COD were 2.44 mg/L. BOD and COD values of water sample from this stream were found to be within the limit (Current National Recommended Water Quality Criteria). Mean value of suspended solids was 5.25 mg/L.

Region B
The mean river width at the region is about 3.6 m. Number of flexion was one (score = 4) in this region (Table 3). Transversal & longitudinal sandbar was one (score = 4). Diversity of flood velocity was wide and very fast (score = 1). Diversity of flood velocity was wide and fast (score = 2). Bed materials were composed of boulders and gravel (score = 2). Diversity of low channel width was moderate (score = 3). Materials of river shore at low channel width were state of nature without protecting materials (score = 1). Materials of river levee at low channel width were shown artificial soil-levee (natural vegetation, lawn). The value for index of degree of river structure according to the river morphology was a mean of 2.429.

The vegetation of low water's edge was naturally formed various vegetation communities by natural weeds, shrubs, and mixed (Table 4). The flood way vegetation was removed vegetation artificially. Land uses in riparian zones within river levee were arable land (paddy fields, orchards). Land use in flood plains beyond river levee was arable land or artificial vegetation. Transverse direction of artificial structures was one bypass reservoir or slope waterway reservoir. 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 2.143. The mean of pH was 7.23 across stations, varying from 7.01 to 7.40 (Table 5). The average value of DO was 4.30 mg/L. The average value of BOD was 3.20 mg/L. The average value of COD was 2.93 mg/L. Mean SS was 6.08 mg/L.

Region C
The mean river width at the region was about 5.3 m. Number of flexion was absent (score = 5) in this region (Table 3). Transversal & longitudinal sandbar was five (score = 2). Diversity of flood velocity was wide and very fast (score = 1). Diversity of flood velocity was wide and fast (score = 2). Bed materials were composed of sand, silt, and clay (50% >). Diversity of low channel width was moderate (score = 3). Materials of river shore at low channel width were state of natural materials and artificial vegetation (score = 2). Materials of river levee at low channel width were composed of stonework and natural type block with artificial vegetation. The value for index of degree of river structure according to the river morphology was a mean of 2.714.

The vegetation of low water's edge was blocked by stonework etc. (Table 4). The flood way vegetation was removed vegetation artificially. Land uses in riparian zones within river levee were arable land, roads, residential mixed. Land use in flood plains beyond river levee was artificial vegetation or natural vegetation mixed. Transverse direction of artificial structures was one bypass reservoir and two slope waterway reservoirs. 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 2.857. The mean of pH was 7.14 across stations (Table 5). The average value of DO was 3.99 mg/L. The average value of BOD was 3.58 mg/L. Mean BOD values varied between 3.68 mg/L. The BOD and COD were within unacceptable levels. Mean SS was 7.33 mg/L.

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 environmental factors

Item	Estimated index and scores				
	1	2	3	4	5
The low 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
Water quality (BOD)	Class 1 (crystal clear)	Class 2 (clear relatively)	Class 3 (tan, the bottom green algae)	Class 4 (blackish brown, the floor is not looked)	Class 5 (an ink color, odor)
Sleep width /river width ratio	20% or more	20 ~ 10%	10 ~ 5%	5 ~ 1 %	Less than 1%

Table 3. River structure of the Jungchoncheon Stream

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	4	5	1	2	2	1	1	2.286
Middle	4	4	1	2	3	1	2	2.429
Low	5	2	1	3	3	2	3	2.714

Table 4. The degrees of river naturality according to the environmental factors at the Jungchoncheon Stream

Region	The low 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	Water quality (BOD)	Sleep width /river width ratio	Mean
A	1	4	1	4	1	2	2	2.143
B	3	5	2	2	2	2	1	2.429
C	5	5	3	2	2	2	1	2.857

Table 5. Water quality for three regions at the Jungchoncheon Stream in Korea. The values are mean of four seasons at each station and standard deviation

Item	St. A	St. B	St. C
pH	7.18±0.13	7.23±0.15	7.14±0.20
DO (㎎/L)	4.82±0.31	4.30±0.49	3.99±0.58
BOD (㎎/L)	2.90±0.37	3.20±0.39	3.58±0.28
COD (㎎/L)	2.44±0.77	2.93±0.55	3.68±0.31
SS (㎎/L)	5.25±1.92	6.08±1.79	7.33±4.35

DISCUSSION

For river, stream, and wetland ecosystems, the flow regime is the most important determinant of ecosystem function and services provided by these functions. The sustainability of aquatic ecosystems can best be ensured by maintaining naturally variable flows, adequate sediment and organic matter inputs, natural fluctuations in light, clean water, and a naturally diverse plant and animal community (Baron & Poff, 2004). The fluvial ecosystem in the hydrological and ecological functioning of riparian systems has increased. This has happened not only because of scientific reasons related to the development of Riverine Landscape Ecology (Tockner et al., 2002), but also as a consequence of riparian areas being one of the main targets in environmentally-sound river management. Nowadays, riparian and floodplain systems are seriously degraded by different human activities, and the scientific understanding of their hydrological and ecological functioning is greatly needed for their restoration (del Tánago & de Jalón, 2006).

The riparian zone includes the immediate vicinity of the stream, which consists of the bed, banks and adjacent land, as well as the floodplain, which carries large floods. The mean river width at Upland streams is about 3.6 m and narrow valley widths have smaller riparian zones (1.0-2.3 m). Lowland streams have broader valley widths and are more prone to meandering, therefore usually have larger riparian zones (3.0-4.5 m). Water quality is another indicator of poor condition in a riparian area.

As a result of an analysis about environmental factors for the numbers of fishes in each surveyed sites, the most effective groups were, pH, COD, DO, SS, excluding BOD (Table 5). In particular, SS has a significant increase in the middle and low regions (B and C). It is considered that the increase of SS is discharged from the residential area in the upstream area. The rise of the riverbed and water table are problematic for many reasons. If the river bed and water table continue to rise in this area, this type of flooding (i.e., flooding outside of the levees which cannot be controlled) will become more frequent, the efficiency of the width of Jungchoncheon Stream will continue to be reduced and water table elevation will rise in heavy rain. Mean annual precipitation at Hapcheon-gun ranges from 15.2 (December) to 294.5 mm (August) with 1275.6 mm. Floods rarely follow the precise boundaries on a map, especially flash floods associated with sudden, heavy downpours. Flood damages can and often do occur outside the limits of the regulatory floodplain. This tends to slow the increase in stage with increase in discharge: the channel can pass a given discharge at higher velocity and lower stage because of the reduced resistance to flow afforded by the plane bed.

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