FLUVIAL MORPHOLOGY AND WATER QUANTITY AT THE IMGI STREAM, GIJANG-GUN, KOREA

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ABSTRACT

Rivers play an important role in the sustenance of life systems of nature. This study was carried out on the Imgi Stream located at Imgi-ri, Busan-ci province in Korea. Index of degree of river structure according to the river morphology was analyzed. Transversal & longitudinal sandbars at upper section were absent and velocity of flood was very fast. The law water's edge vegetation and flood way vegetation at upper section were shown naturally formed vegetation communities. At middle section, the average value of biological oxygen demand (BOD) was 3.048 mg/l. The average value of dissolved oxygen (DO) was 6.085 ㎎/L. The average value of chemical oxygen demand (COD) was 5.148 mg/l. Mean total suspended solids (SS) was 26.425 ㎎/L. Total phosphorus and nitrogen were 2.225 ㎎/L and 0.253 ㎎/L, respectively. At low section, number of flexion was one in this region and transversal & longitudinal sandbars were four. Bed materials were composed of sand, silt, and clay (50% >) and diversity of channel width was slight. The mean of pH was 6.963. The average value of DO was 5.123 ㎎/L. The average value of BOD and COD were 5.115 mg/L and 6.805 mg/L, respectively. BOD and COD values of water sample from the Imgi Stream were found to be within the limit (Current National Recommended Water Quality Criteria). The agricultural sector with its fertilizers and manure enrichment of soil increases the concentrations of nutrients (nitrates, ammonium and phosphorus) in water.

Keywords: Biological oxygen demand (BOD), Imgi Stream, river morphology.

INTRODUCTION

Healthy, self-sustaining river systems provide important ecological and social goods and services upon which human life depends (Postel & Richter, 2003). A watershed approach toward assessment of fluvial processes and morphology requires utilization of methods that may be put into a framework to both incorporate data collected locally and well as illustrate the processes that link the area under investigation to upstream/upslope and downstream areas within the watershed. In watershed assessment, common classification of river morphology based on some type of general characteristic. 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. 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).

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. There is a growing need to assess physical and biological or chemical components in determining the ecological state of streams or rivers. Thus in this paper, I focus on local scales could affect river ecosystem structure and functioning.

METHODOLOGY

Surveyed Regions

This study was carried out on the Imgi Stream (upper region: 35°323′787″N/129°1348′794″E, low region: 35°319′942″N/129°114′306″E), located at Imgi-ri, Busan-ci province in Korea (Fig. 1). Geographical ranges of the Imgi Stream were a total length of 2.4 kilometers from the Mangyeol Mountain (500 m) to the confluence of the Suyeong River. Lowlands are usually no higher than 120 m (394 ft.), while uplands are somewhere around 250 m (820 ft.) to 350 m (1148 ft.). Throughout the course of a river, the total volume of water transported downstream composed of the visible free water flow together with a substantial contribution flowing through rocks and sediments that underlie the river and its floodplain called the hyporheic zone (Huh, 2016). The relatively level land can be developed either as agricultural fields or sites for habitation or business. It is estimated that 80-90% of the Imgi-River water has be used for irrigation. 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 temperate ranges from climate -0.6℃ in January to 29.4℃ in August with 14.7℃, mean annual precipitation is about 1519.1 mm with most rain falling period between June and August.

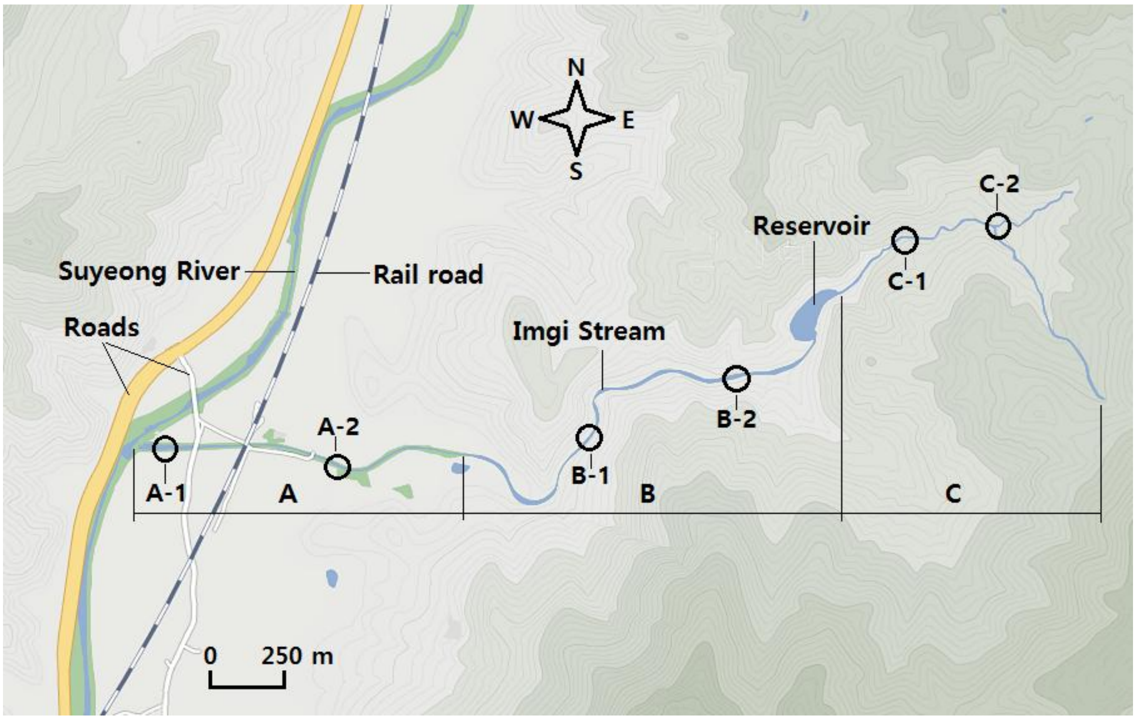

Figure 1. The eight stations (A-1 – C-2) and three sections at the Imgi Stream in Korea.

Index of degree of river structure

The three sections of Imgi Stream 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). Biochemical oxygen demand (BOD) is similar in function to chemical oxygen demand (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 (C section)

The mean river width at this region is about 2.8 m. Number of flexion was six in this region (Table 3). Transversal & longitudinal sandbars were absent. Velocity of flood was very fast. Bed materials were composed of boulders and gravel. Diversity of channel width was large. Materials of river shore and river levee at low channel width were state of nature without protecting materials. The law water's edge vegetation and flood way vegetation were shown naturally formed vegetation communities (Table 4). Land use in riparian zones and flood plains within river levee were bush or grassland with nature structures. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 1-5%.

The mean of pH was 7.225 across stations, varying from 7.081 to 7.452 (Table 5). The average value of DO was 7.423 ㎎/L. The average value of BOD and COD were 2.288 mg/L and 3.435 mg/L, respectively. BOD and COD values of water sample from the Imgi Stream were found to be within the limit (Current National Recommended Water Quality Criteria). Mean value of suspended solids was 15.728 ㎎/L. T-N and T-P were 0.625 ㎎/L and 0.036 ㎎/L, respectively.

Middle region (B section)

The mean river width at the region is about 5.3 m. Number of flexion was one in this region (Table 3). Transversal & longitudinal sandbars were two. Velocity of flood was slight. Bed materials were composed of sand, silt, and clay. Diversity of channel width was moderate. Materials of river shore and river levee at low channel width were natural materials and artificial vegetation. The vegetations of low water's edge were weeds, natural weeds, and artificial mixed composition (Table 4). The flood way vegetation was both of natural vegetation and artificial vegetation. Land uses in riparian zones within river levee were arable

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land (paddy arable land, about 1/2 fields, orchards). Land use in flood plains beyond river levee was arable land or manmade artificial vegetation. Transverse direction of artificial structures was one fish migration reservoir, fish migration difficulty. The ratio of sleep width/river width was 5-10%. The value for index of degree of river naturality according to the environment factors was a mean of 2.833.

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 (Table 5). Biological Oxygen Demand (BOD) is an indication of water contamination by organic materials and bacteria, especially from sewage water. The average value of BOD was 3.048 mg/l. The average value of DO was 6.085 ㎎/L. The average value of COD was 5.148 mg/l. Mean SS was 26.425 ㎎/L. T-N and T-P were 2.225 ㎎/L and 0.253 ㎎/L, respectively.

Low region (A section)
The mean river width at the region was about 7.8 m. Number of flexion was one in this region (Table 3). Transversal & longitudinal sandbars were four. Velocity of flood was very absent. Bed materials were composed of sand, silt, and clay (50% >). Diversity of channel width was slight. Materials of river shore and river levee at low channel width were stonework or penetrating river shore. Materials of river shore and river levee at low channel width were stonework, penetrating levee with natural type block. The law water's edge vegetation were shown artificial composition (Table 4). Flood way vegetation was shown removed vegetation artificially. Land use in riparian zones and flood plains within river levee were arable land or artificial vegetation. Land use in flood planes beyond river levee were impervious man-made structures, parking, etc. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 5-10%.

The mean of pH was 6.963 (Table 5). The average value of DO was 5.123 ㎎/L. The average value of BOD and COD were 5.115 mg/L and 6.805 mg/L, respectively. BOD and COD values of water sample from the Imgi Stream were found to be within the limit (Current National Recommended Water Quality Criteria). Mean value of suspended solids was 36.025 ㎎/L. T-N and T-P were 2.653 ㎎/L and 2.373 ㎎/L, respectively.

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 Imgi 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	1	5	1	2	2	1	1	1.857
Middle	4	4	3	3	3	2	3	3.142
Low	4	3	4	3	4	4	4	3.714

Table 4. Index of degree of river naturality according to the environment of river at the Imgi Stream

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	1	1	1	1	4	1.500
Middle	3	3	2	2	4	3	2.833
Low	4	5	2	5	1	3	3.333

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

Item	Section A	Section B	Section C
pH	6.96±0.25	7.04±0.24	7.23±0.14
BOD (mg/L)	5.12±0.83	6.09±0.39	7.42±0.29
SS (mg/L)	5.11±1.09	3.04±0.24	2.29±0.09
DO (mg/L)	6.81±0.78	5.15±0.08	3.44±0.19
COD (mg/L)	36.03±2.04	26.43±3.16	15.73±1.06
T-N (mg/L)	2.65±0.40	2.23±0.56	0.63±0.32
T-P (mg/L)	0.38±0.13	0.25±0.19	0.04±0.01

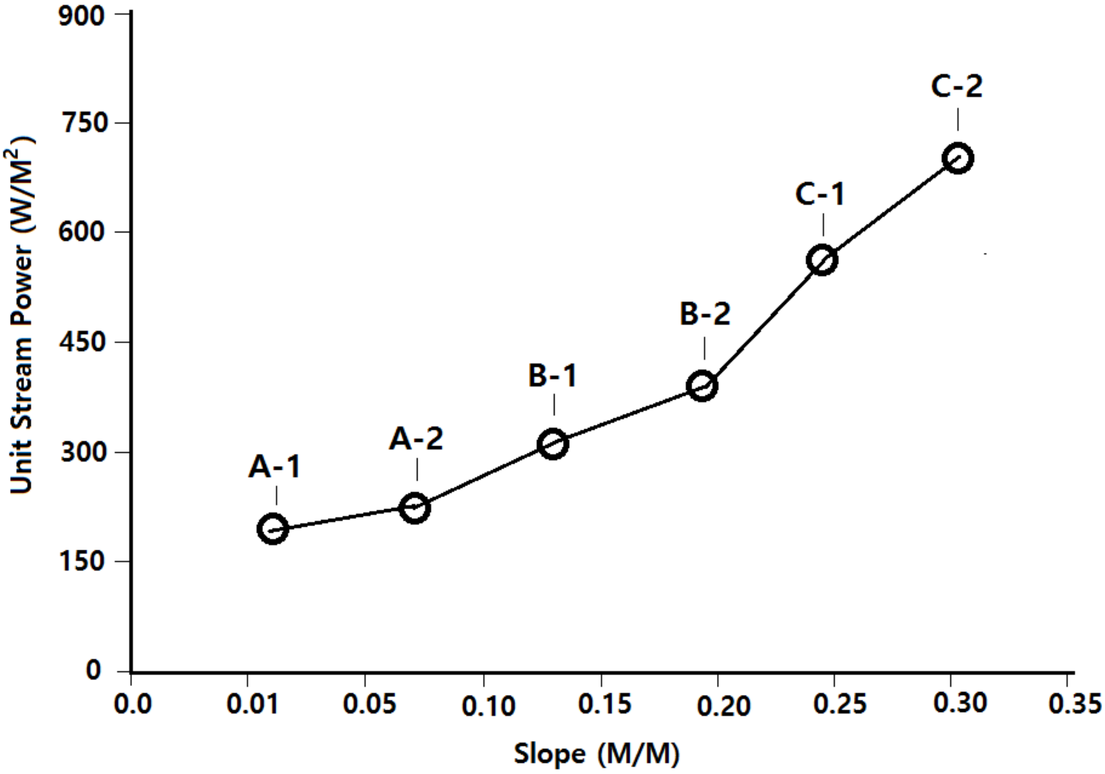

Figure 2. Relationship of unit stream power to gradient in Imgi Stream, Korea. Values for unit power are mean for the 20-year recurrence interval flood, across cross-sections of the 20-year floodplains. Data are based on Korea Meteorological Administration (KMA). A-1 – C-2 are the same as Fig. 1.

DISCUSSION

In any valley that is confined for part of its course within bedrock gorges or has reaches where the stream gradient is controlled by bedrock, flood severity will reflect bedrock influence (Baker and Costa, 1987). Stream gradient interacts significantly and deterministically with the width, depth and velocity of floods, the factors that control flood discharge and power along a reach (Bendix & Hupp, 2000). Increased stream gradient usually increases unit stream power (Fig. 2). Changes in river width, water depth or velocity are related to variation in channel geometry and flood intensity (Table 3). Great unit stream power experienced greater amounts of flood damage that resulted in artificial bedrock and impervious man-made structures at the Section A in Imgi Stream. Results indicate that unit stream power does have a significant effect on the riparian vegetation, but that the amount of that influence and its importance relative to the influence of height above the water table varies between watersheds (Bendix, 1999). The recognition and analysis of hydrogeomorphological influences on riparian vegetation are complicated by multiple scales of environmental interactions, by the covariance of some environmental variables, and by feedbacks between vegetation and flood regimes (Table 4).

BOD level was class clear 1 and mean value of BOD was 2.29 at the Section C (Table 5). However, mean of BOD was 5.115 mg/L. 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. 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. Stone dust was carried on the surface of particles and stone powders might cover the gills of the fish. It could be affected as one indicator of mortality of fishes.

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. 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 (Table 5). This increased acidification can result in a toxic environment that has a significant negative impact on the ecosystems of rivers (USEPA, 2002). The nation's waterways are brimming with excess nitrogen from fertilizer and plans to boost biofuel production threaten to aggravate an already serious situation. We need to either maintain or, in many cases, restore the integrity of this stream network, including small streams such as the Imgi Stream.

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