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River Health and Distribution of Riparian at the Tributary of Hakri River, Hapcheon-gun, Korea

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Keywords

Environmental factors,
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River Naturality.

Abstract

This study is to investigate the degree of river naturality according to the environmental factors and the flora on the tributary of Hakri River at three regions during four seasons. That of middle region was absent. Materials of river shore and river levee at low channel width were state of nature without protecting materials at low region. Those of middle and upper regions were many artificial levees. The flora on this river was a total of 73 taxa, including 28 families, 65 species, and 8 varieties. Naturalized species were 8 families and 24 species. The oxygen-demand parameters COD, and BOD were within unacceptable levels at middle and low regions. Many cement blocks were creating instead river grasslands by the Direct-stream Rivers Project and wide road construction. This artificial action reduced the water's natural filtration action.

Introduction

Riparian vegetation is increasingly being recognized for its importance in influencing the hydrology and morphology of fluvial systems (Tooth and Nanson, 1999). The existence of vegetation within fluvial settings has important roles for open channel hydraulics and flow resistance. Relationships exist between vegetation and flow velocities, with dense vegetation increasing flow resistance along the banks and on the floodplains (Erskine, 2002). For example, flow resistance induced by vegetation such as a tree falls into the channel or the flexible stems of the vegetation can dramatically change during a flood.

The relationship between riparian forest and the river is important. It provides a number of benefits to aquatic and terrestrial habitat and the species that live there. The removal and modification of vegetation in sensitive riparian areas has been a common land management practice in the past, and has had a number of significant impacts on the health of both terrestrial and aquatic ecosystems.

With regard to natural rivers, this vegetation forms a continuous belt from the river spring to the mouth. Increases in water resources development and utilization over the last 40 years have led to significant environmental and hydrological degradation in many Korean rivers (Ministry of Environment Republic of Korea, 2012). Most agricultural and urban land use practices, reduced water quality. The tributary of Hakri River is started at the low mountains and ends at the Hakri River. This river has provided water purification and flow rate of deceleration, and fish habitat. Recently the many aquatic plants of tributary of Hakri River were destroyed or damaged by wide road construction and the so-called Direct-stream Rivers Project. The purpose of this study is to investigate river morphology and the flora on the tributary of Hakri River at three regions. Therefore, this survey recorded material significance for the future appears in the environment to restore or improve the problem may be.

Materials and Methods

Surveyed Regions

This study was carried out on the tributary of Hakri River, located at Samga-meon province (upper region: 35°416′773″N/128°063′657″E, low region: 35°413′677″N/ 128°083′935″E), Hapcheon-gun in Korea (Fig. 1). Located to the north west of the city of Hapcheon, the tributary of Hakri River is approximately 2.3 kilometers in length with a varying width of between 2.0 and 4.5 meters. The flora and vegetation on the tributary of Hakri River were investigated at three regions and adjacent areas during four seasons.

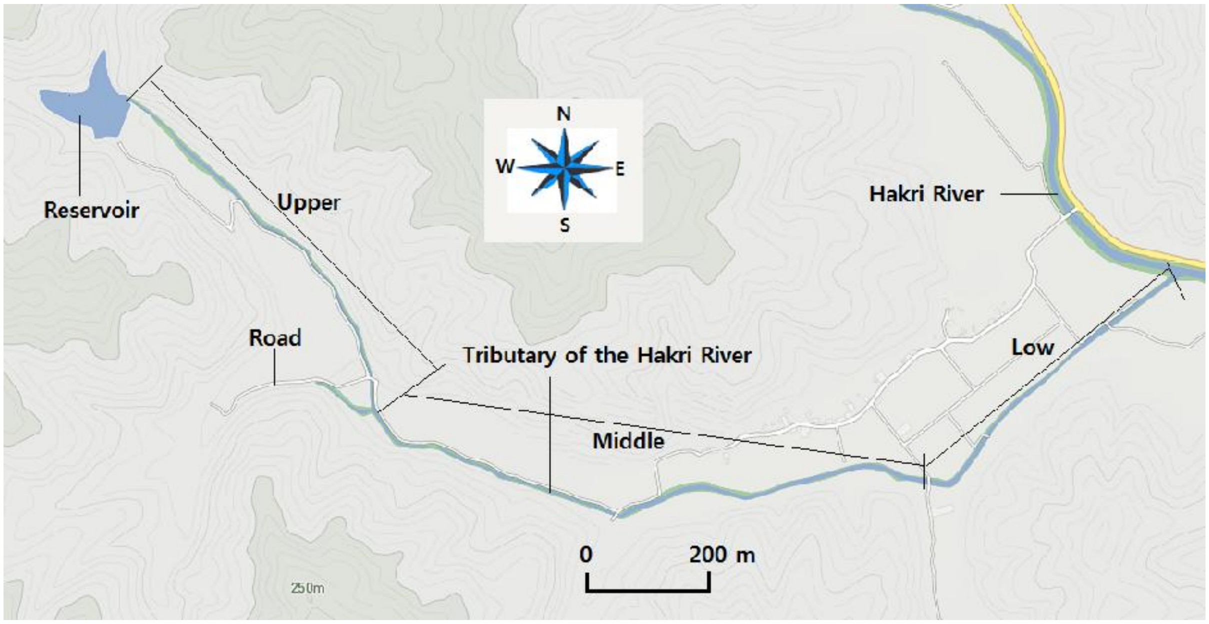

Figure 1: Location of the study area and the three detailed internodes at the tributary of Hakri River.

Index of degree of river structure

The three regions of tributary of Hakri River were divided by the geographic location with considering length of the river. 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). All plants of riparian vegetation were sampled in the field for the purpose of identification. The system of plant classification system was followed by Lee (2007). Naturalized plants were followed by Korea National Arboretum (2012).

Oxygen-demand parameters

The test for biochemical oxygen demand (BOD) is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter (Sawyer and McCarty, 1978). The change in DO concentration is measured over a given period of time in water samples at a specified temperature. 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). Total suspended solids (SS), total nitrogen (T-N), and phosphate (T-P) were calculated as described in Standard Methods for Water and Wastewater.

Results

Upper Region (upstream)

The river width at this region is about 2.0 m. The law water's edge vegetation and flood way vegetation were naturally formed a variety of vegetation communities (Table 2). Land use in riparian zones and flood plains within river levee were partly bush or grassland as natural floodplain. Land use in flood plains beyond river levee was artificial vegetation or natural vegetation mixed. Transverse direction of artificial structures was absent. The oxygen-demand parameters BOD and COD were within acceptable levels at upper region. 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 1.571.

Near shore and riparian vegetation provides habitat for many wildlife species (Table 3). Left and right riparian areas were distributed Pinaceae vegetation (*Pinus densiflora* and *Pinus rigida*) and Fegaceae vegetation (Quercus acutissima). Riverbed area was dominated by *Salix gracilistyla* community. Dominant species in flood plains were *Astragalus princeps* and *Trifolium repens.* The survey region was a total of 37 taxa, including 20 families, 35 species, and two varieties. Naturalized plants were 5 species.

Table 1: Index of degree of river naturality according to the environment factors

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
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 2: The degrees of river naturality according to the environment factors at the tributary of Hakri 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	Water quality (BOD)	Sleep width /river width ratio	Mean
Upper	1	1	1	3	1	2	2	1.571
Middle	1	2	1	5	1	2	3	2.143
Low	3	2	2	5	1	3	3	2.714

Table 3: List of vascular plants at the tributary of the Hakri River

Family	Species	Region			
		Upper	Middle	Low	
Equisetaceae	*Equisetum arvense* L.	○	○	○	
Aspidiaceae	*Athyrium vidalii* (Fr.et Sav.) Nakai	○			
Ginkoaceae	*Ginko biloba* L.	○	○		
Pinaceae	*Pinus densiflora* S. et Z.	○			
	Pinus rigida Mill.	○			
Salicaceae	*Salix gracilistyla* Miq.	○			
Fegaceae	*Quercus acutissima* Carruth.	○			
	Quercus dentata Thunb. ex Murray	○			
	Quercus variabilis Blume	○			

Moraceae	*Morus alba* L.			○	
Cannabinaceae	*Humulus japonicus* S. et Z.	○			
Urticaceae	*Boehmeria nivea* (L.) Gaudich.	○			
	Boehmeria platanifolia Fr. et Sav.	○			
Polygonaceae	*Persicaria hydropiper* (L.) Spach.		○	○	
	Persicaria thunbergii H. Gross	○			
	Rumex acetocella L.		○	○	NAT
	Rumex acetosa L.	○			
	Rumex crispus L.		○	○	NAT
	Rumex conglomeratus Murr.	○	○	○	NAT
Chenopodiaceae	*Chenopodium album var. centrorubrum* Makino		○	○	
	Chenopodium ficifolium Smith			○	NAT
Amaranthaceae	*Amaranthus lividus* L.		○		NAT
	Amaranthus patulus Bertoloni		○		NAT
Phytolaccaceae	*Phytolacca americana* L.			○	NAT
Portulacaceae	*Portulaca oleracea* L.		○		
Ranunculaceae	*Ranunculus japonicus* Thunb.		○	○	
Cruciferae	*Capsella bursa-pastoris* (L.) Medicus		○		
	Lepidium apetalum Willd.		○		NAT
	Lepidium virginicum L.			○	NAT
	Rorippa indica (L.) Hiern	○			
	Thlaspi arvense L.			○	NAT
Rosaceae	*Duchesnea chrysantha* (Zoll. et Morr.) Miquel	○			
	Potentilla fragarioides var. major Max.	○			
	Prunus serrulata var. spontanea (Max.) Wils.			○	
	Rosa multiflora Thunb.	○			
Leguminosae	*Amorpha fruticosa* L.	○	○		NAT
	Amphicarpaea edgeworthii var. trisperma Ohwi		○		
	Astragalus sinicus L.	○			NAT
	Kummerowia striata (Thunb.) Schindl.		○	○	
	Pueraria thunbergiana Benth.	○			
	Trifolium pratense L.		○	○	NAT
	Trifolium repens L.	○	○	○	NAT
Aceraceae	*Acer pseudo-sibolianum* (Paxton) Kom.	○			
Oxalidaceae	*Oxalis corniculata* L.		○	○	
Violaceae	*Viola mandshurica* W. Becker	○			
Onagraceae	*Oenothera odorata* Jacq.	○	○	○	NAT
Umbelliferae	*Oenanthe javanica* (Bl.) DC.	○	○		
Oleaceae	*Forsythia koreana* Nakai		○		
Plantaginaceae	*Plantago asiatica* L.	○	○	○	
Caprifoliaceae	*Lonicera japonica* Thunb.	○			
Compositae	*Ambrosia artemisiifolia var. elatior* Descourtils			○	NAT
	Artemisia princeps Pampan.	○	○	○	
	Aster ciliosus Kitamura		○		
	Bidens bipinnata L.			○	

	Cirsium japonicum var. ussuriense Kitamura		○		
	Cosmos bipinnatus Cav.	○		○	NAT
	Conyza canadensis L.		○		NAT
	Erechtites hieracifolia Raf.			○	NAT
	Erigeron annuas (L.) Pers.		○	○	NAT
	Galingosa ciliate Blake	○			NAT
	Taraxacum officinale Weber			○	NAT
	Xanthium strumarium L.	○		○	NAT
Gramineae	*Avena fatua* L.		○	○	NAT
	Argostis clavata var. nukabo Ohwi.		○		
	Cymbopogon tortilis var. goeringii Hand-Mazz.		○		
	Digitaria sanguinalis (L.) Scop.	○	○		
	Echinochloa crus-galli (L.) Beauv.		○		
	Miscanthus sacchariflorus Benth.	○		○	
	Miscanthus sinensis var. purpurascens Rendle	○	○		
	Phragmites japonica Steud.		○	○	
	Poa sphondylodes Trin.		○		
	Setaria viridis (L.) Beauv.			○	
	Zoysia japonica Steud.	○		○	

NAT: Naturalized plants.

The tributary of Hakri River has a pH up to 7.51 (Table 4). The average value of DO was 7.61 mg/ l. The average value of BOD and COD were 1.52 mg/ l and 1.73 mg/l, respectively. The amounts of suspended solids (SS), total nitrogen (T-N), and phosphate (T-P) in the river were 14.95 mg/ l, 0.06 mg/ l, and 0.04 mg/l, respectively.

Middle Region (middle-stream)

The river width at the region is about 3.0 m. The law water's edge vegetation was naturally formed a variety of vegetation communities (Table 2). The flood way vegetation was naturally formed various vegetation communities by natural erosion and sand bar was absent. Land use in riparian zones and flood plains within river levee were partly bush or grassland as natural floodplain. Land use in flood plains beyond river levee was impervious man-made structures, parking, etc. Transverse direction of artificial structures was absent. The oxygen-demand parameters BOD and COD were within acceptable levels at upper region. 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 2.143.

There were occurred in *Equisetum arvense*, *Ginko biloba*, *Persicaria hydropiper*, *Rumex acetocella*, *Rumex crispus*, *Chenopodium album var. centrorubrum*, *Amaranthus lividus* and so on (Table 3). The survey region was a total of 35 taxa, including 15 families, 30 species, and 5 varieties. Naturalized plants were 13 species.

The pH was a mean of 7.48 (Table 4). The average value of DO was 7.40 mg/ l. The average value of BOD and COD were 2.29 mg/ l and 2.04 mg/l, respectively. The amounts of suspended solids (SS), total nitrogen (T-N), and phosphate (T-P) in the river were 16.47 mg/ l, 0.08 mg/ l, and 0.07 mg/l, respectively.

Table 4: Water quality at four stations in the studied areas

Item	St. A	St. B	St. C	St. D
pH	7.51±0.08	7.48±0.16	7.32±0.0.14	7.24±0.04
DO (㎎/L)	7.62±0.17	7.40±0.07	6.03±0.41	4.95±0.41
BOD (㎎/L)	1.52±0.49	2.29±0.30	2.43±0.78	2.88±0.33
COD (㎎/L)	1.73±0.51	2.04±0.11	2.93±0.87	4.13±0.49
SS (㎎/L)	14.95±1.33	16.47±2.75	17.78±2.17	19.67±2.01
T-N (㎎/L)	0.06±0.02	0.08±0.02	0.11±0.01	0.15±0.03
T-P (㎎/L)	0.04±0.01	0.07±0.02	0.08±0.01	0.10±0.02

Low Region (downstream)

The river width at the region was about 4.5 m. The law water's edge vegetation was natural weeds, shrubs, and mixed (Table 2). The flood way vegetation was naturally formed various vegetation communities by natural erosion and sand bar was absent. Land use in riparian zones and flood plains within river levee were arable lands (paddy fields, orchards). Land use in flood plains beyond river levee was impervious man-made structures, parking, etc. Transverse direction of artificial structures was absent. The oxygen-demand parameters BOD and COD were not good at low region. 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 2.714.

There were occurred in *Equisetum arvense, Morus alba, Persicaria hydropiper, Rumex acetocella, Rumex crispus, Rumex conglomeratus, Chenopodium album var. centrorubrum, Chenopodium ficifolium* and so on (Table 3). The survey region was a total of 32 taxa, including 14 families, 29 species, and 3 varieties. Naturalized plants were 16 species.

The pH was a mean of 7.32 (Table 4). The average value of DO was 6.03 mg/ l. The average value of BOD and COD were 2.43 mg/ l and 2.93 mg/l, respectively. The amounts of suspended solids (SS), total nitrogen (T-N), and phosphate (T-P) in the river were 17.78 mg/ l, 0.11 mg/ l, and 0.08 mg/l, respectively

Discussion

Riparian vegetation provides terrestrial and aquatic fauna habitat, food, access to water, refuge from predators and extreme weather and acts as a corridor for wildlife to pass from one area to another. The vegetated zone also provides a local microclimate with less extreme temperatures and more humid conditions than the local area (Lovett and Price, 2007). Understanding watershed structure and natural processes is crucial to grasping how human activity can degrade or improve the condition of a watershed, including its water quality, its fish and wildlife, its forests and other vegetation, and the quality of community life for people who live there (Klapproth and Johnson, 2000). In recent years the deterioration of vegetation formations around the upper region of the tributary of Hakri River has increased at an alarming rate. For example, the oxygen-demand parameters COD, and BOD were within unacceptable levels at middle and low regions (Table 4). The portion of BOD and COD in the river increased exponentially along the upper-down gradient. This artificial action reduced the water's natural filtration action. Riparian area is the transition area between water and land regions.

The portion of suspended solids (SS), total nitrogen (T-N), and phosphate (T-P) in the river increased exponentially along the upper-down gradient. T-N also has a significant influence at the lowstream. They are important as pollutants in water system. Fertilizer supplies of N and P are the most important impacts on water quality. One of the most important impacts of N on the environment is that on water quality. Because N as well as P are frequently the nutrient most limiting biological productivity in estuaries (Vitousek et al. 1997), inputs of soil and fertilizer N from agricultural fields can be a major contributor to N-induced eutrophication. 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 (USEPA, 2002). Thus there was decreased the number of species in this river. Many artificial actions reduced the water's natural filtration action and eliminated many species at their habitat in the tributary of Hakri River.

Although it is often difficult to determine its exact boundaries on ecosystem, the riparian is recognized producers as an important ecological value of vegetation. The tributary of the Hakri River was characterized a lot of riparian at ten year ago. Generally, the Pacific side of Korea has heavy rain in June or July (rainy season) between August and October (Typhoons) in a short time. The heavy storms results in widespread landslides and extensive flood discharges. Suddenly flood events from the mountains have influenced riparian vegetation and sand dunes directly through inundation, mechanical damage, and indirectly through changes in channel morphology. Many cement blocks at upper region were creating instead river grasslands by the Direct-stream Rivers Project and wide road construction. Riparian areas have been reduced. In considering limited water supplies at tributary of the Hakri River basin and possible short- or long-term reductions in water availability, it is natural to consider how water supplies might be augmented (Moorhouse and Elliff, 2002). The traditional approach was by constructing storage reservoirs. However, for a number of reasons, including costs and potential environmental impacts, prospects for constructing small-scale water projects today are much less likely than in the past (Nilsson et al., 2003; Ogg and Keith, 2002).

In summary, reduced flows are a major cause of reduced river health at the tributary of the Hakri River. However, the full impacts of the current level of abstraction and other changes to the water's edge vegetation. The various ecological and geomorphic responses to the altered conditions that have been imposed will require many decades to complete.

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