Evaluation of River Health and Water Quantity at the Anseong River, Changwon City, Korea

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***Abstract*— The paper aims to analyse the degree of river naturality according to the river morphology and the flora at raparian regions on the Anseong River during four seasons. Number of flexion was one at upper and low regions. That of middle region was absent. Bed materials were boulders and gravel in upper region and sand, silt, and clay in middle and low regions. Material of river shore at low channel width was the state of nature without protecting materials at upper region, but that was concreted impervious. Those of middle and upper regions were many artificial levees. The flora on the Anseong River was a total of 61 taxa, including 25 families, 54 species, and 7 varieties. 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.**

***Index Terms*— Anseong River, river morphology, river naturality.**

I. INTRODUCTION

Rain water flowing down slopes comes together to form a stream flow. River morphology is the shape or form of a river along its length and across its width. River morphology is decided many factors such as river width and depth, water surface slope, water velocity, water edge's vegetation, river bed materials, and land use in riparian zones, etc. [1].

Throughout geological history, river changes in base level as a result of tectonic or isostatic forcing have a direct impact on the longitudinal profile form of a fluvial channel. Rivers have altered their channels through erosion and deposition or human intervention [2].

Humans are affected on rivers directly or indirectly by changing land use in river morphology. They also simultaneously accelerate and decelerate fluxes of water, sediments, and nutrients on a scale that exceeds natural filtration action [3]. One of worldwide problems appears to be much nutrients and trace element fluxes by both due to agricultural and urban pollution.

Rapid population growth has already increased aggregate water demand to the point that it exceeds the available water supply in some years. Increases in water resources development and utilization over the last 40 years have led to significant environmental and hydrological degradation in many Korean rivers [4]. Most agricultural and urban land use practices, reduced water quality [3].

The Anseong River is started at the low mountains and ends at the Pacific Ocean. Many factors influence the morphology of the Anseong River system. Urbanization in this region and near areas strongly impacts river flood characteristics. Road construction is another cause of changes in sediment flux of the Anseong River. The many aquatic plants of the Anseong River were destroyed or damaged by wide road construction and the so-called Direct-stream River Project.

The purpose of this study is to investigate river morphology and the flora on the Anseong 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.

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II. MATERIALS AND METHODS

A. Surveyed regions

This study was carried out on the Anseong River, located at Anseong province (upper region: 35°103′104″N/128°796′354″E, low region: 35°102′153″N/128°791′673″E), Changwon city in Korea (Fig. 1). In this region, the mean annual temperature is 14.9 ℃ with the maximum temperature being 26.5℃ in August and the minimum 2.8 ℃ in January. Mean annual precipitation is about 1545.4 mm. Geographical ranges of the Anseong River were a total length of 766 meters from the Anseong Resovoir to the confluence of the Pacific Ocean. The flora and vegetation on the Anseong River were investigated at three regions and adjacent areas during four seasons.

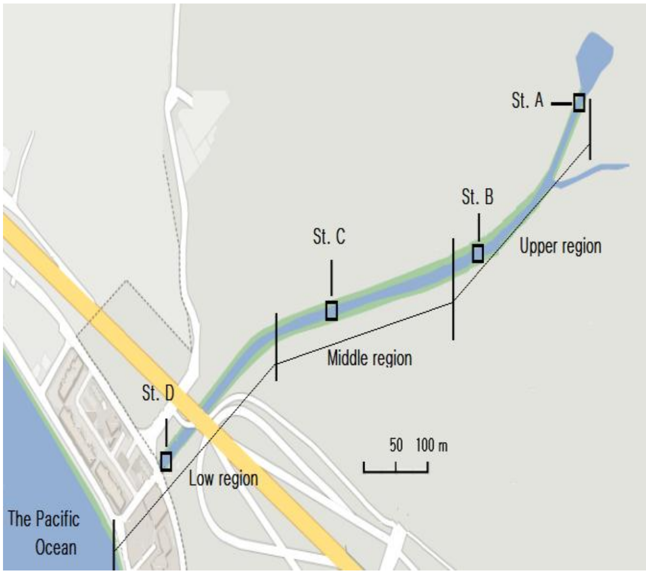

Figure 1: The four surveyed locations and three regions at the Anseong River.

B. Index of degree of river structure and identification of species

The three regions of Anseong 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. River terminology was followed by Hutchinson [5]. All plants of riparian vegetation were identified. The system of plant classification system was followed by Lee [6]. Naturalized plants were followed by Korea National Arboretum [7].

C. BOD and COD measurements

The test for biochemical oxygen demand (BOD) is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter [8]. 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) [9]. COD is a widely known parameter used to measure water quality using the 910 colorimeter (YSI Incorporated, Ohio, USA).

III. Results

A. Upper region

The river width at this region is about 2.0 m. Number of flexion was one (the score of degree is 4) in this region (Table 3). Transversal and longitudinal sandbar was one. Velocity of flood was fast. Bed materials were composed of boulders and gravel. Diversity of low channel width was slight. Materials of river shore and river levee at low channel width were composed of state of nature without protecting materials or artificial levee. Mean score for river naturality according to the river morphology was 2.57. The law water's edge vegetation and flood way vegetation were shown naturally formed a variety of vegetation communities (Table 4). Land use in riparian zones and flood plains within river levee were bush or grassland as natural floodplain. Transverse direction of artificial structures was slope waterway reservoir. The ratio of sleep width/river width was 20% or more. The oxygen-demand parameters BOD and COD were within acceptable levels at upper region (Fig. 2). The average values of BOD and COD at St. A and St. B were 3.80 mg/l and 3.64 mg/l, respectively. Near shore and riparian vegetation provides habitat for many wildlife species (Table 5). Dominant species in flood plains and riparian areas were *Pueraria thunbergiana* and *Miscanthus sacchariflorus.* The survey region was a total of 33 taxa, including 20 families, 31 species, and two varieties. Naturalized plants were six species.

B. Middle region

The river width at the region is about 3.2 m. Number of flexion was absent in this region (Table 3). Transversal and longitudinal sandbars were none. Velocity of flood was slight. Bed materials were composed of sand, silt, and clay. Diversity of low channel width was moderate. Materials of river shore at low channel width were composed of natural materials and artificial vegetation. Materials of river levee at low channel width were state of nature without artificial levee. Mean score for river naturality according to the river morphology was 3.0. The law water's edge vegetation communities were natural weeds, shurbs and mixed (Table 4). The flood way vegetation was shown both of natural vegetation and artificial vegetation. Land use in riparian zones were arable land (paddy fields, orchards). Transverse direction of artificial structures was made fish migration difficulty. The ratio of sleep width/river width was 10-20%. The average values of BOD and COD four seasons were 5.31 mg/l and 5.73 mg/l, respectively (Fig. 2). There were occurred in *Rumex acetocella*, *Rumex crispus*, *Persicaria hydropiper*, and *Oenothera odorata* (Table 5). The survey region was a total of 33 taxa, including 14 families, 29 species, and 4 varieties. Naturalized plants were 10 species

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 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 Anseong 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	4	4	2	2	4	1	1	2.57
Middle	5	5	2	3	3	2	1	3.00
Low	4	5	4	4	2	5	3	3.86

Table 4. Index of degree of river naturality according to the environment of river at the Anseong 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	2	1	1	2	1	1.33
Middle	3	3	2	3	4	2	2.83
Low	5	4	5	5	1	2	3.67

Table 5. List of vascular plants at the Anseong River

Family	Species	Region			
		Upper	Middle	Low	
Equisetaceae	*Equisetum arvense* L.	○			
Aspidiaceae	*Athyrium niponicum* Hance	○			
	Athyrium vidalii (Fr.et Sav.) Nakai	○			
Ginkgoceae	*Ginko biloba* L.		○	○	
Pinaceae	*Pinus densiflora* S. et Z.	○			
	Pinus rigida Mill.	○			
Salicaceae	*Salix gracilistyla* Miq.	○			
Fegaceae	*Castanea crenata* Sieb. et Zucc.	○			
	Quercus acutissima Carruth.	○			
Moraceae	*Morus alba* L.	○	○		
Cannabinaceae	*Humulus japonicus* S. et Z.	○	○		
Polygonaceae	*Persicaria hydropiper* (L.) Spach.	○			
	Rumex acetocella L.		○		NAT
	Rumex acetosa L.	○	○	○	
	Rumex crispus L.		○		NAT
	Rumex conglomeratus Murr.		○	○	NAT
Chenopodiaceae	*Chenopodium album* var. *centrorubrum* Makino		○	○	
	Chenopodium ficifloium Smith		○		
Amaranthaceae	*Achyranthes japonica* (Miq.) Nakai	○	○		
	Amaranthus lividus L.	○			NAT
Phytolaccaceae	*Phytolacca americana* L.	○	○		NAT
Portulacaceae	*Portulaca oleracea* L.		○		
Caryophyllaceae	*Pseudostellaria heterophylla* (Miq.) Pax.	○		○	
Ranunculaceae	*Ranunculus japonicus* Thunb.			○	
Cruciferae	*Brassica campestris* spp. *napus* var. *nippo-pleifera* Makino		○		
	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.	○			
	Rosa multiflora Thunb.	○			
Leguminosae	*Amorpha fruticosa* L.		○		NAT
	Amphicarpaea edgeworthii var. *trisperma* Ohwi	○			
	Kummerowia striata (Thunb.) Schindl.		○		
	Robinia pseudo-acacia L.	○			
	Pueraria thunbergiana Benth.	○	○		
	Trifolium pratense L.	○		○	NAT
	Trifolium repens L.	○		○	NAT
Violaceae	*Viola mandshurica* W. Becker	○			
Onagraceae	*Oenothera odorata* Jacq.	○		○	NAT
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		○		
	Conyza canadensis L.		○	○	NAT
	Cosmos bipinnatus Cav.			○	NAT
	Erechtites hieracifolia Raf.			○	NAT
	Erigeron annuas (L.) Pers.		○	○	NAT
	Taraxacum officinale Weber		○		NAT
	Xanthium strumarium L.		○	○	NAT
Gramineae	*Miscanthus sacchariflorus* Benth.	○	○		
	Miscanthus sinensis var. *purpurascens* Rendle		○	○	
	Poa sphondylodes Trin.	○			
	Setaria viridis (L.) Beauv.		○	○	
	Zoysia japonica Steud.	○	○		

NAT: Naturalized plants.

C. *Low region*

The river width at the region was about 4.0 m. Number of flexion was one in this region (Table 3). Transversal and longitudinal sandbar was absent. Velocity of flood was slight. Bed materials were composed of silt and clay. Diversity of low channel width was large. Materials of river shore at low channel width were concreted impervious. Materials of river levee at low channel width were composed of stonework and natural type block with artificial vegetation. The law water's edge vegetation was vegetation blocked by stonework, etc (Table 4). The flood way vegetation was artificial vegetation. Land use in riparian zones within river levee was 1/2 or more urban resident. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 10~20%. The average value of BOD and COD were 5.40 mg/l and 6.23 mg/l, respectively (Fig. 2). There were occurred in *Rumex acetosa*, *Rorippa indica*, and *Plantago asiatica* (Table 5). The surveyed region was a total of 22 taxa, including 12 families, 19 species, and 3 varieties. Naturalized plants were 10 species.

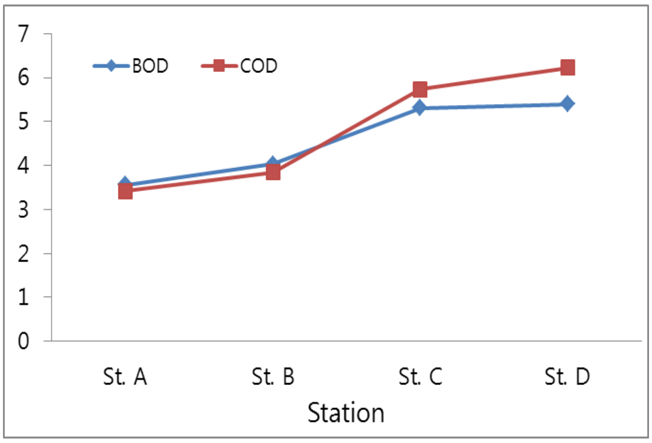

Figure 2: Water quality at four stations of three regions in the studied areas.

IV. Discussion

In recent years the deterioration of vegetation formations around the middle and low regions of the Anseong River has increased at an alarming rate. Activities such as clearing forests for construction of houses, and building roads can put too much soil and particulate matter in rivers. This sediment can harm plants and animals by carrying toxic chemicals into the water, smothering fish eggs and small organisms used by fish as food and reducing the amount of sunlight penetrating the water. Thus, the oxygen-demand parameters COD and BOD were within unacceptable levels at low regions (Fig. 2). This artificial action reduced the water's natural filtration action. Riparian area is the transition area between water and land regions [10].

People can pollute the lands and water resources. They affect the quality of rainwater and of water resources both above and below ground, and damage natural systems. 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. The Anseong River after the construction of the cement blocks has brought a lot of changes. Riparian areas have been reduced. In considering limited water supplies in the Anseong River basin and possible short- or long-term reductions in water availability, it is natural to consider how water supplies might be augmented [11]. 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 [12].

V. Conclusions

The reduced flows are a major cause of reduced river health in the Anseong 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. The problem of water pollution is the overall lack of adequate information about the quality of water around the Anseong River and its river morphology.

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