FLUVIAL MORPHOLOGY AND WATER QUANTITY AT UNAM STREAM, UIRYEONG-GUN IN KOREA

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ABSTRACT

There has been a recent, increased awareness that the fate of water quantity, quality, and ecological status is strongly dependent on an array of human activities. This study was carried out on the Unam Stream located at Unam-ri, Uirjeong-gun, Gyeongsangnam-do province in Korea. Index of degree of river structure according to the river morphology and river naturality was analyzed. Transversal & longitudinal sandbars at upper section were eight and velocity of flood was moderate. The law water's edge vegetation and flood way vegetation were shown naturally formed various vegetation communities by natural erosion (sediment exposure) were absent. The average value of biological oxygen demand (BOD) and chemical oxygen demand (COD) were 2.56 mg/L and 2.44 mg/L, respectively. At the Section B, the average values of BOD, dissolved oxygen (DO), and COD were 2.72, 5.69, and 2.56 mg/L, respectively. The average values of BOD and COD at low region were higher than those of at high regions, a and b. Total phosphorus and nitrogen were higher than those of at stations a and b. The value for index of degree of river structure at Sections A, B, and C were a mean of 2.14, 2.86, and 3.29, respectively. The values for index of degree of river naturality according to the environment factors at Sections A, B, and C were a mean of 2.50, 2.67, and 2.33, respectively.

Keywords: BOD, COD, Unam Stream, river morphology, river naturality.

INTRODUCTION

Rivers begin in mountains or hills, where rain water or snow melt collects and forms tiny streams called gullies. When one stream meets another and they merge together, the smaller stream is known as a tributary. The two streams meet at a confluence. It takes many tributary streams to form a river. River systems in the industrialized world today have largely lost their original characteristics. Primarily evident is the disappearance of channel patterns of preindustrial rivers (Hohensinner et al., 2018). Such patterns range from deeply incised bedrock channels (gorges) in the headwaters to alluvial anastomosing rivers in the lowlands close to the estuary.

Understanding the complex spatiotemporal nature of river landscapes is an essential prerequisite for sustainable and integrative river restoration.

Physical habitat of rivers or streams is the living space of instream biota; it is a spatially and temporally dynamic entity determined by the interaction of the structural features of the channel and the hydrological regime (Maddock, 1999). A better understanding of the ways in which the spatial and temporal dynamics of physical habitat of streams determine stream health, and how these elements can be incorporated into assessment methods, remains a key research goal (Smith et al, 2021).

The morphology and behavior of channels have long been considered a sensitive indicator of the ‘state’ of any river as well as a record of processes acting within a watershed. . Rather than routing all sediment through quickly, rivers will typically store sediment within a variety of depositional sites. Short term storage occurs in channel bars and in the channel bed. Intermediate storage occurs within the flood plain. Long-term storage occurs within elevated alluvial terraces. Declines in capacity and competence lead to deposition within all of these sites. Excessive stream power or declines in sediment supply can cause a river to selectively erode material in these sites. A river balances and minimizes its energy expenditures through adjustment of its channel cross section. Along the entire length of a river the shape and size of an infinite number of cross sections are in constant variation, adapting to the discharge and sediment load that is delivered to it by the channel reach that lies immediately upstream. In aggregate these adjustments produce the distinctive channel patterns that record the establishment of dynamic equilibrium within the overall river system.

While physical hydrologists focus on water quantity and supply, water quality is of fundamental concern for ecological and human health. Source water quantity and quality have always been critical for drinking water treatment and distribution systems. Asia has 60% of the world's population but only 36% of the world's freshwater (Zimmerman et al., 2008), a distribution that is not expected to change in the coming decades. Extensive alteration of global climate and the associated changes in water resource distribution and water utilization will challenge engineered systems designed around the expectation of a stationary hydrologic cycle (Wu et al., 2017; Alcamo, 2019).

There has been a recent, increased awareness that the fate of water quantity, quality, and ecological status is strongly dependent on an array of human activities hence the need to engage and cooperate with stakeholders from the planning to the implementation stage of the management process.

Human activities are the major drivers for generating multiple pressures (Grizzetti et al., 2016). Pressures affect the biodiversity and the status of the aquatic ecosystem, which can result in a change in the ecosystem services and their economic value. The excessive exploitation of ecosystem services can turn into a pressure for an ecosystem. For this reason is important to consider the resilience of the system and to introduce the notion of sustainability when assessing the delivery of ecosystem services

One of the main aims in this study I assess the river or stream health is by looking at the key values they support, which reflect their structure, biological and chemical importance. These values are in turn supported by river conditions: the overall state of the river health and key processes vital to its ecosystem.

METHODOLOGY

Surveyed Regions

This study was carried out on the Unam Stream (upper region: 35.35040251346756N, 128.22086350451E. low region: 35.32923380995035N, 128.2251213481324E), located at Unam-ri, Uirjeong-gun, Gyeongsangnam-do province in Korea (Fig. 1). Geographical ranges of the Unam Stream were a total length of 1.627 kilometers from the two high mountain (600 m and 610 m) to the confluence of the Uiryeong River. Lowlands are usually no higher than 100 m, while uplands are somewhere around 125 m. There are two reservoirs at the top of the river. The river originating from a larger reservoir is a tributary. Reservoirs are for agricultural use. In agriculture, a field isan area of land, enclosed or otherwise, used for agricultural purposes such as cultivating crops such as rice, cabbages, and radishes.

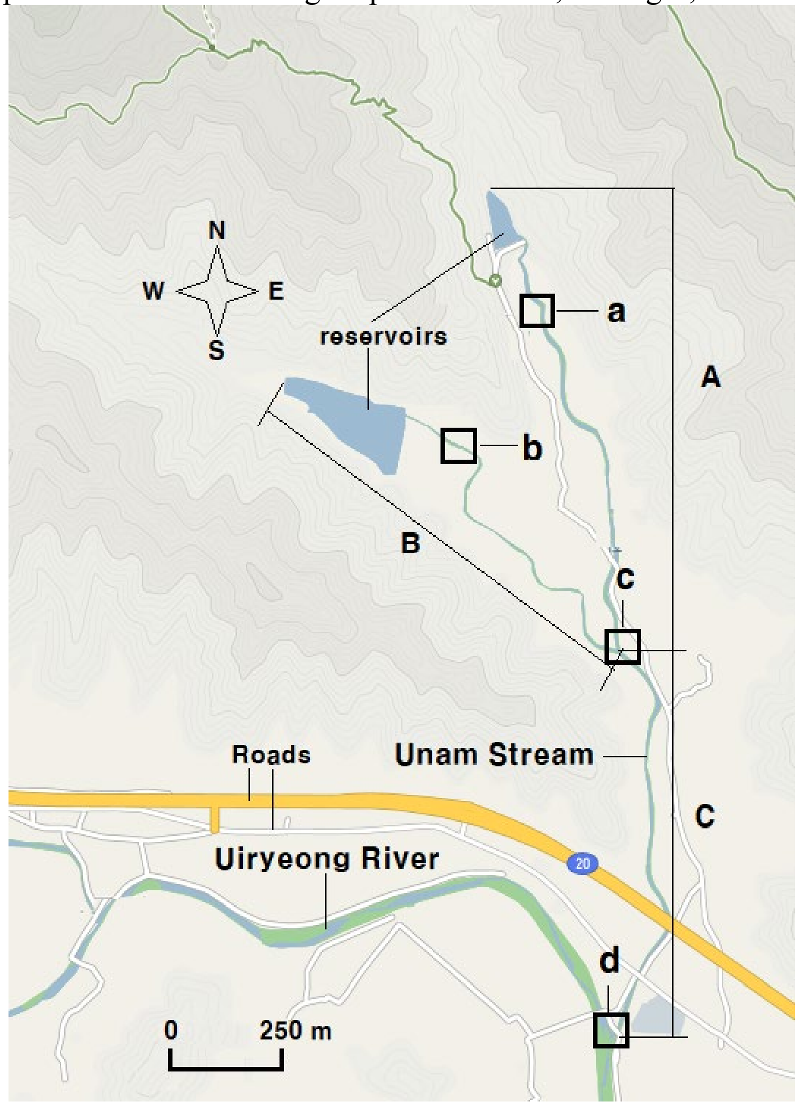

Figure 1. The three sections (A, B, and C) for fluvial morphology and four stations (St. a, b, c, and d) for water quantity fish at the Unam Stream in Korea.

Index of degree of river structure

The three sections of Unam Stream were divided by the geographic location with considering physical length of the stream (Fig. 1). It was divided from the upper stream to the middle and from the middle to the downstream. Index of degree of river or stream structure according to the river morphology was analyzed according to Table 1. Seven items, including the structure of the river, such as number of flexion, were analyzed. Index of degree of river naturality according to the environment of river was also analyzed according to Table 2. Six items, including the structure of the river, such as the law water's edge vegetation, were analyzed.

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 (T-P) and total nitrogen (T-N) 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. Total organic carbon (TOC) is the amount of carbon found in an organic compound and is often used as a non-specific indicator of water quality and was used Giner On-line TOC Modular Analyzer.

RESULTS

A section and station a

The mean stream width at this region is about 3.2 m. Number of flexion was five in this region (Table 3). Transversal & longitudinal sandbars were eight. Velocity of flood was moderate. Bed materials were more than 50% of sand, silt, and clay. Diversity of channel width was slight. Materials of river shore and river levee at low channel width were state of nature without protecting materials. Materials of river levee at low channel width were artificial soil-levee (natural vegetation, and lawn). The value for index of degree of river structure was 2.14.

The law water's edge vegetation and flood way vegetation were shown naturally formed various vegetation communities by natural erosion (sediment exposure) were absent (Table 4). Flood way vegetation was naturally formed a variety of vegetation communities. Land use in riparian zones and flood plains within river levee were bush or grassland as natural floodplain. Land use in flood plains beyond river levee was arable land or manmade artificial vegetation. Transverse direction of artificial structures were reservoir of height 0.3-0.4 m, fish migration difficulty. The ratio of sleep width/river width was 1-5%. The value for index of degree of river naturality according to the environment factors was a mean of 2.50.

The average value of BOD and COD were 2.56 mg/L and 2.44 mg/L, respectively (Fig. 2). BOD and COD values of water sample from the Unam Stream were found to be within the limit (Current National Recommended Water Quality Criteria). The average value of DO was 5.84 ㎎/L. TOC was 3.17 ㎎/L. T-N and T-P were 0.02 ㎎/L and 0.07 ㎎/L, respectively (Fig. 3). The mean of pH was 7.03 across stations, varying from 6.98 (spring season) to 7.08 (winter season) (Fig. 2). Mean value of suspended solids (SS) was 4.12 ㎎/L.

B section and station b

The mean river width at the region is about 3.0 m. Number of flexion was five (the estimated index and score is 1) in this region (Table 3). Transversal & longitudinal sandbars were five. Velocity of flood was slight. Bed materials were more than 50% of sand, silt, and clay. Diversity of channel width was slight. Diversity of channel width was slight. Materials of river shore and river levee at low channel width were the mixes of natural materials and artificial vegetation. Materials of river levee at low channel width were some stonework, impervious levee with concrete.

The law water's edge vegetation and flood way vegetation were shown naturally formed various vegetation communities by natural erosion (sediment exposure) were absent (Table 4). The flood way vegetation was naturally formed various vegetation communities and natural erosion (sand bar) was absent. Land use in riparian zones and flood plains within river levee were bush

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or grassland as natural floodplain. 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 1-5%. The value for index of degree of river naturality according to the environment factors was a mean of 2.67.

As a result of an analysis about environmental factors for water quality in each surveyed sites, the most effective groups were, pH, COD, DO, TOC, SS, T-N, and T-P excluding BOD. BOD is an indication of water contamination by organic materials and bacteria, especially from sewage water. The average values of BOD, DO, and COD were 2.72, 5.69, and 2.56 mg/L, respectively (Fig.2). BOD and COD values of water sample from the Unam Stream were found to be within the limit (Current National Recommended Water Quality Criteria). The average value of DO was 5.69 ㎎/L. TOC was 3.21 ㎎/L. T-N and T-P were 0.02 ㎎/L and 0.10 ㎎/L, respectively (Fig. 3). The mean of pH was 7.01 across stations, varying from 6.86 (spring season) to 7.11 (winter season) (Fig. 2). Mean value of suspended solids (SS) was 4.11 ㎎/L.

C section and stations c, d

The mean river width at the region was about 11.2 m. Number of flexion was three in this region (Table 3). Transversal & longitudinal sandbars were two. Velocity of flood was slight. Bed materials were more than 50% of sand, silt, and clay. Diversity of channel width was slight. Diversity of channel width was slight. Materials of river shore and river levee at low channel width were the mixes of natural materials and artificial vegetation. Materials of river levee at low channel width were some stonework, natural type blocks with artificial vegetation.

The law water's edge vegetation and flood way vegetation were shown naturally formed a variety of vegetation communities (Table 4). Land uses in riparian zones were bush or grassland as natural floodplain. Land use in flood planes beyond river levee were impervious man-made structures, parking, etc. Transverse direction of artificial structures was bypass reservoir or slope waterway reservoir. The ratio of sleep width/river width was less than 1%. The mean values of pH at stations c and d were 6.83 and 6.82, respectively (Fig. 4). The average values of DO at same stations were 3.12 and 3.37 ㎎/L, respectively. The average values of BOD and COD at stations c and d were higher than those of at stations a and b. The BOD and COD values of water sample from the Unam 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 at stations c and d were higher than those of at stations a and b.

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 Unam Stream according to the river morphology

Section	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
A	1	1	3	3	4	1	2	2.14
B	2	1	4	3	4	2	5	2.86
C	2	4	4	3	4	2	3	3.29

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

Section	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
A	2	1	1	2	4	5	2.50
B	2	2	1	2	5	4	2.67
C	1	1	1	4	2	5	2.33

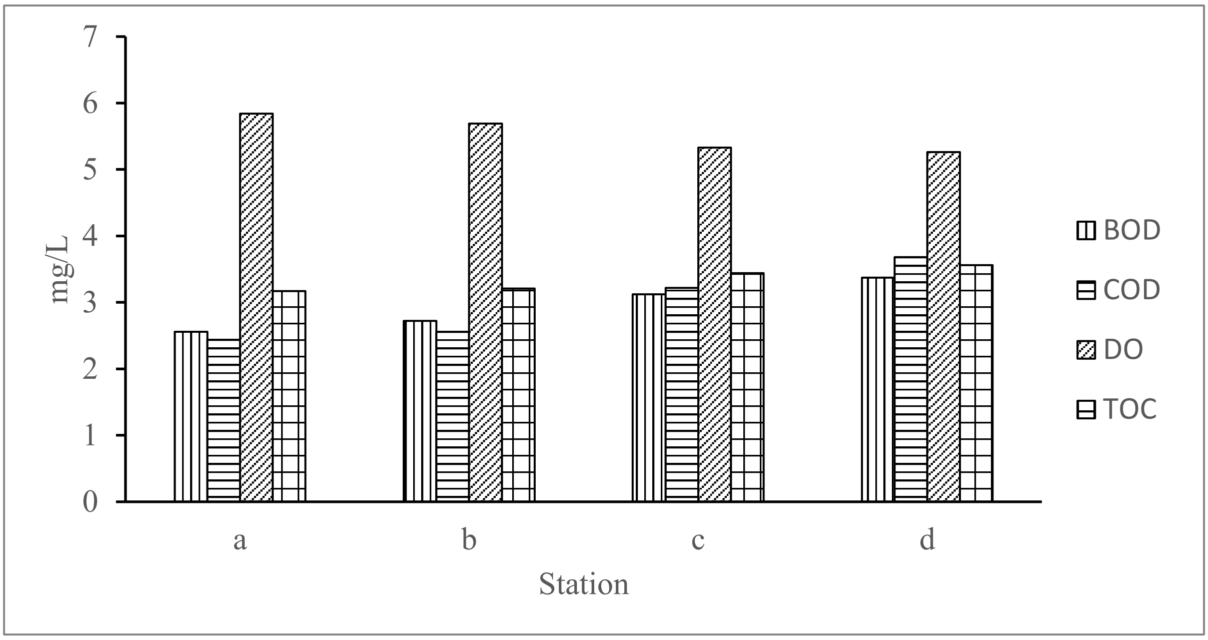

Figure 1. Relationship of unit stream power to gradient in Unam Stream, Korea. Values for unit power are mean for the 20-year recurrence interval flood, across cross-sections of the 20-year floodplains. Data are based on Korea Meteorological Administration (KMA). A-1 – C-2 are the same as Fig. 1.

Fig. 2. The change in dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) for four stations at the Unam Stream in Korea.

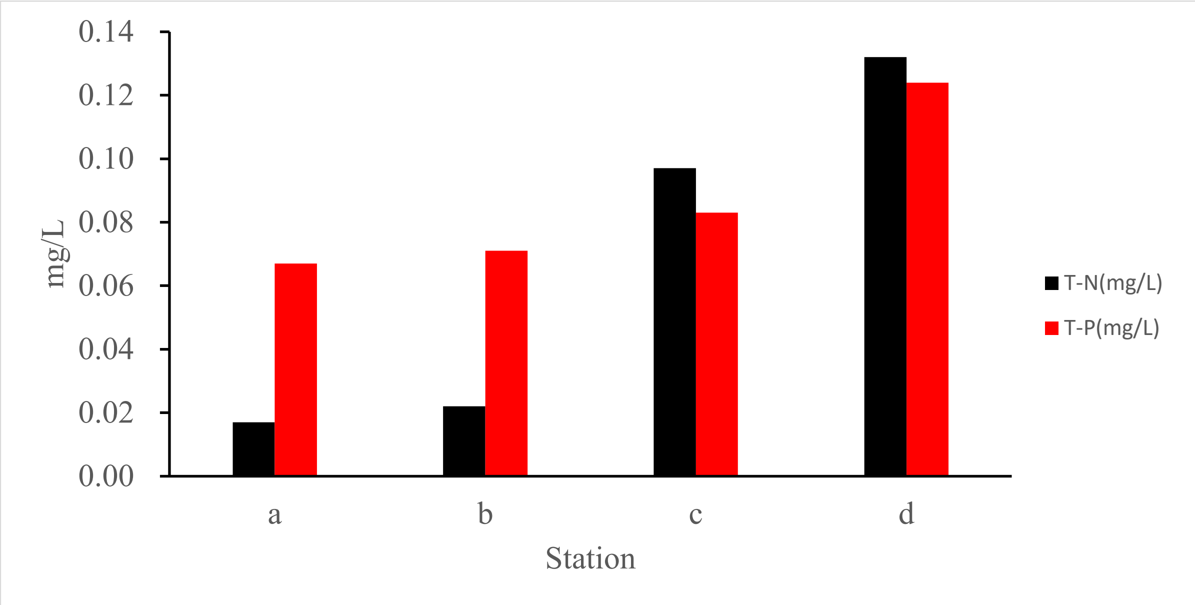

Fig. 3. The change of total phosphorus (P) and nitrogen (N) for four stations at the Unam Stream in Korea.

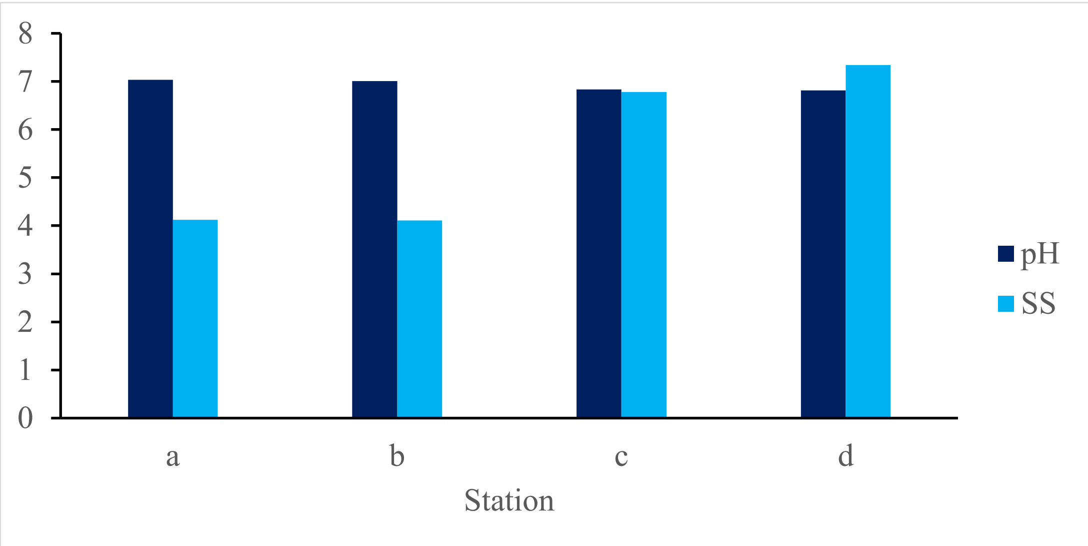

Fig. 4. The change of pH and total suspended solids (SS) for four stations at the Unam Stream in Korea

DISCUSSION

Since section a and ection b of at the Unam Strea are not abundant in quantity, reservoirs have been artificially made hundreds of years ago to farm. In winter, water is not required for farming, so it is stockpiled without discharging water from the reservoir. It becomes a dry stream where water does not flow from late autumn to early spring. In Korea, the rainy season begins in late spring and it rains frequently. In addition, heavy rains fall in summer and early autumn. During such a period, the river suddenly increased, so it was not enough as a natural

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embankment, so artificial embankments were mostly built in rivers. Unamcheon Stream is no exception.

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). Major ¯oods may, depending on the climaticcontext, allow for the establishment of stands of vegetation, or restart processes of plant community change. Low-gradient, meandering streams in broad valley bottoms may operate under different hydrogeomorphological conditions. Great unit stream power experienced greater amounts of flood damage that resulted in artificial bedrock and impervious man-made structures at the Section A and Section B in Unam Stream. An additional factor complicating the assessment of flood impacts is the possible role of the water table in influencing riparian vegetation. With increasing height above the stream channel, the distance to the water table generally increases. This imposes a gradient of distance to water that may influence the valley-bottom vegetation (Frye & Quinn 1979; Parikh 1989, 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).

The portion of BOD, COD, and TOC in the river increased exponentially along the upper-down gradient (Fig. 2). The most popular sum parameter in waste water analysis are the BOD (biochemical oxygen demand), COD (chemical oxygen demand), TOD (total oxygen demand) and TOC (total organic carbon). The TOC reflects the organic pollution on the basis of a direct carbon determination. The other parameters are based on oxygen, which is required to reduce or to oxidise the samples' substances.

BOD and TOC increase as micro-organisms accumulate to degrade organic material. BOD and COD are currently used for water quality indices, but adoption of TOC is being suggested (Lee et al., 2013).

Fertilizers have transformed the way the world produces food. Nitrogen and phosphorus are the two main fertilizers that farmers add to their fields. Research presented here shows that nearly two-thirds of the nitrogen we use on our crops becomes a pollutant; more than half of applied phosphorus does (West et al., 2014). Most of the countries that overapply nitrogen are the same ones that also overapply phosphorous. Singapore, New Zealand, Japan, South Korea, and Belgium, are all near the top of the list.

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 (Fig. 4). 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 (Huh, 2016). We need to either maintain or, in many cases, restore the integrity of this stream network, including small streams such as the Unam Stream.

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