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Research Article

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Fluvial Landscape Ecology and Water Quality at the Jupo River, Korea

Man Kyu Huh*
Department of Molecular Biology, Dong-eui University, Busan 614-714, Korea
*Corresponding Author E-mail: mkhuh@deu.ac.kr

ABSTRACT

The purpose of this study is to investigate the fluvial landscape ecology including river morphology, riparian vegetation, and water quality on the Jupo River in Jinhae province, Korea at four regions during four seasons. A transversal and longitudinal sandbar in this river was absent. Bed materials at upper regions were composed of boulders and gravel. Bed materials at low regions were composed of sand, silt, and clay (50% >). The flora on the Jupo River was a total of 66 taxa, including 28 families, 57 genera, 59 species, and 7 varieties. Naturalized plants were 20 species at overall regions. Upper region of this river was considerable high richness in flora. Naturalized plants were shown with the relative high individual density and the number of species in low region. The portion of BOD and COD in the river increased exponentially along the upper-down gradient. There is evidence for a relationship between the ecological distance and environmental variables.

Keywords: *Fluvial landscape ecology, the Jupo River, riparian vegetation, water quality*

INTRODUCTION

Water covers 70% of the Earth's surface and makes up two-thirds or more the weight of most animals and up to 95% of the weight of plants. It plays an important role in metabolism, the chemical reactions of cells. Despite its crucial role in our lives, water is one of the most badly abused resources. Water pollutants come from numerous natural and anthropogenic sources. Anthropogenic sources are the most important because they tend to be much localized and thus contribute significantly to the deterioration. Thus, increasing human population and growth of technology require human society to devote more and more attention to protection of adequate supplies of water[17]. 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[8]. Most agricultural and urban land use practices, reduced water quality[11].

Water is an important downstream dispersal agent of propagules of plants as well as animals[15]. Rivers can transport millions of propagules and deposit them hundreds of kilometers away from their sources[10]. Thus, riparian habitats can act as 'conveyor belts' for propagules[16], and implies they might be important corridors for seed dispersal, both for native and alien species[1,15].

The Jupo River is started at low mountains and ends at the Seongdong River. The vegetation of Jupo River has provided water purification and flow rate of deceleration, and fish habitat. In addition, vegetation is the site of the distribution of fish, birds, amphibians, reptiles etc and is very important to build food networks. Many human activities including farming, gardening or construction of factory have removed existing natural vegetation in this area.

The purpose of this study is to investigate the fluvial landscape, riparian vegetation, and water quality on the Jupo River at four regions during four seasons. Therefore, this survey may help to identify appropriate actions needed to improve current conditions and for the future appear in the environment to restore or improve the problem may be.

MATERIAL AND METHODS

Surveyed regions

Geographical ranges of the Jupo River were a total length of 1.1 kilometers from origin to the confluence of the Seongdong River (Fig. 1). This study was located at Jinhae province (upper region: 35°118′741″N/128°836′144″E, low region: 35°115′082″N/128°838′687″E), in Korea. 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.

Index of degree of river structure and identification of species

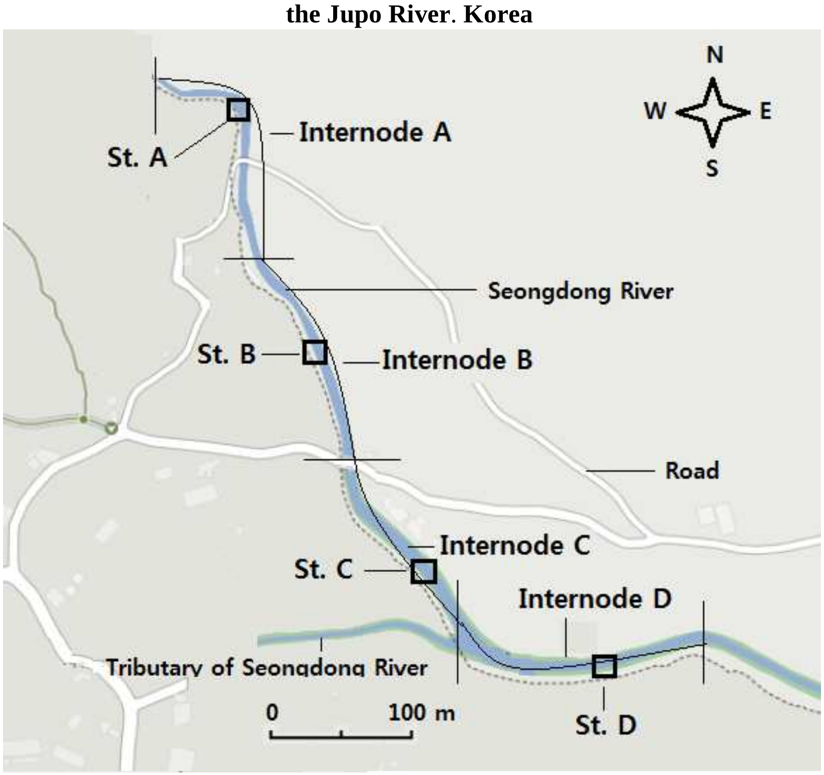
Regions of the Jupo River were divided by the geographic location with considering length of the river. Index of degree of river structure according to the river morphology was analyzed according to Table 1. Index of degree of river naturality according to the environment of river was also analyzed according to Table 2. River terminology was followed by Hutchinson[3]. All plants were identified at each survey region to the emergence of bilateral embankment into the river embankment and the distribution characteristics (ecotype plants, naturalized plants, endemic plants, court protection plants, etc.) were also examined. The system of plant classification system was followed by Lee[9]. Naturalized plants were followed by Korea National Arboretum[8].

pH, BOD, and COD measurements

Laboratories and equipment were used to measure a range of water quality parameters including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). DO and pH were measured with YSI field meters (Professional Plus, Geotech, Colorado, USA). The test for biochemical oxygen demand (BOD) is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter[18]. 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)[2]. COD is a widely known parameter used to measure water quality using the 910 colorimeter (YSI Incorporated, Ohio, USA).

An ecological distance describes the difference in species composition[6]. The relationship between a distance matrix and a quantitative environmental variable can be analyzed with Mantel test.

Fig. 1: The four surveyed sections for river morphology and four surveyed sites for water quality at the Jupo River. Korea



RESULTS AND DISCUSSION

Internode A

This area is the upper portion of Jupo River. The river width at this region is about 2.5~3.5 m. Transition zones of this river were distributed pine vegetation and *Quercus acutissima* community. Riverbed area was dominated by the distribution of the willow community (*Salix gracilistyla*). Number of flexion was three in this internode (Table 3). Transversal and longitudinal sandbar was absent. Velocity of flood was moderate. Bed materials were composed of boulders and gravel. Diversity of low channel width was slight. Materials of river shore at low channel width were composed of natural state. Materials of river levee at low channel width were also composed of natural state. Mean score for river naturality according to the river morphology was 2.57 (Fig. 2). The law water's edge vegetation was natural formed various vegetation communities by natural erosion (Table 4). The flood way vegetation was natural formed various vegetation communities. Land use in riparian zones within river levee was bush or grasses as natural floodplain. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 16%. *Pinus densiflora* and *Pinus rigida* were dominant distributed trees in this internode. *Salix gracilistyla* was distributed in riparian. The survey region was a total of 32 taxa, including 21 families, 29 species, and three varieties. Naturalized plants were four species (Table 5). The value of pH was 7.42 (Fig. 3). The average values of BOD and COD four seasons were 4.24 mg/l and 4.48 mg/l, respectively.

Internode B

The river width at the region is about 3.5~4.0 m. Farmland is very widely distributed in both transition zones of this river. Number of flexion was two in this internode (Table 3). Transversal and longitudinal sandbar was not developed. Velocity of flood was slight. Bed materials were composed of boulders and gravel. Diversity of low channel width was slight. Materials of river shore at low channel width were composed of stonework and artificial vegetation. Materials of river levee at low channel width were also composed of natural state. Mean score for river naturality according to the river morphology was 3.0 (Fig. 2). The law water's edge vegetation was natural formed various vegetation communities by natural erosion (Table 4). The flood way vegetation was natural formed various vegetation communities. Land use in riparian zones within river levee was arable lands. Transverse direction of artificial structures was slope waterway reservoir. The ratio of sleep width/river width was 10%. The survey region was a total of 32 taxa, including 16 families, 29 species, and three varieties. Naturalized plants were six species. The value of pH was 7.39 (Fig. 3). The average values of BOD and COD four seasons were 4.67 mg/l and 4.83 mg/l, respectively.

Internode C

The river width at the region was about 4.0 m. The left area in the river was a mountain and right areas were farmlands, roads, and a residential. Number of flexion was one in this internode (Table 3). Transversal and longitudinal sandbar was absent. Velocity of flood was slight. Bed materials were composed of sand, silt, and clay (50% >). Diversity of low channel width was slight. Materials of river shore at low channel width were composed of stonework and artificial vegetation. Materials of river levee at low channel width were concreted impervious which was not penetrating structure. Mean score for river naturality according to the river morphology was 3.29 (Fig. 2). The law water's edge vegetation was natural weeds, shrubs, and mixed (Table 4). The flood way vegetation was natural formed various vegetation communities. Land use in riparian zones within river levee was arable lands. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 5%. Mean index for river naturality according to the environment was 2.20 (Fig. 2). The survey region was a total of 28 taxa, including 15 families, 26 species, and two varieties. Naturalized plants were ten species. The value of pH was 7.34 (Fig. 3). The average values of BOD and COD four seasons were 5.49 mg/l and 5.20 mg/l, respectively.

Internode D

River width at the region was about 4.5~5.5 m. The sand dune was developed in the internode D. The left and right areas in the river were farmlands. Number of flexion was absent in this internode (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 composed of stonework and artificial vegetation. Materials of river levee at low channel width were stonework and penetrating structure. Mean score for river naturality according to the river morphology was 3.71 (Fig. 2). The law water's edge vegetation was natural weeds, shrubs, and mixed (Table 4). The flood way vegetation was natural formed various vegetation communities by natural erosion. Land use in riparian zones within river levee was arable lands, urban, residential mixed. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 5%. Mean index for river naturality according to the environment was 2.60 (Fig. 2). The survey region was a total of 32 taxa, including 15 families, 28 species, and four varieties. Naturalized plants were 15 species. The value of pH was 7.31 (Fig. 3). The average values of BOD and COD four seasons were 5.71 mg/l and 5.36 mg/l, respectively.

A fundamental starting point for the estimation of river health is to have a record of the living world in terms of the number of species that currently exist and how they are distributed. Although this area was not wide, the flora was very diverse with many taxa, representing 66 taxa 28 families. Naturalized plants were shown with the relative high individual density and the number of species in low region (Internodes C and D). The portion of BOD and COD in the river increased exponentially along the upper-down gradient. These increasing trends (the increase of naturalized plants and facilitates of BOD and COD) were related to an increase of artificial disturbances such as road or house construction in these regions. In addition, the Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among four stations at the Jupo River (Table 6). Neighboring stations such as St. A and St. B or St. C and St. D had the similar species composition. There is evidence for a relationship between the ecological distance and environmental variables. The relationship of the highest remote populations (St. A and St. D) has shown high ecological distance.

Depositional and flooded areas occupied a lot of space of river system and they severed as very important roles during the dry season as well as flood. Depositional areas were supported the grown of the vegetation in the dry season. Riparian area is the transition area between water and land regions[7]. Rivers have altered their channels through erosion and deposition or human intervention[5]. Humans are affected on rivers directly or indirectly by changing land use in river morphology. It is often difficult to determine its exact boundaries on ecosystem. However, the riparian is recognized producers as an important ecological value of vegetation. The Jupo River was characterized a lot of riparian.

This institutional analysis relies on surveys and policy analyses regarding attempts to refocus past conservation programs, which mainly supported riparian conservation and water ensuring[13,14]. It also highlights related technical challenges posed by the site specific and flexible nature of new watershed programs[4,12].

Table 3: 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 Jupo River

Internode	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
A	2	5	3	2	4	1	1
B	3	5	4	2	3	3	1
C	4	4	4	3	3	3	2
D	5	4	4	4	2	3	4

Table 4: Index of degree of river naturality according to the environment at the Jupo River

Internode	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
A	2	1	1	1	1	2
B	2	1	2	2	4	3
C	3	1	2	2	1	4
D	3	2	3	3	1	4

Table 5: List of vascular plants at the Jupo River

Family	Species	Internode				NAT
		A	B	C	D	
Equisetaceae	*Equisetum arvense* L.	○		○	○	
Aspidiaceae	*Athyrium vidalii* (Fr.et Sav.) Nakai	○	○	○		
Ginkgoceae	*Ginko biloba* L.	○	○		○	
Pinaceae	*Pinus densiflora* S. et Z.	○				
	Pinus rigida Mill.	○				
Salicaceae	*Salix gracilistyla* Miq.	○	○			
Fegaceae	*Quercus acutissima* Carruth.	○	○			
Moraceae	*Morus alba* L.	○				
Cannabinaceae	*Humulus japonicus* S. et Z.	○	○			
Urticaceae	*Boehmeria platanifolia* Fr. et Sav.	○	○			
	Urtica thunbergiana S.et z.	○	○	○		
Aristolochiales	*Aristolochia manshuriensis* Kom.	○	○			
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 ficifloium Smith			○		
Amaranthaceae	*Achyranthes japonica* (Miq.) Nakai		○			
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.	○				
	Prunus yedoensis Matsumura			○	○	
	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
	Vicia tetrasperma Schreber		○	○		
Violaceae	*Viola mandshurica* W. Becker	○				

Onagraceae	*Oenothera odorata* Jacq.	○			○	NAT
Oleaceae	*Forsythia koreana* Nakai			○	○	
Plantaginaceae	*Plantago asiatica* L.	○	○	○	○	
	Plantago lanceolata L.			○	○	NAT
Oxalidaceae	*Oxalis corymbosa* L.			○	○	NAT
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	*Cyperus amuricus* Max.		○		○	
	Miscanthus sacchariflorus Benth.		○	○	○	
	Miscanthus sinensis var. *purpurascens* Rendle	○	○	○	○	
	Setaria viridis (L.) Beauv.	○	○	○	○	
	Zoysia japonica Steud.		○	○	○	

NAT: Naturalized plants.

Table 6: Ecological distance (upper diagonal) based on Bray-Curtis' formulae analysis and geographic distances (low diagonal) among four stations at the Jupo River

Station	St. A	St. B	St. C	St. D
St. A	-	0.607	0.879	0.953
St. B	0.208	-	0.707	0.901
St. C	0.384	0.176	-	0.444
St. D	0.556	0.348	0.172	-

Fig. 2: The mean values of river structure and indices of river naturality according to the environment at the Jupo River

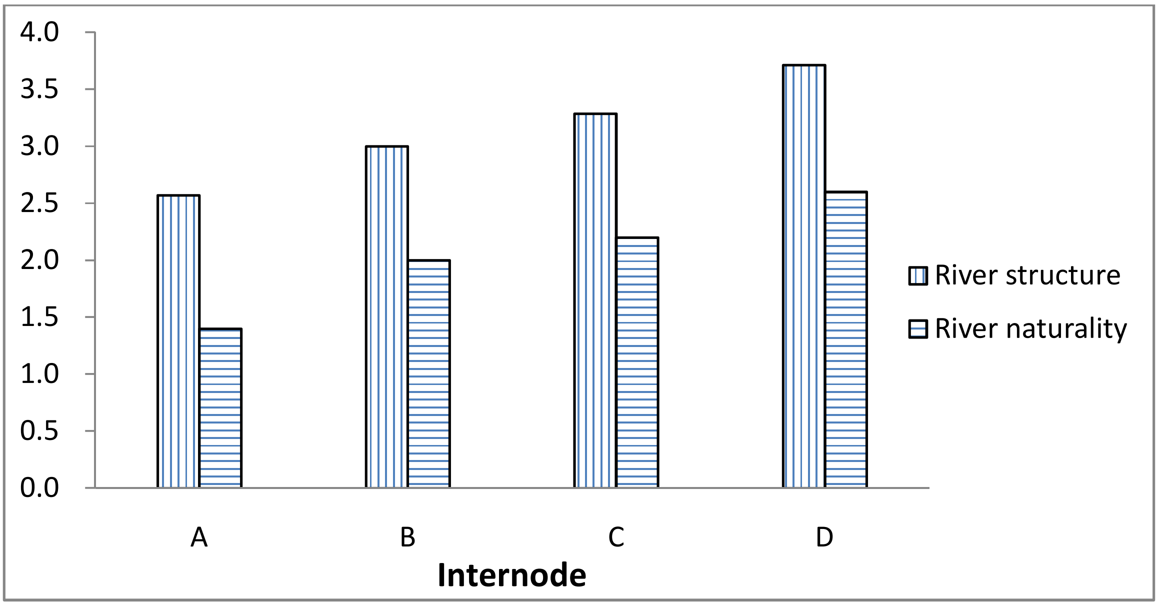
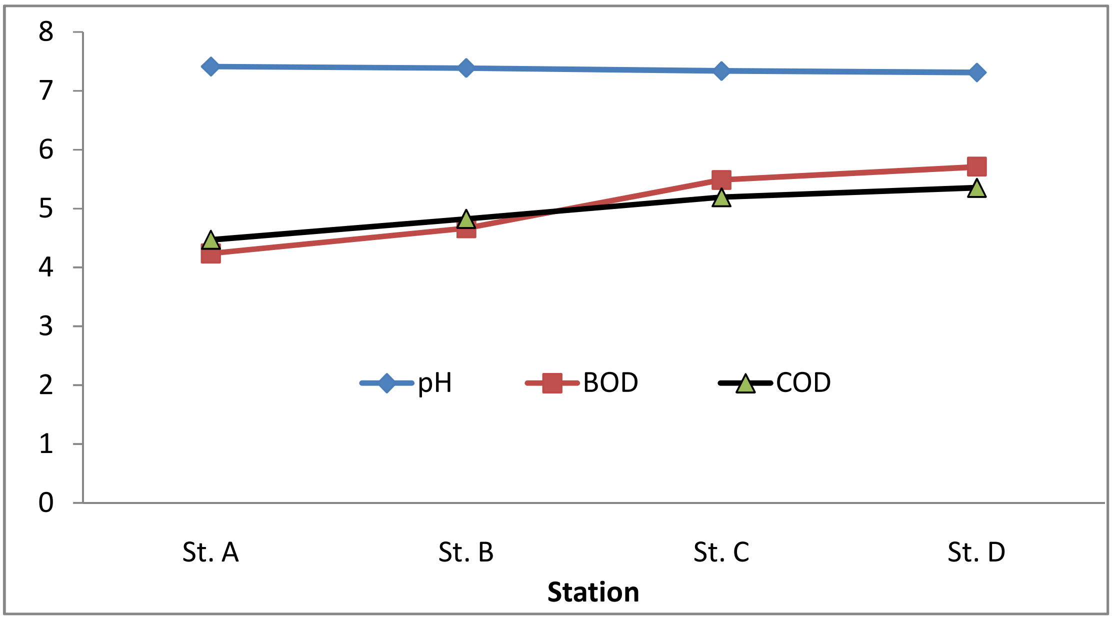


Fig. 3: Water quality at four stations of four internodes in the studied areas



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