

WATER QUALITY MANAGEMENT FOR ECOLOGICAL RESTORATION IN ANYANG STREAM

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ABSTRACT

The Anyang Stream flows through 7 cities of Gyeonggi province and 7 autonomous districts of Seoul metropolitan. Each autonomy has expanded uses of Anyang Stream as spaces for sport, rest, parking, etc., but has not made any effort for preserving stream water quality and natural scenery. As a result, the stream has become devastated. This study was performed to investigate the existing environmental conditions of Anyang Stream, and to present the management plan to restore the stream as a natural and environment-friendly space for both Seoul metropolitan and Gyeonggi province.

BOD of the upstream ranges from 14 to 55 mg/l, while the water quality of downstream improves as 12 to 18 mg/l with relatively good sewage collection and treatment in Seoul. However, T-N and T-P increase with flowing downstream. It is necessary to complete wastewater treatment systems with nutrients removal in Gyeonggi province. Low flow of Anyang Stream has been reduced substantially as urbanization has continued. Flow augmentation could be possible by using upstream reservoirs originally for irrigation purpose, treated wastewater and groundwater from subway foundation. At the moment, transition of devastated stream to nature-oriented one is on the first step by soil covering and transplanting on stream embankment, variation of channel such as making pools and riffles, timber-crib rivetment of shoreline, floating islands. Anyang Stream Watershed Management Committee for Water Quality Improvement composed of 14 autonomies is also functioning to cooperate for integrated management of stream and watershed.

KEYWORDS: cooperation of autonomies, flow augmentation, integrated watershed management, river restoration, water quality improvement

INTRODUCTION

The Anyang Stream, one of four major tributaries to Han River in Seoul metropolitan area enters the Han River that supplies 20,000,000 residents in Seoul metropolitan and Gyeonggi province drinking water, open space and amenities. The BOD of Han River is controlled below 3mg/l up to the confluence of Anyang Stream and the Han River, but BOD of that is 6mg/l downstream after that. Contamination of Anyang Stream has affected seriously water quality of Han River and Yellow Sea. In some parts of the Anyang Stream the terrace land has been used for parking lots and athletic fields, and shore protection works have been made of concrete with a steep slope. And even some parts of stream have been covered and paved for motorway, bridge and building site. In such an existing situation, the Anyang Stream is no longer a natural and environment-friendly space (Lee, 1998). In this study, water qualities of mainstream and tributaries, ecological characteristics and hydrological characteristics were surveyed to find a possible solution to restore the Anyang Stream to an environmentally healthy stream. And pollution load analysis of that was performed. Depending on the results of this study, we are to propose our views for integrated management of Anyang Stream for improvement in water quality and augmentation of low flow and finally show roles of autonomies for restoration of the stream to a natural and environment-friendly space.

STUDY AREA

The length of Anyang stream is 32.2km, and the basin area of that is 275km². Anyang Stream has 21 tributaries which are Dorim branch, Gaehwa branch, Mokam branch, Haki branch, Dangjung branch, and so on. The basin of Anyang Stream includes 7 cities (districts) of Gyeonggi province and 7 autonomies "Gu"(counties) of Seoul metropolitan which are densely populated areas with a total population of about 2.7 million. The metropolitan area included in the basin corresponds to the 33% of the entire basin of the stream, while it has a population about 2.2 million which are 61% of the total population.

In last decades, several dormitory towns have been developed in Gyeonggi province, and the load of water pollutants has continued increasing in the upstream of Anyang Stream and water quality has grown worse as time passes. Especially, water contamination of Anyang upstream has been more serious than that of Anyang downstream, because sewerage systems of Gyeonggi province have not been yet completed. Development of new towns and expansion of existing cities changed unpaved rural area into paved urban area. As a result of reduced percolation of rainwater, groundwater level has been lowered and stream flow has been decreased. Reduced low flow of dry weather makes water quality even worse. High ratio of urban area adopts combined sewer system and there are only two wastewater treatment plants for the Anyang Stream watershed. One is about in the middle of the stream and the other is outside of the watershed. This is also one of reasons to reduce the low flow.

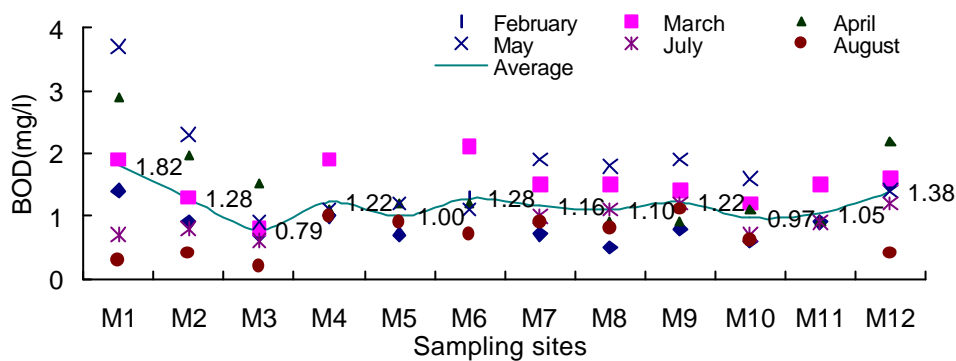


Figure 4 Average BOD of Anyang mainstream

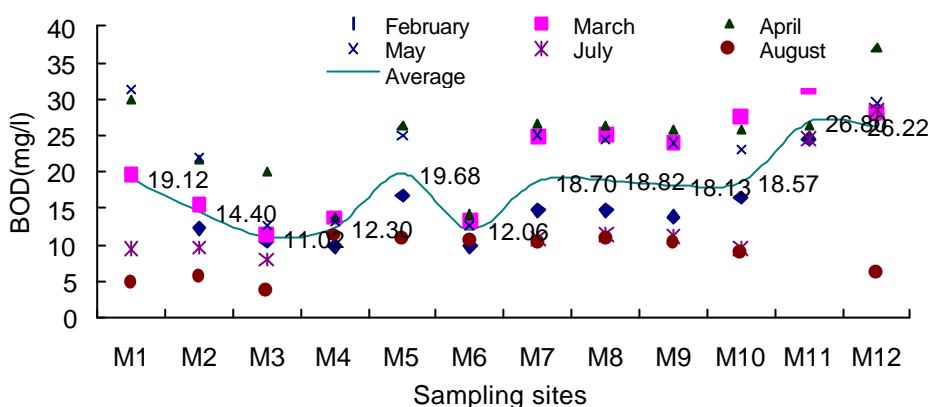


Figure 5 Average T-N of Anyang mainstream

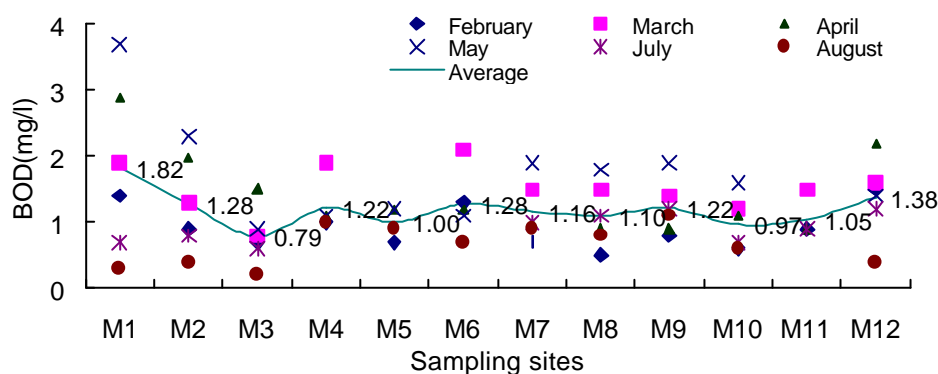


Figure 6 Average T-P of Anyang mainstream

Pollution load

Pollution load analysis was performed with census data of population, status of land use, quantity and quality data of industrial and livestock wastewater, wastewater discharge inventory of each industry, ratio of collection and treatment, status of wastewater treatment systems, and so on. Pollution load is estimated into three steps such as generation, discharge and inflow into the stream. Total generated load of BOD is estimated to be 277,271.9 kg/day as shown in Table 1. Generated domestic load of BOD, which is 211,714.2 kg/day, corresponds to 76.4% of the total generated load of BOD. Total generated load of T-P is 6,839.4 kg/day as shown in Table 1. Domestic generation of T-P load, which is 5,752.6 kg/day, corresponds to the 84.1% of the total generated load of T-P.

Domestic and industrial generation in Seoul metropolitan is higher than those in Geonggi province. However, discharged load in Seoul metropolitan, as shown in Table 2 is lower than that in Geonggi province, because wastewater collection and treatment system in Seoul metropolitan has been completed and operated well. Thus, it is imminent to complete wastewater collection and treatment systems in Geonggi province for improving water quality of Anyang Stream.

Table 1 Generated load of BOD, T-N and T-P (kg/day)

	Domestic	Land use	Livestock	Industrial	Total
BOD(Seoul)	130,018.7	2,561.5	125.2	26,646.1	159,351.6
BOD(Geonggi)	81,695.5	8,496.6	3,376.6	24,351.7	117,920.3
T-N (Seoul)	37,614.4	632.5	28.3	1,168.5	39,443.8
T-N (Geonggi)	23,634.5	848.8	775.4	1,067.9	26,326.6
T-P (Seoul)	3,533.2	89.0	9.4	332.5	3,963.1
T-P (Geonggi)	2,219.4	84.6	268.5	303.8	2,876.3

Table 2 Discharged load of BOD, T-N and T-P (kg/day)

	Domestic	Land use	Livestock	Industrial	Total
BOD(Seoul)	-	256.2	125.2	2,664.6	3,046.0
BOD(Geonggi)	15,866.5	849.7	3,376.6	24,351.7	22,528.0
T-N (Seoul)	-	63.3	28.4	467.4	559.1
T-N (Geonggi)	4,508.5	84.9	775.4	427.2	5,795.9
T-P (Seoul)	-	8.9	9.4	133.0	151.3
T-P (Geonggi)	423.4	8.5	268.5	121.5	821.9

Average flow at the downstream of Anyang Stream is 3.02m³/sec, and BOD and T-P at the same point are 11.7 mg/l and 1.2 mg/l respectively. Inflow loads of BOD and T-P into the stream at this point ratio thus become 11.9% and 32.1% of discharged load respectively as shown in Table 3.

Table 3 Inflow load of BOD and T-P(kg/day)

	Discharged load (kg/day)		Inflow load (kg/day)		Inflow ratio (%)	
	BOD	T-P	BOD	T-P	BOD	T-P
Downstream of Anyang	25,574.0	973.2	3,052.9	313.1	12.0	32.0

Ecological characteristics

Figure 1 shows the sites for investigation of ecological characteristics of Anyang Stream and branches and results are summarized as following (Kim, 1999 ; Seoul Metropolitan Government, 2000). Forty four (44) species of aquatic plants and 131 species of terrestrial plants were found. Thirteen (13) amphibian species recognized, the green frog was the prevailing species. But the amphibian population was very low. Fourteen (14) species of fish were found in the stream. More than 10 species of migratory birds and about the same number of native bird species were observed in the middle stream of Anyang. In case of insects, 9 species of aquatic living and 45 species of land living insects were identified.

IMPROVEMENT

Water Quality

Watersheds of some branches into the Anyang Stream have not completed sewage collection systems and large quantity of sewage is discharged into branches. Water quality management of branch stream is essential for improving the environment of Anyang Stream. However complete collection and treatment in those small watersheds need some time for constructing sewerage systems and purifying facilities. For the moment, in-situ purification at critical branches for stream water quality is now under consideration. Contact oxidation + purification by aquatic plants, and gravel contact oxidation + purification by aquatic plants are two possible options.

Augmentation of flow

The Anyang Stream has been changed from a natural stream to a polluted urban stream, and supply of irrigation water from the stream has been continuously reduced. However minimum flow is still required to maintain other purposes such as preserving water quality, maintaining stream scenery, holding healthy ecology, and so on. Flow requirements for the upstream, middle stream and downstream are estimated to be 10,500 m³/day, 23,000 m³/day, 30,000m³/day for the purposes of ecology, scenery and ecology respectively. However the Anyang Stream even dries up during the prolonged dry weather. Effluent from wastewater treatment (300,000m³/day) in the middle of the Anyang Stream and groundwater (6,400m³/day) from subway foundation can provide the Anyang Stream with reliable water resource to augment the flow during the dry period. As the demand of irrigation water of 2,450,000 m³/year has diminished to 600,000 m³/year in the upper watershed, reservoirs in the upstream of Anyang Stream could supply remaining water to augment the low flow.

Transition to water-friendly and nature-oriented stream

Various projects have been made to restore the Anyang Stream as a water-friendly and nature-oriented stream. In parts of Anyang Stream, soil covering and transplanting on stream embankment was carried out as shown in Figure 7 and natural stream scenery was created with vegetation on the terrace land. In the reaches where lower water channel is meandering

naturally, pools and riffles are created for habitats of fishes and invertebrates. In other reaches, variation on the water line by timber-crib rivetment and floating islands can create diverse stream environment providing habitats for plants and animals.

Some branches such as Gaewha branch without artificial embankment have maintained natural vegetation as shown in Figure 8. Preservation of such superior areas and restoration of damaged area could gradually improve the stream to be nature-oriented.



Figure 7 Embankment with soil covering and vegetation



Figure 8 Natural state without embankment

Cooperation of local autonomies

The Anyang Stream flows through area of two wide area local governments, each one has seven autonomous districts. Local autonomies have expanded uses of terrace land of Anyang River as spaces for sport, rest, parking, etc., but have not made efforts for preserving stream water quality and natural scenery. As a result, the stream has become devastated. In 1999, Anyang Stream Watershed Management Committee for Water Quality Improvement was established. The committee is composed of 7 cities of Gyeonggi province and 7 autonomous districts of Seoul. The committee is aimed to cooperate to make a plan for integrated management of stream and watershed and to implement projects which need joint efforts. It also has a function to settle the conflicts between local autonomies upstream and downstream. The committee has produced some results such as joint survey of water quality, joint regulation of pollutant discharge, water quality improvement plan, naturalization of stream with plants and bed materials and so on.

CONCLUSIONS

The Anyang Stream has been devastated as each autonomy of watershed has expanded uses of stream without any effort to preserve stream quality and natural environment. The following items are considered to be important in restoring and maintaining the quality of Anyang Stream.

- Wastewater collection and treatment systems should be completed in Geonggi province to improve the quality of stream.
- Flow augmentation is essential to restore the stream. Sufficient quantity of water could be introduced from the upstream reservoirs originally for irrigation purpose, groundwater from subway foundation and treated wastewater.
- Transition of damaged stream to nature-oriented one is now on the first step and should continued.
- Several activities of Anyang Stream Watershed Management Committee for Water Quality Improvement have been launched and functions of the committee need to be expanded for integrated management toward restoration of the stream.

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