Water Quality Preservation Measures of Hwasung Lake

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Abstract

In tidal land reclamation project, water quality of freshwater lake is a critical element for success of the whole project. It is expected to be a good example of similar project in other countries, thus this paper is aim to introduces "Hwasung lake water quality conservation measure" that is divided into upper region measure managed by Ministry of Environment and inside lake measure in Korea. Automatic irrigation and drainage and automation system in rural area is to be installed for the higher income. The major work is to develop 1,730ha of fresh water lake to provide agricultural water. The construction was begun with the budget by 678.50million US $ in September 1991 and expected to complete by December 2016, but the water quality is deteriorating due to the rapid urbanization of upstream region. Since the beginning of the construction in April 2002, the ministry of Environment established the water conservation measures, and it will be completed in December 2012. When the water conservation measure is completed, it can provide surplus 5,400 MCM ㎥ water to 4,482ha of the reclaimed land and 660ha of Tando Lake.

1. Introduction

1.1. Overall Situation of Basin

Major Projects include 9.81km-length seadike, 1,730ha-freshwater lake and 4,480ha-reclamation land with the budget of 678.50 million $. Figure demonstrate location map of Hwaong project and its outline.

Figure 1. Location map of the project site

The basin of Hwasung Lake of 23,580ha is investigation to the shore, which the amount of stream water flowing into is not plenty, having only three small streams such as Namyang stream, Jaan stream and Eoeun stream which are managed by local government, where the annual precipitation amounts to 1,319.2mm. The upper region of the Hwasung Lake influence on freshwater lake because of pollutants derived from rapid population increase, domestic wastewater, and livestock water.

Table 1. Characteristic of Basins flowing into Hwasung Lake

Stream	Length (L, km)	Area (A, ㎢)	Average Width (A/L, km)	Average Elevation (E.L, m)	Form coefficient (F, A/L2)	Average Gradient (%)
Namyang	8.05	19.90	2.34	85.0	0.28	19.80
Jaan	13.07	52.63	4.03	9.70	0.31	9.70
Eoeun	7.10	23.50	3.31	33.30	0.47	1.4

1.2. Situation of and Outlook for Pollutants

1.2.1 Situation of Pollutants

① Population and Livestock Farming

Total population in basin area amounts to 52,128, representing low population density of 2.82 persons/ha. Numbers of livestock per unit area are 1.05 cattle/ha and 4.14 pigs/ha.

Table 2. Situation of Population and Livestock Farming in Basin Area

Basin	Population	Number of livestock							
		Dairy cattle		Korean cattle		Pig		Chicken	
		Controlled	Non-Controlled	Controlled	Non-Controlled	Controlled	Non-Controlled	Controlled	Non-Controlled
Namyang	22,367	1,399	4	3,251	7	25,056		144,205	1,300
Mado	2,307	2,165		1,660		13,514		85,696	1,100
Bibong	905	280		314				5,500	
Seosin	2,040	72		656				109,464	
Ujeong	16,685	2,168		2,948	16	13,537		25,048	
Jangan	3,500	811		1,281		8,570		82,840	
Paltan	4,324	765		1,604		15,902		168,812	
Total	52,128	7,660	4	11,714	23	76,579		621,565	2,400

Source: Environment Policy Department, Hwasung City livestock statistics (as of December 31, 2008)

② Wastewater Discharge Arrangements

There are 368 wastewater discharge facilities in the basin area. Wastewater is discharged by 256 commissions, reuse facilities and other facilities.

1.2.2 Estimation of Pollutant Loads

1) Pollutant Generation Loads

Total pollutant loads generated from point source pollution and non-point source pollution can be expressed as BOD of 30,179,2kg/day, T-N of 7,550,6kg/day and T-P of 2,473.8kg/day. BOD, T-N and T-P generated from livestock farming represent 73,9%, 72.3% and 83.7% in total, respectively, dominant contributor to the deterioration of the lake (See Table 3).

Table 3. Generation Loads in Basin Area by Pollutants (unit: kg/day)

Pollutant	BOD		T-N		T-P	
	2001	2008	2001	2008	2001	2008
Population	2,024.7	2,590.6(8.6%)	307.0	674.1(8.9%)	58.2	77.5(3.1%)
Livestock	23,839.7	22,296.2(73.9%)	5,880.2	5,462.5(72.3%)	2,213.3	2,069.7(83.7%)
Industry	352.2	2,966.3(9.8%)	25.7	323.7(4.3%)	4.5	199.9(8.1%)

Culture farm	2,053.3	67.6(0.2%)	402.6	13.1(0.2%)	114.0	3.6(0.1%)
Land use	592.8	2,258.5(7.5%)	791.4	1,077.2(14.3%)	56.1	123.1(5.0%)
Total	28,862.7	30,179.2(100.0%)	7,406.7	7,550.6(100.0%)	2,446.1	2,473.8(100.0%)

Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area (2009)

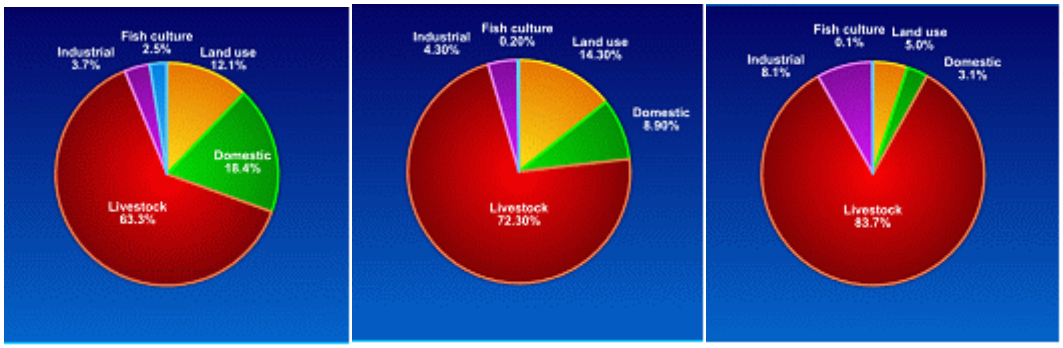

Figure 2. Share of the pollutant generation loads (From left BOD, T-N, T-P)

2) Pollutant Discharge Loads

Total pollutant loads discharged from the basin area represent BOD of 34,569.9kg/day, T-N of 2,972.1kg/day and T-P of 372.7kg/day. BOD, T-N and T-P generated from livestock farming represent 50.9%, 68.6% and 68.6% in total, respectively (See Table 4).

Table 4. Discharge Loads in Basin Area by Pollutants (unit: kg/day)

Pollutant	BOD		T-N		T-P	
	2001	2008	2001	2008	2001	2008
Population	1,482.9	883.1(19.3%)	204.9	296.5(10.0%)	43.4	32.8(8.8%)
Livestock	832.4	2,328.1(50.9%)	661.9	2,040.1(68.6%)	85.0	255.5(68.6%)
Industry	59.4	286.8(6.3%)	44.6	143.4(4.8%)	5.9	19.1(5.1%)
Culture farm	2,053.3	67.6(1.5%)	402.6	13.1(0.4%)	114.0	3.6(1.0%)
Land use	592.8	1,004.3(22.0%)	791.4	479.0(16.1%)	56.1	61.7(16.6%)
Total	5,020.8	4,569.9(100.0%)	2105.4	2,972.1(100.0%)	304.4	372.7(100.0%)

Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area (2009)

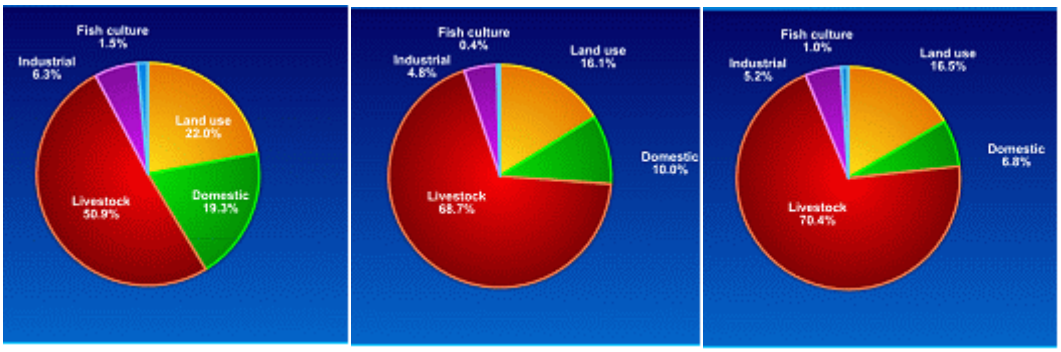

Figure 3. Share of pollutant discharging loads (From left BOD, T-N, T-P)

1.2.3 Outlook for Pollutants

1) Pollutants

Comparing basic data on pollutants in 2002 and number of pollutants in 2009, the population increased by 18,809 persons, accounting

to 65.7% of estimated population in 2012. Change in pollutants is shown in Table 5.

Table 5. Changes in Pollutants over years and outlook

Pollutant	Investigation Result			Outlook to 2012	Remark
	'02	'06	'09		
Population (person)	33,319	72,554	52.128	52,128	
Livestock (head)*	102,339	107,505	95,980	95,980	
Industry (t/day)	2,192	5,318	2,390	2,390	
Culture farm (㎡)	486,663	5,665	9,205	9,205	
Land (ha)	18,550	18,550	18,498	18,498	

Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area (Including cattle, pig and chicken only)

2) Pollutant Loads

Total pollutant loads generated from point source pollution and non-point source pollution in 2009 account to BOD of 30,179㎏/day, T-N 7,551㎏/day and T-P 2,474㎏/day. In comparison with 2002, BOD, T-N and T-P decreased by 3,865㎏/day, 1,291㎏/day and 367㎏/day, respectively. Total pollutant discharge loads are BOD 4,570㎏/day, T-N 2,972㎏/day and T-P 373㎏/day. In comparison with 2002, BOD, T-N and T-P decreased by 6,206㎏/day (57.6%), 1,236㎏/day (29.4%) and 296㎏/day (44.2%) (See Table 6).

Table 6. Change in Pollutant Loads (unit: kg/day)

Class		2002(A)	2007	2009(B)	Increase and Decrease (B-A)
Generation Loads	BOD	34,044	35,856	30,179	△3,865
	T-N	8,842	9,061	7,551	△1,291
	T-P	2,841	3,007	2,474	△367
Discharge Loads	BOD	10,776	7,015	4,570	△6,206
	T-N	4,208	4,455	2,972	△1,236
	T-P	669	611	373	△296

Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area

1.3 Situation of and Outlook for Water Quality

1.3.1 Situation of Water Quality

Based on the results of monthly survey of "Water Quality Preservation Measures in Hwasung Lake" by the Ministry of environment in 2002, three river region influence on water quality because of pollutant increase with rapid urbanization. Since water quality in Hwasung Lake is controlled by seawater flow, the water quality did not deteriorate further than the one in 2002.

Figure 4. The view of the Seawater is circulated into lake twice a day

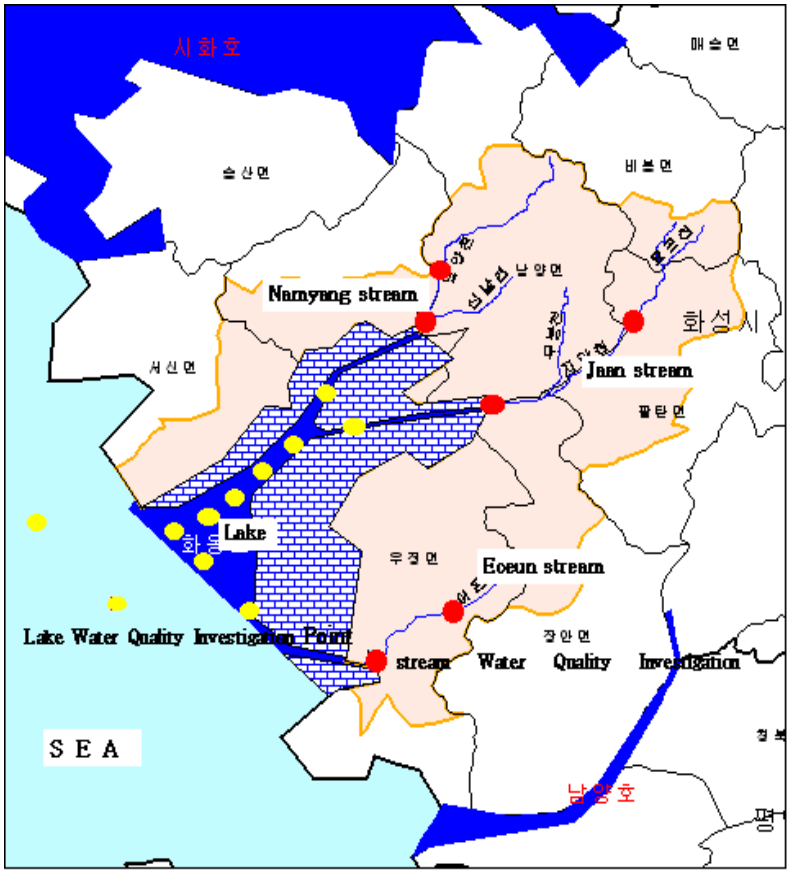

Figure 5. Water Quality Investigation Point in Hwasung Lake Basin

1) Situation of Water Quality of Streams Flowing into Lake

The Ministry of Environment investigates 6 monitoring points on monthly basis in upper stream and midstream of Namyang stream, Jaan stream and Eoeun stream, main streams flowing into the lake, (See Figure 4) for the management of the water quality, as shown in figure 6.

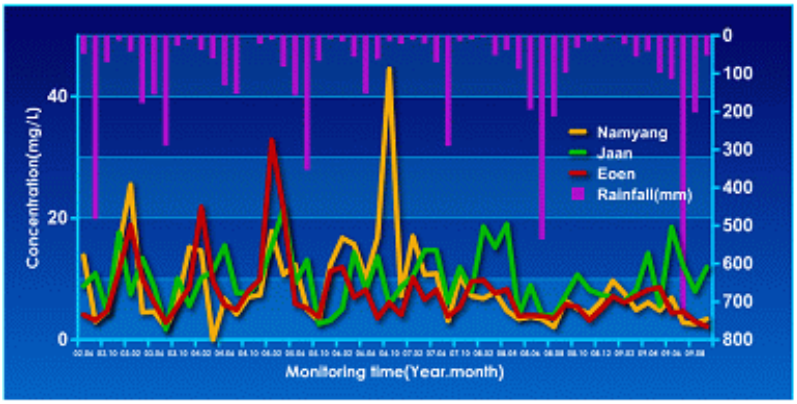

Figure 6. Change in BOD Concentration in streams flowing into Lake in Each Year

Note: 2002-2009: Result of monitoring water quality (Han River Basin Environmental Office)

Not implemented in October, 2009, because of the extension work of the laboratory of Han River Basin Environmental Office

2) Situation of Water Quality in Freshwater Lake and Basin Area in consequence of Seawater Circulation

Seawater circulation was regularly carried out from 2003 to 2009. The result shows a fairly good water quality with Class 3 in Lake Water Quality Standards (See Table 7).

Table 7. Estimation Result of Water Quality by Seawater Circulation (COD) (unit: mg/ℓ)

Class	2002	2003	2004	2005	2006	2007	2008	2009	Remark
Estimated	5.2	–	5.1	–	4.9	4.9	-	-	(2012) COD=6.4
Present	3.5	3.5	4.3	3.7	3.7	5.1	5.6	4.9	

※ Estimated Water Quality: Detailed Plan for Water Quality Preservation Measures of Hwaong Lake, May 2002. 5, Agencies Concerned Joined (Kyeonin Regional Environmental Management Office, Kyeinggi-do, Hwaseong-si, Agriculture Base Corporation)

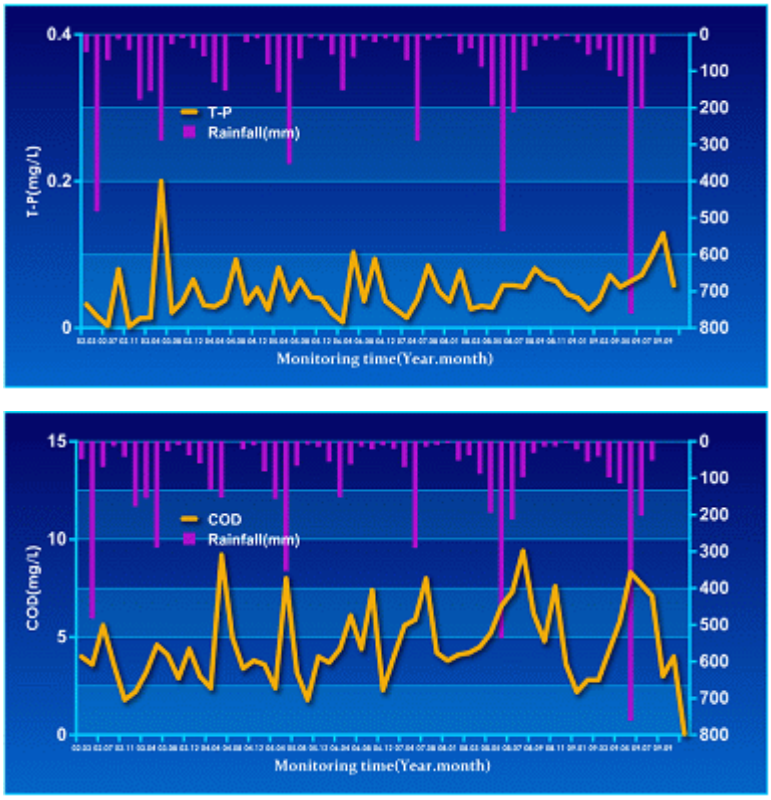

Figure 7. Change in Water Quality of Hwasung Lake in Each Year
(Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area)

1.3.2 Outlook for Water Quality

1) Target Water Quality

When the water quality preservation measures were established, the target water quality for 2012 in the freshwater lake will be was determined below COD 8㎎/, Class Ⅳ according to Environmental Standards of Water Quality and Aquatic Ecosystem under Environment Policy Fundamental Law (See Table 8).

Table 8. Target Water Quality of Hwasung Lake (in 2012)

Class	COD	DO	SS	T-N	T-P	Remark
Ⅳ(unit: mg/ℓ)	below 8	over 2	below 15	below 1.0	below 0.10	Class 2, Industrial water

Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area

3) Estimation of Water Quality

The estimated water quality of the freshwater lake in 2012 for agricultural water is shown in Table 9 below. As COD is estimated 6.40 ㎎/ℓ and T-P is estimated 0.094㎎/ℓ , it is estimated that the target water quality to use for agricultural water would be achieved.

Table 9. Outlook for Water Quality of Hwasung Lake in 2012

Estimated Water Quality	2000 (seawater)	2009	2012
COD(㎎/L)	1.80	4.9	6.4
T-N(㎎/L)	0.35	0.67	2.92
T-P(㎎/L)	0.100	0.062	0.094

*Source: Report on Freshwater Lake Water Quality Investigation in Hwaong Area

2. Water Quality Preservation Measures of Hwasung Lake

2.1. Basic Direction

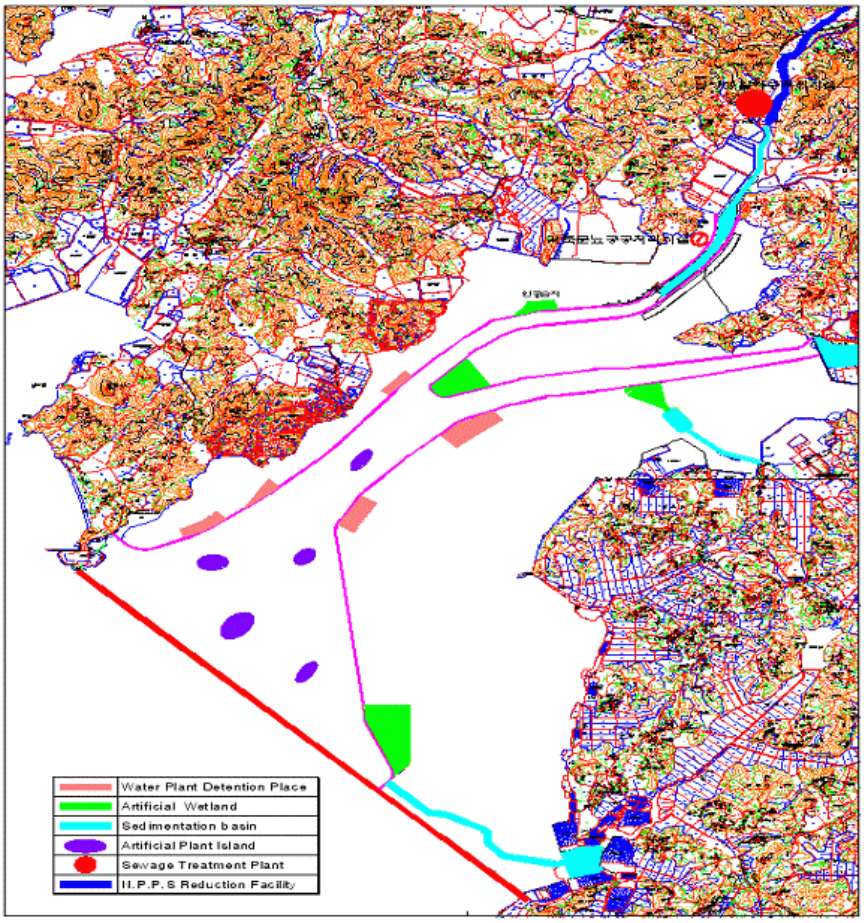

Figure 8. Water quality improvement measures in the Hwaong Lake

Water quality preservation measures are classified into two parts: those for upper basin to install environmental basic facilities; those for lower basin to purify the water of lake. They will be completed by 2012 before the start of desalination that will be launched when the water quality estimated is suitable for the target standard (See Table 9), after installation of environmental basic facilities.

『Council for Water Quality Preservation Measures』 will be established and managed under supervision of Han River Regional Environmental Office, which related agencies and environmental groups participate in, evaluate the measures at every three years to establish and implement connected measures.

2.2. Management of Water Quality Preservation Measures

2.2.1 Water Quality Management of Hwasung Lake

For continuous monitoring the change in water quality in lake and inflow streams, 9 points in the lake, 2 points outside the lake and 6 point of midstream and lower stream flowing into the lake: Namyang stream, Jaan stream and Eoeun stream, is monitored. In addition, "Automatic Measurement System of Flood and Water Quality will be installed and managed at 5 points in the freshwater lake to establish a constant monitoring system and early-warning system.

2.2.2 Evaluation of Water Quality Preservation Measurement

To evaluate the progress of preservation measures and results of water quality monitoring, a Council for Water Quality Preservation Measures composed of 10 members from 6 committee members of related agencies, environmental groups and 4 members appointed by interested parties will be established and managed. Furthermore, the progress of water quality preservation measures will be evaluated once a year, and the result thereof will be reported to the Council for Water Quality Preservation Measures. The connected measures will be renewed at every three years according to the result of measures progress. Working expenses of water quality preservation measures is estimated to 176.8 $ millions in 9 projects including construction of sewage treatment plant at upper stream of $ 128,6 million and inside of the lake lower basin and inside lake measure $ 48.20 million.

2.3. Facilities of Water Quality Preservation Measures

2.3.1 Measures for upper basin

The upper basin measure is composed of four components: sewage treatment plant, village sewage, management of livestock wastewater and reduction of non-point sources from arable land.

- According to the Basic Plan for Sewerage Maintenance in Hwaseong-city, established in 1998, 2 sewage treatment plants in Namyang and Joam which are effective to reduce BOD of 3,189kg/day, T-N of 656.9 and T-P of 163.6kg generated in the upper basin of Hwasung Lake.

Table 10. Sewage treatment plant for upper basin

Name	Capacity	Total working expenses	Construction duration
Namyang sewage treatment plant (in Namyang-dong)	15,000 t/day	31.2 billion won	2002 - 2007
Joam sewage treatment plant (in Ujeong-eup)	16,000 t/day	41.9 billion won	2002 - 2006

- Installation of the sewerage with capacity of 3,700 t/day in 32 small villages that are scattered and excluded from sewage treatment plant, in order to treat domestic wastewater.

- Installation of the liquidated manure tank (10,000 t x 2 stations/day) and public livestock muck treatment facility (70 t/day) in order to collect and dispose the livestock muck generated from non-controlled 4,145 Korean cattle, 8,365 dairy cattle and 10,759 pigs bred by scattered livestock farmers in Hwasung Lake basin area.
- Installation of the purification facility in 2010 for the upper of Namyang stream of 8.05km that contributes highly to the amount of water and pollutants flowing into the lake in order to reduce and dispose the non-point source pollution and then its installation for Jaan stream and Eoeun stream too (after analysis of the effect in Namyang stream).

2.3.2 Purification Measures for Water in Lake

1) Artificial Wetland

After physically settling and filtering the pollutants, biodegradable matter by aerotropic microorganisms around roots can be treated in the wetland to improve the water quality, and retained in retention pond to remove T-N and T-P. According to the formula presented in Kadlec and Knight (1996), wetlands with 0.3m-depth and detention pond of 2.0m-depth with 8 day retention time at 3 parts of reclaimed land with 92.76ha were designed and constructed.

2) Aquatic Plant Water Retention

It is retained temporarily to treat the non-point source pollution generated from paddy and the initial effluent generated from basin at rainy occasion so that the aquatic plant absorbs the pollutants and the biodegradable deposited pollutants by soil microbe. Specification of the retention pond is 0.6m-deep basins for 3 day retention time at 10 inlets of freshwater lake, which is 61ha in total.

3) Sedimentation basin

To remove the suspended organic matter such as non-point source pollution and initial effluent flowed into the lake by inflow streams of the lake, the settling zone of 1.0m-3.0m depth on the basis of 77% of total COD at 3 inlets of freshwater lake (Maehyang 23ha, Jugok 13ha, Namyang 45ha, 81ha in total) were installed. As the existing freshwater lake of 50ha that is located at the inlet of lake, Jaan stream serves as sink zone.

4) Artificial floating island

It aims to remove nutrients and to prevent algal blooming through installation of floating plant island absorbing and treating suspended

nutrients by plants. Artificial floating island at 3 basins (800㎡ x 2 sets x 3 stations) and 2 stations in freshwater lake in front of the reclaimed land (1600㎡ x 4 sets x 2 stations) will be installed.

2.4 Situation of Project of Water Quality Preservation Measures

2.4.1 Performance evaluation according to business

Regarding measures for upper basin enforced by local government, sewage treatment plant, sewer pipe, village sewerage was working until 2009. Livestock and human waste treatment facilities are expected to complete in 2012 and reduction measures for Non-Point source pollution is expected to complete in 2010. As for purification measures for water in lake, sedimentation basin, wetland is under construction for completion in 2012. Aquatic plant water retention and artificial floating island need changes due to delay in its original plan.

Table 11. Water quality preservation measure in lake

Countermeasure			**Project quantity**	**Project period**	**Project subject**
Upper stream basin countermeasure	Sewage treatment plant		Namyang: 12,900㎥/day	'02~'07 (Completion)	Hwasung city
			Joam: 8,000㎥/day	'02~'06 (Completion)	
	Sewer pipe maintenance		28.57km	'02~'07 (Completion)	
	Village sewer system facility		14Number of places	'03~'08 (99%)	
	Livestock excretions treatment	Liquid fertilizer storage	10,000 t×2 places	'02~'11	
		Public treatment	150㎥/day	'06~'11	
	Natural style river		3 places	'04~'10	
Inside lake countermeasure	Artificial wetlands		92.76ha	'04~'09	Korea Rural Corporation
	Water plant detention place		61ha (10 places)	'09~'12	
	Lakes & marshes inflow part sinking land		81ha	'05~'09	
	Artificial plant island		5 places (14 sets)	'09~'12	

3. Conclusions and recommendations

Population, industry, and land uses are changed by urban development in upper region, so it is necessary to understand the accurate source of pollution in Hwasung lake and it also needs the expansion of original sewage disposal in Joam, Namyang due to pollutant increase caused by urbanization.

For better results of the project, linkage countermeasure will be published at every three years by government. When the linkage

countermeasure is published, changing in source pollution must be reflected on countermeasures for preservation of water quality. Additional installation of Non-point Source Pollution facility is conducted in Jayan stream and Eoeun stream after analyzing the effect of Non-point Source Pollution facility implemented in Namyang stream.

One of the important success points in the project driving is to introduce participatory management of the project in the planning stage. We constantly promote importance of Hwasung Water Quality Preservation to local residents and prevent illegal dumping of pollutant for successful completion and management. Paper focuses on water quality improvement measures in the reclaimed project site Hwaong in Korea and current status for the measures. It is expected to be a good example of reclamation projects in other countries that have a potential of the development in Asia and Africa. Another recommendation is close cooperation between interested parties like local government, central government and local residents.

Reference

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