Three Great Lakes in Korea: Soyang Lake, Chungju Lake and Daechung Lake

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Keywords: Soyang Lake, Chungju Lake, Daechung Lake, Eutrophication, Turbidity, TMDL

Abstract

Soyang Lake, Chungju Lake and Daechung Lake are the three largest man made lakes in Korea that serve for water supply and hydropower for more. While each lake has different basin characteristics and they all face difficulties in water quality management. Soyang Lake, being located in the upper stream area of the North Han River, has been known to have the best water quality of the country. But this lake experiences long lasting turbidity problems due to clay particles from increased soil erosion of basin area. Chungju Lake is located in the upper stream area of the South Han River, and it shows higher nutrient concentrations and also experience turbidity problems. Daechung Lake is located in the middle of the Geum River, the third largest river in Korea and it shows periodic eutrophication problems. While nutrient concentrations are high enough to support excessive phytoplankton growth in the summer, most of water quality management plans in the basins are focused on BOD (Biochemical Oxygem Demand). BOD concentrations in most of Korean lakes continuously decreasing due to increased operation of sewage treatment plants. However, COD (Chemical Oxygen Demand) concentrations keep increasing in most of the cases and there are no significant changes in nutrient concentrations. It seems water quality management strategies in Korean lakes need to be re-evaluated considering integrated basin scale pollutant management.

1. Introduction

Korea started to build reservoirs from A.D. 600 of Shilla Dynasty and has approximately 18,000 reservoirs nationwide as of March 2009. In general, medium and smaller reservoirs are used for agricultural purposes (17,591) and managed by Ministry of Agriculture and most of large dams are managed by Ministry of Land and Ocean. Large dams are usually built for multi-purposes and provide drinking and industrial water for urban areas.

Vast amount of fund has been invested for public safety from water disaster including flood and drought. Also there have been serious amount of investment for farming sectors to promote economic productivity. If we could have integrated the above investment with environmental management it would have been a lot more helpful in the management of lake water quality that supports daily lives of people in the country.

Korea is influenced by Monsoon weather pattern where two third of annual fall is concentrated in the summer periods (Jones et al, 2009). Higher rainfall intensity may carry increased nonpoint sources from basin areas and human impact in the basin make this effect more significant. Construction of structures, paved roads and rainwater pipelines in the basin are major factors decreasing water retention time in the basin and this can carry pollutants more easily to surface waters. Increased cattle breeding operations due to diet change in the country and organic farming in high land areas are origins of increased nutrient loads and soil erosion.
This paper will discuss about environmental management of three great artificial lakes, Soyang Lake, Chungju Lake and Daechung Lake in Korea.

2. Description of the Lake

Overview

Figure 1 shows locations of three great lakes of Korea; Soyang Lake, Chungju Lake and Daechung Lake. Table 2-1 shows general information of the three great lakes. These three dams have effective storage to supply water to over 40 million people and are being used to provide water for more than half of the population of the country.
They have played vital role in economic development of Korea during 1970's and 1980's but have been suffered from increased pollutant inflow from basin areas and thus face serious water quality problems.

Figure 2-1 Locations of Three Great Lakes in Korea

Table 2.1 General Characteristics of Three Great Lake in Korea

Category/Lake	Soyang	Chungju	Daechung	Unit
Basin Area	2,703	6,648	4,134	㎢
Lake Area	70	97	72.8	㎢
Total Storage	2,900	2,750	1,490	million ㎥
Effective Storage	1,900	1,789	790	million ㎥
Average Annual Inflow	1,750	4,888	3,220	million ㎥
Annual Water Supply	1,200	3,380	1,469	million ㎥
Hydro Power Capacity	200	200	90	GW
Water Residence Time	1.66	0.56	0.46	Year
Flood Control Storage	500	616	250	million ㎥
Average Annual Rainfall	1,100	1,198	1,230	Mm
Year Completed	1973	1973	1981	Year
Basin Characteristics	Mountain	Mountain and Rural	Mountain and Rural	
Major Pollutants	Sediment	Nutrients Sediment	Nutrients	

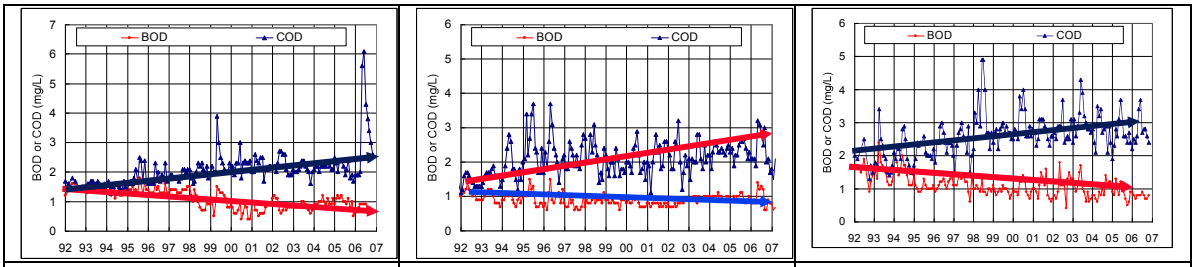
State of the Lake

Figure 2-2 shows BOD and COD concentrations variation trend for last 20 years in three lakes. While BOD concentrations show decreasing tendency, COD concentrations show increasing tendency. Eq(1) shows stoichiometric relationship of a theoretical perfect degradation of an organic material expressed as in $C_6H_{12}O_6$. BOD and COD are indicates amount of oxygen consumed as shown in the equation. BOD uses oxygen-respiring micro organism and COD uses oxydizing agent in the experiment. However, due to errors and inhibitions in

experiment neither BOD nor COD can accurately measure oxygen requirement completely. Kim (2007) reported that BOD and COD only can explain 6.6% and 33.3% of TOC, respectively in Korean river system. Eventually BOD and COD indicators of organic material in water, biodegradable and chemically oxydizable, respectively

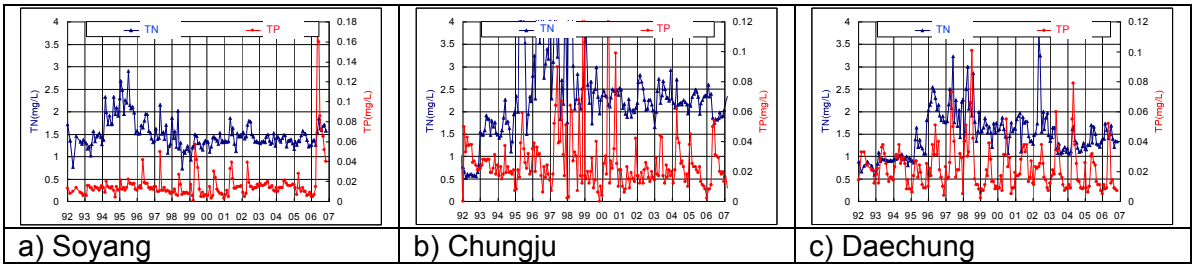
$C_6H_{12}O_6$	+	$6O_2$	=	$6CO_2$	+	$6H_2O$	---(1)
Organic Material		BOD or COD		Carbon Dioxide		Water	

Figure 2-2 shows confusing signals in water quality management of lakes in Korea. In Korean water quality standard, BOD is the major target for rivers. Most of sewage water treatment system can reduce organic loads if they use conventional treatment system. However, removal of nutrient such as Nitrogen and Phosphorus in wastewater require advanced treatment method that also requires much more expenses.



a) Soyang b) Chungju c) Daechung

Figure 2-2 Water Quality of Three Manor Lakes in Korea (BOD and COD) (Seo, 2008)

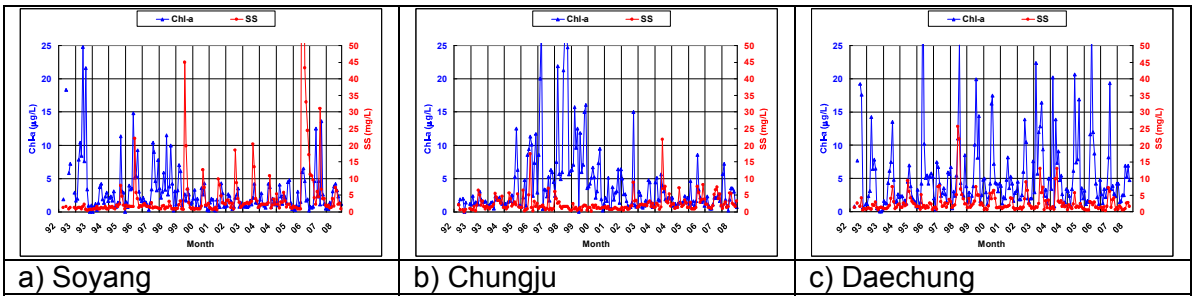


a) Soyang b) Chungju c) Daechung

Figure 2-3 Water Quality of Three Manor Lakes in Korea (TN and TP) (Seo, 2008)

Figure 2-3 shows TN (Total Nitrogen) and TP (Total Phosphorus) concentration variation trend in lakes for last 20 years. This figure shows that Nitrogen concentration was significantly low in early 1990's and abruptly increased in mid 1990's all three lakes. This figure also shows summer phosphorus concentration peaks became evident and occurring in every year. Those nutrient concentrations are sufficient level to cause eutrophication in lakes.

Figure 2-4 shows Chl-a and SS (Suspended Solid) concentration in three lakes. While so yang shows lowest level of Chl-a concentration level among three lakes. Summer peak of SS concentration began to be observed in recent years. Similar trend, though lee significant, can be found in Chunghu lake. Daechung Lake shows periodic peaks of Chl-a concentration especially in the summer indicating more frequent occurrence of eutrophication. It seems summer eutrophication has strong relationship with summer phosphorus concentrations in the lake.



a) Soyang | b) Chungju | c) Daechung

Figure 2-4 Water Quality of Three Manor Lakes in Korea (Chl-a and SS)

3. Management of the Lake and Its Basin

- ✓ The major resource values of the lake and its basin, how are they used/exploited economically, and who benefits and who loses in the use/exploitation?

Soyang, Chungju and Daechung Lakes are major water resources for more than half of population of Korea. Soyang Lake and Chungju Lake provide water for Seoul Metro Area, Gyeonggi Province and western part of Kangwon Province. Daechung Lake provides water for people in Daejeon Metro City, Chungnam Province, Chungbuk Province, and part of Jeonbuk Province. Water usage includes drinking water, industrial water and irrigation water. Three dams are also used for hydropower generation. On the other hands, people in the upper stream area of the lakes may be required to limit their development activities for the purpose of protection water quality for people living in down stream areas. People in Kangwon province and in Jeonbuk Province have been in such cases. Korea recently developed a law of “Water Use Tax” that can collect fund from users in down stream areas and this fund can be used to assist people in upper stream area. But the use and distribution method of the fund invite much discussions.

- ✓ Major socio-economic and political implications of the lake and its basin, particularly with respect to development, use and conservation of their resources, to the drainage population?

For Soyang Lake basin, high profit organic farming practices began active and caused turbidity problem and associated water quality problems
Daechung Lake basin experiences increased development demand including urban sprawl and road constructions. Construction of sewage treatment plant can reduce organic pollutant loading but is not sufficient in reducing nutrient loading unless they use advanced wastewater treatment system (Seo et al, 2007). Chungju Lake shows both side effects described in the above

- ✓ What are the resource use conflicts, and how are they managed? Are they managed well?

Soyang Lake basin is composed of less populated forest areas with steep mountainous terrain. Therefore, its water quality is relatively better than the other lakes in Korea as discussed in the above. However, Figure 2-3-a) shows abrupt increase in TP concentrations as well as increase of SS concentrations as shown in Figure 2-4-a). As shown in Fig 3-1-b), many high land farming activities became active recently in high elevation mountainous areas since less requirement of pesticides due to low temperature. However, steep mountainous areas usually do not have enough soil and nutrients to support vegetation growth. Producers in those areas bring soils and fertilizers to the site without proper protective

measurement of soil erosion protection. As a result, enormous amount of eroded soil with high nutrient flush down to the rivers and lakes (Jeon and Choi, 2004) .
Soil erosion has not been managed well and STP construction is not built for nutrient removal.

a) Turbidity Discharge from Soyang Dam, Left: discharge from hydroelectric power generator, Right: Spill way discharge

b) Major High Land Farming Areas in the Han River Basin

Figure 3-1. Turbidity Discharge from Soyang Dam and Locations of High Land Farming Areas

a) Transported Soil and Application of Fertilizers (in white bags)

b) Bottom Water Quality of a River (Youngwol) in the Upper Stream of Chungju River

Figure 3-2. High Land Farming Activities and River Water Quality Down Stream of the Farming Area.

- What is currently wrong with the lake and/or its basin, and how are the problems/issues being managed? As examples:
  - ✓ What do the basin inhabitants, including fishermen, consider the overall environmental and ecosystem status of the lake to be? Are their perceptions consistent with scientific findings?

Many inhabitants regard that the water quality of lakes has become worse and those are consistent with scientific findings.

- ✓ What is (are) the apparent and not-so apparent root cause(s) of the identified problems?

Apparent causes are soil erosion. Not-so apparent cause is construction of the sewage treatment plant. Many, including government, believe that building STP may solve the problem. However, STP may act as a legal nutrient disposal point if not properly treated. Under Korean efflfuent discharge regulation, a STP discharge limit for TN and TP are 20 mg/L and 2 mg/L, respectively. Due to increased eutrophication and turbidity, aesthetic quality of lakes becomes worse as well. This is another not-so apparent causes.

- ✓ Who or what suffers from the impacts of these problems/issues, and how?

Drinking water becomes worse and treated water may have taste and odour problems. Therefore, every people who receives treated water from the lakes sufferes from the impact.

Basin areas of most large dams are protected as “drinking water resources protection areas” by law. So many activities are limited in the vicinities of lakes. However major pollution load can be introduced via waterways that can deliver pollutants from outside of the protection areas.

4. Major “Impact Stories”

Korean government has launched “total waste load management act” in 2002. This is similar in concept with TMDL (Total Maximum Daily Loads) by Clean Water Act in US (Stow et al, 2007).
Currently, BOD is the major variable to control and point sources abate is the current target. Total phosphorus will be added in the control list and nonpoint loads also will be considered to be managed in the near future.

5. Major Lake Basin Governance Issues

- Who (individuals, groups, institutions) are key players in developing and implementing the actions/programs that need to be undertaken to address the identified lake basin problems?

While most of large dam (larger than storage of 300 million m^3) basins are designated as “drinking water source protection area,” most of other basin areas for medium and small sized reservoirs do not have proper management. Ministry of Agriculture and Ministry of Land and Ocean only control reservoirs and lakes inside water edge. Waste in basin areas is controlled by local governments and Ministry of Environment.
Most of local governments dependent on central government in financial support and this financial issue has been the most important limiting factor for effective implementation of basin scale environmental management actions.
Cooperation between governmental agencies is crucial and often this is the major problem. As wrote earlier, when there are project for flood or drought related project by governmental agency, the budget can be efficiently used for better environmental management.

6. Key Lake Basin Governance Challenges

Key lake basin governance challenges may be characterized by answering the types of questions exemplified below:

- What attempts have been made to establish sustainable institutions to address multi-national and mult-sectoral issues, and mult-stakeholder interests involved in managing a lake, its basin and its resources for sustainable use?

  DLSM (Daechung Lake Save Movement) has been the only NGO dedicated for lake environment. Though DLSM has networks with other environmental NGO's, there has not been any critical issues (Seo, ** need to add)

- Has there been an emergence of political interest and/or commitment to managing and/or using a lake, its basin and its resources in a more sustainable manner and, if so, what were the reasons for this emergence?

  There have been general acceptances that this issue is important. However, due to insufficient education and advertisement, integrated management of lakes and basins has not been fully acknowledged in Korea, yet.

  However, there is movement that a local government wants to use a lake (Paldag Lake near to Seoul Metropolitan) for their political interests (Seo….need to add). Paldang Lake Management Group is the typical example for such cases. This group was found by governer of Gyeong-Gi province and also KIST also joined in the team

- Will efforts be undertaken to establish a new legislative framework and/or policies for managing lake basins for sustainable use and, if so, why?

  Korean TMDL will be applied to additional pollutant for wider area including nonpoint load sources (Seo et al, 2009).

- Will efforts be undertaken to enhance stakeholder participation in the design and implementation of lake basin management programs?

  May be not

- Will plans/programs be developed to strengthen linkages between lake basin management programs, and broader national and regional water resources management efforts?

  This will be necessary and should be implemented for Korean lakes.

- Will efforts be undertaken to better incorporate scientific information and research results into lake basin management programs?

  This needs to be done by lake management agency. KOWACO (Korea Water Resources Corporation (or K-Water) controls most of large dams in Korea and KARICO

- Will efforts be undertaken to develop financing and/or subsidizing mechanisms for lake basin management activities that focus on sustainable use?

Acknowledgment

Author thank for assist of Dr. Hyungjoon Kim in KARICO, Dr. Kyunghyun Kim in KIER and Dr. Wuseok Lee in K-Water in the preparation of this paper.

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