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Review

Preface for the report on Yellow River Groundwater Project

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As the groundwater literally means water in the ground, we cannot see it readily. However, digging wells and analyzing its hydrological characteristics enable us to understand the true face of groundwater. From many studies by many people in the past and from our own experiences we know that groundwater flows slowly in the ground and it has some relations with river and sea water as well as meteoric water in the atmosphere.

The fact that groundwater is flowing suggests that it is recharged and discharged somewhere and it is connected with other types of water. Flowage and interaction of water on earth is called hydrologic cycle (water cycle), and the groundwater forms a part of hydrologic cycle. To know how the groundwater has existed is not only to improve our scientific knowledge but also is essential to predict its future and more efficient utilization of groundwater as one of the precious resources as well as to protect our environment.

One of the four pre-historic civilizations of the world developed in this Yellow River basin (In recent years the fifth ancient civilization, in Changjiang, separated from the Yellow River basin is also recognized.). Other three, Egyptian, Mesopotamian, and Indus Valley, were all developed along large rivers. Overall, large rivers must have given rich bounties rather than hazards for the people of the time. Around the time of 21 centuries BC the first dynasty of China, Xia, was established in the mid to downstream area of Yellow River followed by Shang (or Yin) dynasty in 18 centuries BC in present day Henan Province. Xia and Shang had been considered as mythical dynasties but proved to be real after excavations at Erlitou site for Xia and Yinxu site for Yin in recent years. Internet search reveals that Shang commerce was quite active and it is said that 'man of Shang,' meaning merchant in Chinese, has originated from there.

Following Xia and Shang, most dynasties that ruled major parts of China were located in or around Yellow River basin as well. First emperor of China, the Emperor Shihuang of Qin, had his capital located in Xianyang (presently west of Xian, Shaanxi Province), and the next dynasty Qian Han had its capital in Changan (presently Xian) under Liubang. Xianyang and Changan are situated along Weihe, a branch of Yellow River. After those times, Han and other races established many nations in turn and sometimes small nations juxtaposed at the same period in the history, but always the nations ruled Yellow River dominated China. From ancient times, the Yellow River has been historically and economically the mother river of China, as all the Chinese people agree.

The Yellow River is a big river; 5,464 km long, and according to Rika Nenpyo 2000 (Chronological Scientific Tables 2000 edited by National Astronomical Observatory in 1999) it is the sixth largest river in the world in terms of length. The Yellow River basin has a catchment area of 795,000 km^2 including closed inland Ordos catchment, and the total area is twice as large as that of whole Japan. The headwater is in the high mountains of Qinghai Province flowing down to east, then to north, again to east, to south, and finally to east before reaching to Bohai Bay. It passes Gansu, Ninxia Hui Autonomous Region, Inner Mongolia Autonomous Region, Shanxi, Shaanxi, Henan, and Shandong Provinces. Compared to Tone River, one of the biggest rivers in Japan with a length of only 322 km, the size of the Yellow River is overwhelming.

Several years ago in Tokyo, I had an opportunity to listen to expert members of China Yellow River Committee spoke. The summary of their talks was that the Yellow River is characterized by 'scarce water rich sand, and uneven distribution in space and time.' It means that the amount of water is not much but the amount of sand the river carries is large, and the water availability is uneven in time and space. The annual flow rate of the Yellow River is merely 58 billion m^3 while that of the other big river in China, Changjiang, is estimated to be 1 trillion m^3, but it carries 1.6 billion m^3 of sediments a year. About 60% of water is estimated to be fed from upstream areas of Lanzhou, Gansu

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Province, but most sediment is from loess provinces. In the 1990s Yellow River flow was often cut and dried up in the mid- to down-streams, especially in 1997 the river had dried up for 226 days. Furthermore the river flooded many times and during the last 2,000 years floods occurred more than 1,500 times. The river bed was raised over surrounding areas (raised bed river) and changed its course many times. There was a time when the river discharged even onto the southern side of Shandong Peninsula.

Flooding of the Yellow River delivered fertile soil to the downstream areas and the river irrigated agricultural land. In general the catchment area receives little rain (in the eastern area 700 mm per year and 200 mm in the west) and as a whole, the area is under semi-arid to arid conditions. Amount of evaporation is large and because of poor drainage after use in irrigation the farmland has troubles from accumulated salt. Loess region has poor plant cover causing excessive soil erosion so that danger of desertification is serious. Therefore utilization of groundwater became rampant to compensate shortage of water in the rapidly developing downstream areas of the basin. The trend would continue for the foreseeable future. We wonder how the future of groundwater situation stands in this trend.

As was pointed out at the beginning of this preface, wells may be used to examine the state of groundwater. Repeated sampling for a considerable span of time is essential. Also as the groundwater is used for various purposes, excessive pumping up may result in problems. Stable supply of groundwater may be disrupted from overuse, for example. To understand the status of groundwater, knowledge of geologic formations that contain groundwater is essential.

A five-year project to understand the whole picture of the groundwater of the Yellow River basin was started in 2002. In Japan, it was a part of a larger project called "Harmonious coexistence of man, nature, and the earth" in the Research Revolution 2002 (RR2002) Plan, and was specifically devoted for the prediction of changes in water circulation under the auspices of Ministry of Education, Culture, Sports, Science and Technology, Japan. Other projects such as prediction of global warming from ocean–atmosphere modeling, development of high resolution high precision climate modeling, and water resource development and risk management program were under operation in parallel with our program. However, ours was the only research program on groundwater.

Official title of the project is "Modeling and future prediction of balance, circulation and utilization of groundwater in the Yellow River basin, China" but often abbreviated as Yellow River Groundwater Project. As the Yellow River basin was the major research field, a memorandum of understanding was exchanged in March 2003 between AIST Geological Survey of Japan and China Geological Survey. Based on this memorandum, details of research and cooperation of two countries were coordinated and annual workshop was held. Actual research activities were carried out with close cooperation among Geological Survey of Japan, China Geological Survey, Institute of Hydrogeology and Environmental Geology (China), China Institute of Geo-environmental Monitoring and related provincial institutions in China, the University of Tsukuba, Hokkaido University and Geosphere Environmental Technology Corp. National Institute for Environmental Studies was in charge of another theme, "Current status of groundwater utilization and development of future prediction method" of the Yellow River Groundwater Project.

The Yellow River basin extends in EW and the difference in elevation between headwater and river mouth is over 5,000 m. At the headwater there exist small glaciers and permafrost areas. In the Yellow River Groundwater Project, surveys and observations of permafrost were carried out at headwater area. Hydrologic surveys of groundwater and surface water were conducted throughout the basin, and collected water samples were analyzed for general quality and oxygen and hydrogen isotope ratio. As the knowledge of rocks and formations containing groundwater is very important, information concerning geology, especially the thickness of aquifers and locations of faults were carefully inspected. The final target of the project was reconstruction of past groundwater condition by developing a groundwater circulation model of the vast Yellow River basin, taking account of all data collected, and prediction of the future from the model thus constructed. The model we developed is a three-dimensional groundwater circulation model covering an area of about 1.6 million km^2. Simulation results, for example on the North China Plain, predict an extreme lowering of the deep groundwater head in twenty years if groundwater will be extracted with the same pumping trend as at present.

Water is an extremely important resource everywhere. Without water lives and economic developments would be severely restricted. Especially in arid and semi-arid areas importance of water cannot be overemphasized. The Yellow River flows through arid and semi-arid areas in China. So, the quality and availability of water would impose a great influence in the economic development of the area. At the same time, water is an essential ingredient to maintain and control the environment. It is derived from the unique nature of water; water takes fluid form at normal temperatures, has high latent and sensible heat capacities, and many substances are highly soluble in water. The water as resource and environmental element is connected through hydrological cycle process. The groundwater forms a part of this cycle but hard to

observe directly. Here lies a great challenge to our project.

Reference

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黄河地下水プロジェクト報告書序文

石井武政

要　旨

文部科学省「人・自然・地球共生プロジェクト（RR2002）」の1テーマとして実施された日中国際共同研究「黄河流域の地下水循環モデルの構築および地下水資源の将来予測に関する研究」の概要を報告する．このテーマには産総研，筑波大学，北海道大学，（株）地圏環境テクノロジー，国立環境研究所，中国地質調査局，中国地質環境監測院，中国水文地質環境地質研究所，黄河流域の各省・自治区の地質環境監測站が共同して取り組み，黄河流域の地下水の姿をシナリオに基づいて予測する研究を展開した．