CCOP-GSJ Groundwater Project Report GW-10

Report of the CCOP-GSJ-GAI Groundwater Project Phase IV Kick-off Meeting

2-4 December 2019, Bali, Indonesia

COORDINATING COMMITTEE FOR GEOSCIENCE PROGRAMMES IN EAST AND SOUTHEAST ASIA (CCOP)

in cooperation with

GEOLOGICAL SURVEY OF JAPAN (GSJ), AIST

Gaurav Shrestha (Chief Editor)

I. PREFACE

Groundwater is one of the important natural resources essential for different purposes in human life. However, its improper exploitations have resulted in various groundwater issues and problems, mainly in the late 20th century. In recent days, land subsidence, seawater intrusion and groundwater pollution by toxic substances are serious problems all around the world. East and Southeast Asia also have faced many of these problems which need international cooperation to be solved. The CCOP-GSJ Groundwater Project has been launched aiming to provide some solutions for groundwater management in the CCOP region.

The CCOP-GSJ-GAI Groundwater Project Phase IV Kick-off Meeting was held in Bali, Indonesia on 2-4 December 2019. The meeting was hosted by Geological Agency of Indonesia (GAI). It was attended by 28 participants from Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Myanmar, Philippines, Thailand, Vietnam and the CCOP Technical Secretariat. In the meeting, participants confirmed the outcome of the CCOP-GSJ Groundwater Project Phase III and discussed the plans for the Phase IV.

Each CCOP member country made a presentation on the topic of "Issues and improvement ideas for the Phase III Groundwater Database" (DB1 & DB2 Groups) and "Present hydrogeological data and problem for making groundwater database" (Public Policy Group). All the member countries discussed on the groundwater database compilation planned for the Phase IV.

This publication compiles all the country reports presented in the CCOP-GSJ-GAI Groundwater Phase IV Kick-off Meeting.

I am very grateful to the authors for their invaluable contribution to the project and to their organization for giving the permission for this publication.

Gaurav SHRESTHA
Chief Editor

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and

Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)
CCOP Building, 75/10 Rama VI Road, Phayathai, Ratchathewi, Bangkok 10400, Thailand
https://www.ccop.or.th/

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II. The Minutes of the CCOP-GSJ-GAI
Groundwater Project Phase IV Kick-off Meeting
2-4 December 2019, Bali, Indonesia

The CCOP-GSJ-GAI Groundwater Project Phase IV Meeting was held on 2-4 December 2019 in Bali, Indonesia. It was attended by 28 participants from Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Myanmar, Papua New Guinea, Thailand, Vietnam and the CCOP Technical Secretariat (CCOPTS).

The Opening Ceremony started with the Welcome Remarks delivered by **Dr. Young Joo Lee**, CCOPTS Director, and **Dr. Uchida Youhei**, CCOP-GSJ Groundwater Project Leader, Geological Survey of Japan (GSJ), AIST. The meeting was officially opened by **Mr. Rudy Suhendar,** Head of the Geological Agency of Indonesia (GAI) and Permanent Representative of Indonesia to CCOP.

Dr. Uchida Youhei presented the outcome of the CCOP-GSJ Groundwater Project Phase III which included publication of technical report (GW-9) consisting the following:

1. Report titled "Hydrogeological map –Present status and future plan–"
2. Explanation documents for the country's capital city or representative area in DB1& DB2
3. Public policy for Groundwater observation system in Public Policy Group

GW-9 Report was distributed at the 55th CCOP Annual Session in November 2019 in Chiangmai, Thailand as well as at this kick-off meeting of the phase IV. The electronic version of GW-9 will be made available for download at CCOP and GSJ websites. Under the same phase, a sub-project on "Development of Renewable Energy for Ground-Source Heat Pump System in CCOP Regions" was also carried out. During this phase three GSHP systems were installed in Thailand, one in Vietnam and a heat exchanger in Indonesia.

Dr. Uchida also presented the plans for the CCOP-GSJ Groundwater Project Phase IV as follows.

- Database advancement. Data upload by each MCs.
- Addition of data related to pollution problems in MCs of Public Policy Group
- Field survey and discussion on solving groundwater problems in MCs of PP Group. What kind of GW problems exist should be prepared before the field survey and discussion.
- To continue Ground Source Heat Pump sub-Project

To date the following data are available from the GSi Groundwater Portal, https://ccop-gsi.org/gsi/groundwater/index.php.

Country	No. of GW Wells	Location
China	0	
Indonesia	292	Java Island, Sumatra Island
Japan	519	Kanto, Yamagata, Ishikari, Kumamoto, Nobi Plain, Sendai
Korea, RO	221	Whole Korea
Malaysia	21	Langat Basin, Sabah *(Coordinates to be corrected)*
Philippines	1,256	Luzon Island, Bohol, Camarines Norte, Pampanga, Pangasinan, Quezon, Zambales
Thailand	2,027	Chaophraya, Khonkean Province
Vietnam	147	Thanh Hoa, Ha Tinh, Quang Nam, Quang Ngai Provinces, Red River Delta
Total	***4,483***	

Country reports on the "Issues and improvement ideas for the Phase III Groundwater Database" (DB1& DB2) and "Present hydrogeological data and problem for making Groundwater Database" (Public Policy Group) were presented.

Dr. Gaurav Shrestha from GSJ will be the Project Leader for the CCOP-GSJ Groundwater Phase IV. **Dr. Shrestha** led the discussion on the data compilation planned for Phase IV, and the following were agreed.

- There will only be 2 groups for Phase IV,
  1) DB1 (China, Indonesia, Japan, Korea, Malaysia, Philippines, Thailand and Vietnam)
  2) DB2 (Cambodia, Lao PDR, Mongolia, Myanmar and Papua New Guinea).
- Additional data items to be collected which could be useful for studies on land subsidence caused by over abstraction of groundwater and groundwater pollution problems.
  1) Survey date
  2) GW level (static)
  3) GW level (dynamic)
  4) Aquifer name (stratigraphy)
  5) Aquifer type (lithology)
  6) Well-type (monitoring or production)
  7) Pumping rate (production well only)
  8) Number of screens (production well only)
  9) Screen depth (from/topmost)
  10) Screen depth (to/lowest)
  11) Land subsidence in the area
  12) Region/province (well location)
  13) Total dissolved solid
  14) Total arsenic
  15) Ecoli
  16) Total coliforms

- Well-ID should start with the country's 2-letters code

The next meeting is targeted to be in Naypyitaw, Myanmar in early 2021. Two alternative dates were identified as follows.

- 25-28 January 2021
- 22-25 February 2021

From next meeting, an additional day will be allocated for technical field survey in the DB2 countries for discussion on solving the country's related groundwater problems.

Deliverables until the next meeting in Naypyitaw were agreed as follows.

- Update DB1 countries data to include the additional data items and bring the updated excel file in the next meeting in Naypyitaw for upload to the GSi Groundwater Portal, https://ccop-gsi.org/gsi/groundwater/index.php with the guidance of the GSi Project Coordinator who will be invited to the next meeting.
- Vietnam will provide additional groundwater data from South Vietnam in the next meeting.
- China will discuss with China Geological Survey (CGS) which published data on groundwater that can be shared to this project and communicate with the CCOP Technical Secretariat for update before the next meeting in Naypyitaw.
- DB2 countries will collect groundwater data on their existing monitoring wells and bring the excel file to the next meeting in Naypyitaw for upload to the GSi GW Portal.
- Mongolia will discuss with Mineral Resources and Petroleum Authority of Mongolia (MRPAM) on the groundwater data that they can provide, and will feedback to the CCOPTS before the next meeting in Naypyitaw.
- All countries will bring respective country hydrogeological map (if available) in shapefile format to Naypyitaw for upload to the GSi Groundwater Portal.
- Submission deadline of full paper of GW-10 country reports is end of February 2020.

Dr. Mawiti Infantri Yekti, lecturer from Udayana University Bali, gave a talk entitled "Water Allocation of Subak Irrigation Schemes in Yeh Ho River Basin". She guided the field trip on the last day at PT. Coca Cola, Ulun Danu Temple, Beratan Lake, Bedugul and Jatiluwih Rice Terraces.

This minutes is adopted as signed.

Cambodia

China

Indonesia

Japan

Lao PDR

Malaysia

Mongolia

Myanmar

Papua New Guinea

Thailand

Vietnam

CCOPTS

Present hydrogeological data and problem for making groundwater database in Cambodia

Virinrath Yang

Department of Geology,
General Department of Mineral Resources, Ministry of Mines and Energy, Cambodia
e-mail: yang.virinrath@gmail.com

Abstract

Cambodia has abundant water resources both surface water and groundwater. Cambodia has abundant water in wet season and scarcity of water in the dry season, thus groundwater resources has a significant role and widely used for drinking water, household water supply and irrigation. However, data and information on actual use is lacking, with knowledge gaps across local and national scales. In future, population growth and economic development will place rapidly increasing demands groundwater resources. To develop and use groundwater resources in sustainably way, all relevant availability of groundwater data needs to be gathered and groundwater database need to be established. This paper presents the overall status of hydrogeological condition and problem for making groundwater database.

Keywords: groundwater, hydrogeological, database, Cambodia

1. Introduction

Cambodia is situated in Southeast Asia region, southwestern part of Indochina block, bordered to the west, north, east and south by Thailand, Lao PDR and Vietnam and by the Gulf of Thailand to the south-west. Topography is divided into four main terrains: mountain ranges, hilly plateau, central flood plain and coastal plain. The Tonle Sap (Great Lake) is situated in the center of the country, the most productive inland water and the largest freshwater lake in Southeast Asia which has an elevation of 10-30 m above sea level and covers an area about 3,000 km^2. The great lake was formed less than 6000 years ago when the most recent subsidence of the Cambodian platform took place along northwest-southeast direction (Baran, 2005).

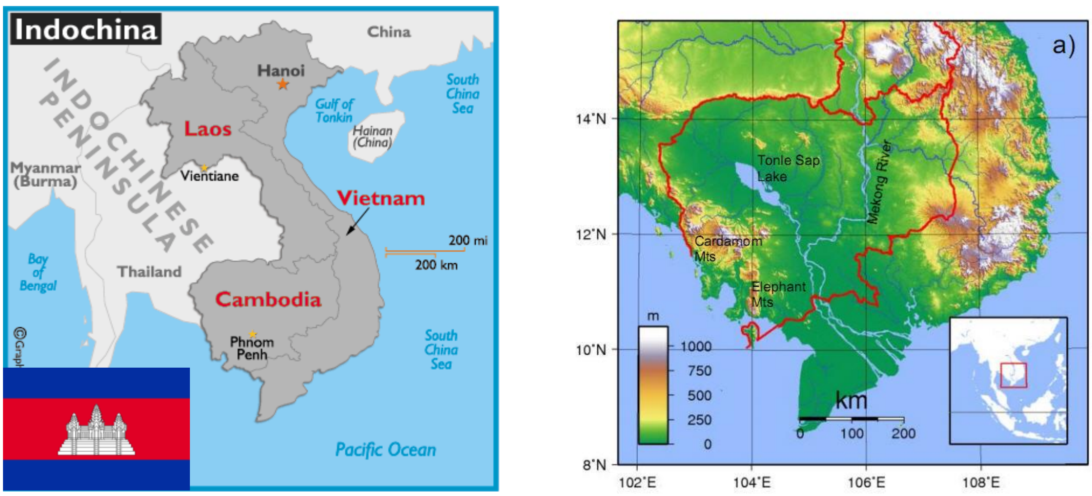

Fig. 1. Map of Cambodia; Topographic map.

Cambodia has a tropical monsoon climate. There are two major seasons, the dry season from November to April and the wet season from May to October which rainfall is largely derived from the southwest monsoon. Annual rainfall varies from 2,700 mm in the coastal area, through 2,400 mm in the mountain range (Cardamom and Elephant mountains), to around 600-800 mm in the central area. Average annual is about 1000-1500 mm. Average temperatures vary from 22-36 ℃ (BGS, 2016). Cambodia has a diverse range of freshwater sources, including rivers, streams and lake and these contribute to abundant water resources. About 750 to 790 × 10^6 m^3 of water is used in Cambodia each year (Mak, 2017).

Country geologically composed of four different structures, the central plain is covered by alluvial deposit of Quaternary, thickest in the Tonle Sap river system and Mekong Delta, as most of the north mountain regions and coastal region are largely composed of Cretaceous granite, Triassic and Jurassic sandstone formation.

The Quaternary units are distinguished as follow (UN ESCAP, 1993):

- The Holocene sediment cover is represented on the coastal and interior plains and in small upland valleys, by recent deposits of fluvial, lacustrine and shallow-sea
- The Middle-Upper Quaternary (principal sedimentary aquifer) is widespread in the north, southeastern and northwestern sectors of Cambodia, where it is known as the Battambong formation. On the Mekong plain, the upper Quaternary is recognized as the Mochoa formation, occupying the 10-15 m terraces in the southeast of Phnom Penh. It is composed of grits, sands and clays outcropping on higher relief levels on the outer parts of the central plains
- Quaternary plateau basalt of Middle-Upper Pleistocene and Neogene-Quaternary platform basalt rock
- Lower Quaternary (Q1) consists of sands, silts and clay-stone both fluvial and marine origin.

2. Present status of hydrogeological data

The two dominant hydrological features of Cambodia are the Mekong River and the Tonle Sap Lake. The lake is connected to Mekong River through the 100 km long Tonle Sap channel. During the rainy season (May to October), the Mekong river drainage into the Tonle Sap to northwest and as the water level of the Mekong fall during dry season, water drain from the Tonle Sap back down into the Mekong. The tonle sap lake has several input rivers, the most important being the Tonle sap river during raining season, which contributes 62 % of total water supply. The other rivers in the sub-basin and direct rainfall on the lake contribute 38 % (FAO-Aquastat, 2011).

Groundwater recharge in Pleistocene through Miocene deposits occurs in terraces along the margins of the Holocene alluvial plain. These terraces are generally coarse-textured and more productive aquifers that fine-textured Holocene surficial sediments. The main aquifers consist of Plio-Pleistocene sediments (sands, silts and clays), contiguous to the Tonle Sap and Mekong delta are believed to be shallow aquifers with water table 5-10 m of the surface water. Multi-layered aquifers can be found in Quaternary layer in the eastern section of Mekong River. In the western section, aquifers are found in the weathered zone and fissures of basement rocks. Groundwater is abstracted mainly from boreholes at shallow depths, less than 50 m in rural area but deeper in urban area. In the central lowlands, water levels are usually shallow and abstracted with hand pumps.

We are currently working on two projects on hydrogeological and groundwater survey under the cooperation with GDMR-KIGAM-CCOP and GDMR-CGS as follow:

Hydrogeological and Environmental Geological Mapping Project

The Project on Hydrogeological and Environmental Geology Mapping (2017-2020) under cooperation with CGS, aim to generate the map and provide data support for sustainable utilization of water resources in Cambodia. In 2018, more than 160 sites in SE part of Cambodia, was investigated include 61 dug wells, 71 pumping wells and 28 streams. Every single site was recorded the water feature and hydrology condition (**Fig. 2.**). In 2019, field survey was conducted in 100 sites which in 11 provinces. The data processing, interpreting and map generation will be carried out and finalized in 2020. The result of the project will provide national hydrogeological data and hydrological map scale 1: 500,000 with explanatory notebook.

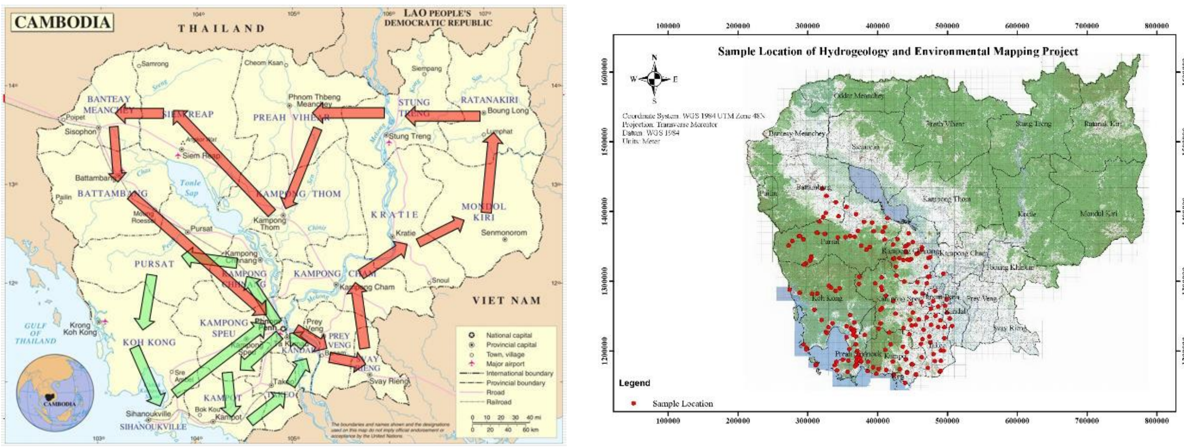

Fig. 2. Hydrogeological survey and sample collection by GDMR-CGS team.

Groundwater Monitoring Well Project

The Project on Groundwater Monitoring well in transboundary aquifer is a cooperation project between GDMR-KIGAM-CCOP. In 2019, there are total three monitoring wells were drilled and installed along Mekong River, in Kandal province, southern of Phnom Penh where the transboundary aquifer of Lower Mekong delta between Cambodia and Vietnam (**Fig. 3**). The groundwater monitoring project will help to understand more about groundwater condition in transboundary aquifer.

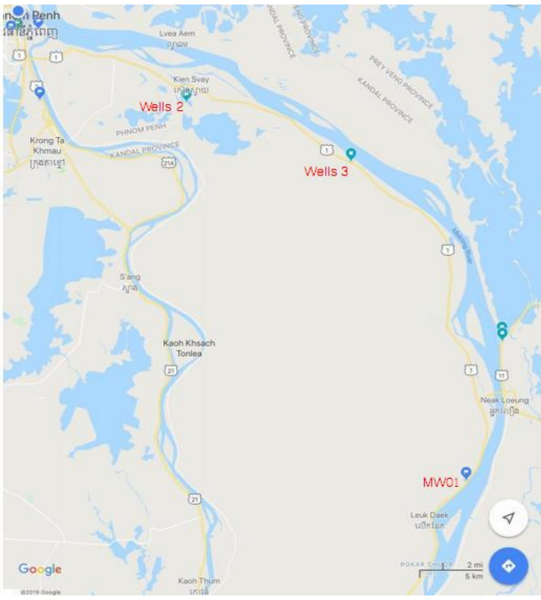

Fig. 3. Location of three monitoring wells, Kandal province.

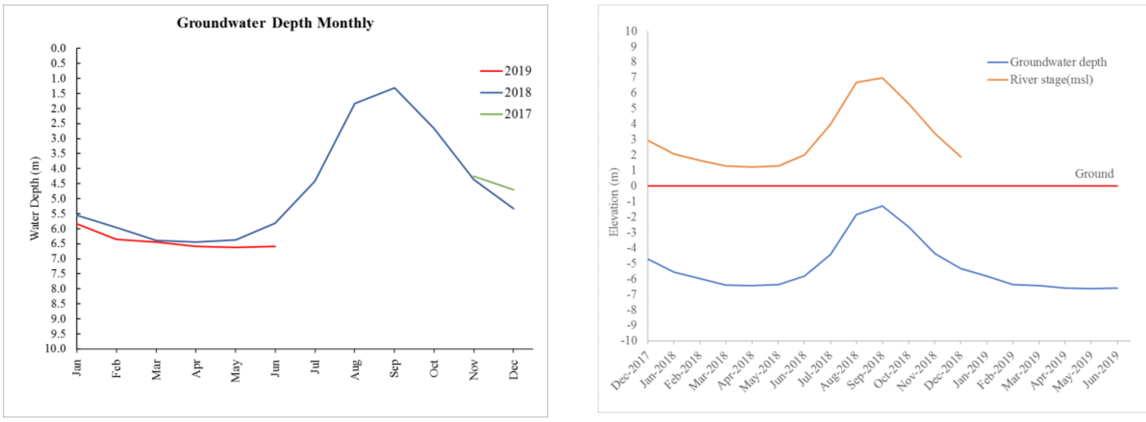

Fig. 3. (a) Groundwater depth, (b) River level and GW depth.

According to data from groundwater monitoring well, groundwater level in 2018 drop down 0.63 m compare to December 2017. The effect of El Nino, the temperature rises up to 42 ℃, the evaporation and groundwater exploitation is increase. In 2019 groundwater level continue drop down up to 0.77 m compared to 2018. Under framework of Ministry of Water Resource and Meteorology, the river level in Neak Loung station is used to study interaction between aquifer and surface water. Following the graph in **Fig. 3. (b)**, the river and aquifer level movement are related to each other. In dry season, groundwater discharge to river while river discharge to groundwater in rainy season. According to well-logged data, the aquifer lithology, the monitoring well is in confined aquifer which present of aquitard from 40 to 45 m in depth and second aquitard is in depth 67 to 69 m. Therefore, this confined aquifer in monitoring zone might be interacted with surface water.

Groundwater survey in Central Cambodia

The Kampong Chhnang province and Kampong Cham province, the survey area, are area rural region in central Cambodia where there are hardly no water supply facilities and the local people rely on dug wells, ponds and rivers for water supply. Most of these water sources get depleted in the dry season, only 13 % of total population has access to stable drinking water supply. In addition, the groundwater resources area also high in iron, nitrate, arsenic and observed to be contaminated by manmade activities. This project survey was carried out by ministry of rural development, JICA and Kogyo Co., Ltd, in 2002.

According to geological conditions of the survey area, it can be divided into 3 regions by groundwater potential in Table 2. In Kampong Chhnang province, groundwater is generally taken from the fissure zone or weathered zone of the basement rocks. The maximum yield recorded is 100 L/min where rhyolite occurs. Pleistocene, unconsolidated sediments covering basement rocks are thin in thickness and poor in groundwater.

In Kampong Cham province, Pliocene unconsolidated sediments are most important aquifers. more than 200 L/min of groundwater is yielded from this aquifer at five test drilling holes and maximum yield reached 900 L/min. in addition, groundwater is also taken from fissure zone or weathering zone of the basement rocks and basalt.

Table 1. Area Distinction by groundwater potential.

Province	Geology	Main Aquifer	Groundwater Potential
Kampong Chhnang	Hill, Gentle slope and Lowland composed of basement rocks, Pleistocene and alluvial sediments.	Fissure and weathered zone of the basement rocks.	Alluvial and Pleistocene aquifer yield small amount and inferior water quality, high in iron and salinity. Arsenic is locally contained. Basement rock aquifer has greater yield and good water quality. Exploration is difficult.
Western Kampong Cham	Alluvial Lowland Plateau composed of Plio-Pleistocene sediments and basalt	Plio-Pleistocene sediments and basalt	Alluvial aquifer is same as the above. Plio-Pleistocene and basalt aquifers have greater yield. Flowing well can be seen. Water quality is slightly high in iron.
Eastern Kampong Cham	Hill and Plateau composed of Plio-Pleistocene sediments and basalt.	Plio-Pleistocene sediments and basalt and basement rocks.	Plio-Pleistocene aquifers are same as the above. Flowing well can be seen. Basalt and basement rock aquifers have greater yield. Water quality is excellent.

The pumping test and water quality test conducted on sites, the groundwater potential in central area show in Table 3. Productivity of the alluvial aquifer is poor in Kampong Cham province as same as in Kampong Chhnang. Plio-Pleistocen sand and gravel layer form excellent aquifers as well as basalt in Kampong Cham province. According to the pumping test, the pumping rate range from several ten m^3/day to several hundred m^3/day. Yield of the basement rock aquifer which is lying beneath the basalt is also high in Memot District.

Table 2. Groundwater potential in Kampong Chhnang and Kampong Cham province.

Province	District	Main Aquifer	Specific Capacity (m^2/day)	Water Quality	Groundwater Potential
Kampong Chhnang	Kg.Tralaach Rolea Bier Saamakki Mean Chey Baribour	Fissure and Weathered Basement Rocks	0.2-11.1	Locally high Iron and Fluoride content	Low groundwater potential except fissure of the basement rocks.
Kampong Cham	Memot	Fissure and weathered Basalt	2.9-52.0	Low Iron content	High groundwater potential
		Fissure and weathered Sand Stone	18.7-115.8	Same as the above	Same as the above
	Ponhea Kraek Steung Trang Tboung Khmum Ou Reang Ov Chamkar Leu Cheung Prey	Plio-Pleistocene Sand	15.6-303.2	Locally high Iron content	Sandy aquifer is excellent and productive. Yield is high. Locally flowing well.

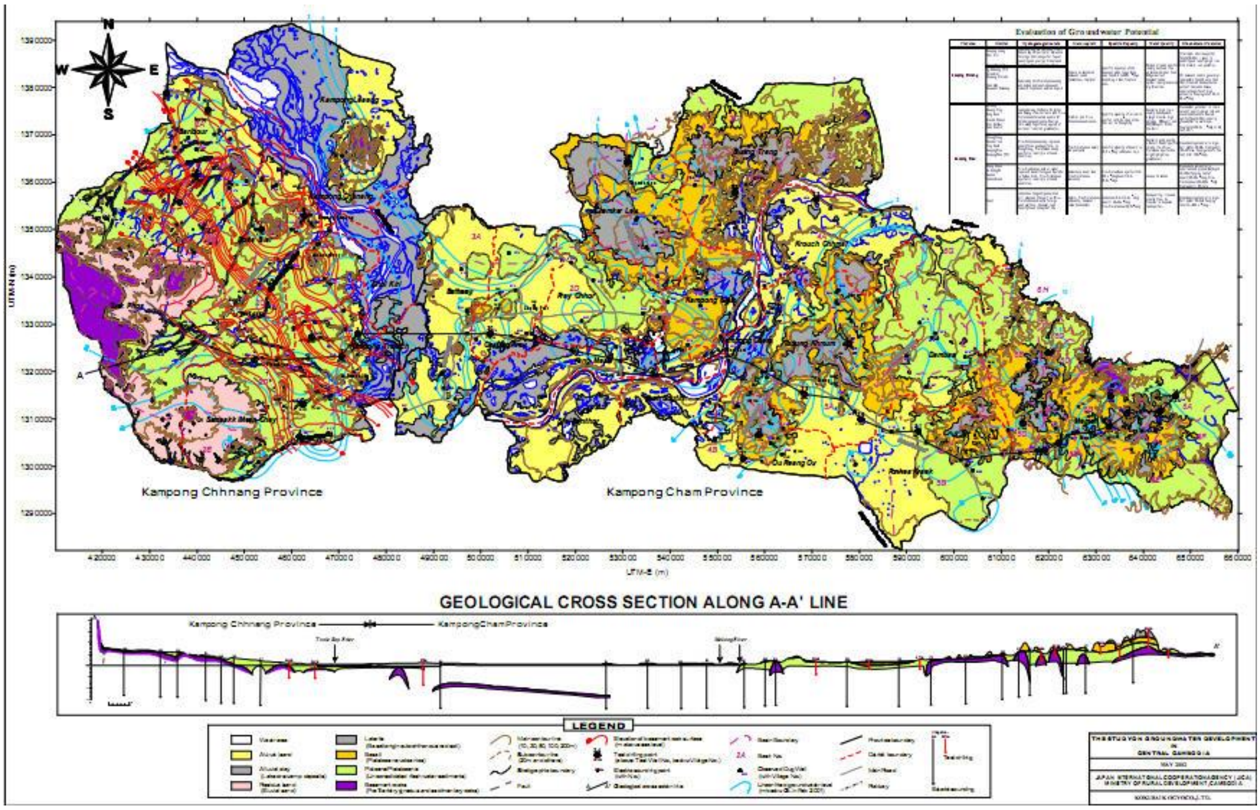

Fig. 4. Hydrogeological map of central Cambodia (Kampong Cham and Kampong Chhnang province), JICA 2002.

Current issues on groundwater resources

Cambodia has a relatively small population and underdeveloped economy, but future population growth and economic development will place rapidly increasing demands groundwater resources. Groundwater quality is one of main challenge for groundwater management in Cambodia. Cambodia faces water resources-related issues as follows:

- Monitoring of groundwater is little known
- Urban wastewater pollution
- Aquifers in southeast threat by saline intrusion
- Land subsidence and exacerbation due to over extraction
- Arsenic contamination
- Impact of climate change

3. Problem and barriers for making groundwater database

The groundwater database is an important tool to organize and systematize all relevant available groundwater data in order to prepare an overview of groundwater resources in terms of quantity, quality and availability; and use for a sustainable strategy of groundwater resources management and for planning of future groundwater development. In order to facilitate efficient and appropriate groundwater resources management, it has to design for groundwater database, based on the available information on data both static and dynamic data.

The major problem to establish groundwater database are comprehensive data, reliability and validity of groundwater data no available even though there are many projects studies on groundwater in Cambodia, existing data is extremely difficult to access, and those data available not up to date. There are also other problems with internal ministerial set up. The role and responsibilities of relevant agencies in hydrogeological and groundwater survey are still unclear, lack, financial support, human resources and technical skill.

4. Plan and ideas for constructing groundwater database

Plan Activity and Support need:

- Build up capacity on groundwater data collection/management
- State of groundwater data collection/management and information sharing need to be improved
- Equipment support/Install pilot wells for groundwater level monitoring at crucial areas
- Require software to create/store/manage the database
- Develop groundwater database bases on standard guideline
- Technical guideline to construction GW database/standardized data structure

- Require Technical support of database construction (Data formats, data structure, data collection, data analysis)

- Transfer skill and technology of groundwater development and management

References

Akira, K., 2002, Study on Groundwater Development in Central Cambodia, Japan International Cooperation Agency (JICA), Ministry of Rural Development, Cambodia.

Baran, E., 2005, Cambodian Inland Fisheries: Facts, Figures and Context. WorldFish Center and Inland Fisheries Research and Development Institute, Phnom Penh, Cambodia, 9 p.

British Geological Survey, 2016, Groundwater Quality: Cambodia, Natural Environmental Research Center, 1-8 p.

FAO, 2011, AQUASTAT Country Profile-Cambodia, 4 p.

Frenken, Karen., 2012, Irrigation in Southern and Eastern Asia in figures-AQUASTAT Survey, FAO Water Reports, 208-209 p.

Mak, S., 2017, Water Governance in Cambodia: From Centralized Water Governance to Farmer water User Community, 6-7 p.

United Nation, 1993, Economic and Social Commission for Asia the Pacific, Volume 10, Cambodia, Explanatory brochure, 10-11 p.

Present hydrogeological data and problem for making groundwater database in China

Guo Haipeng

China Institute of Geo-Environment Monitoring, China
e-mail: guohp@cigem.cn

Abstract

This paper briefly introduces the achievements of hydrogeological survey and monitoring in China in the past few decades. China has paid much more attention to hydrogeological investigation and research of groundwater. The hydrogeological survey in small scale, mainly in 1:200,000 scale has been completed through all the country. In order to meet the needs of economic and social development, China Geological Survey (CGS) has carried out hydrogeological survey in 1:50,000 scale with new technology and theory in key areas such as Ordos Basin, Qaidam Basin and Karst area in Southwest China. The groundwater resource was evaluated and the first round of regional investigation on groundwater quality has been fulfilled. The National Groundwater Monitoring Project (NGMP) was built just in 2019, but reasonable methods need be developed to estimate groundwater regime and groundwater quality. At present, China is carrying out a new stage of hydrogeological survey focusing on major river basins such as Yangtze River Basin, Yellow River Basin, Haihe River Basin, Huaihe River Basin, Songliao River Basin, Pearl River Basin and Inland Basins in Northwest China. More attention is being paid to ecological environment problems such as groundwater-derived land subsidence. These efforts have played a vital role in supporting national economic and social development and ecological civilization construction.

Keywords: groundwater, hydrogeological survey, China

1. Introduction

Water resources are distributed unevenly in China, which has contributed to a North-South divide in resource access. Southern China has 81 % of the country's natural water resources, and the northern provinces have the remaining 19 % (James, 2013). Northern China is considerably drier since it receives far less rain and at the same time experiences higher evaporation rates than the southern provinces. The uneven distribution of water resources has created intense water scarcity in many local areas north of the Yellow River. Similar to the total water resource, groundwater resource is more abundant in Southern China, accounting for about 68 % of the total groundwater resource, while the evaluation area is only 40 % of the total evaluation area. Groundwater resource is scarce in Northern China, accounting for about 32 % of the total groundwater resources, while the evaluation area is up to 60 %.

From1950s to 1990s, a large number of hydrogeological investigation and groundwater resource evaluation were carried out in China. In this period, China completed national hydrogeology survey mainly in scale of 1:200,000 covering an area of 6.3×10^6 km^2. Other surveys with a scale of 1:50,000-1:100,000 were also finished for different purpose such as water supply in agricultural and pastoral areas and water supply in cities. From 1999 to 2005, CGS has carried out hydrogeological survey in main basins and plains of China, such as North China Plain, SongnenPlain, Liaohe River Plain, Erdos Basin, Yinchuan Plain, Hexi Corridor, Qaidam Basin, Tarim Basin and Junggar Basinon in scale of 1:250,000, covering an area of more than 2.0 × 10^6 km^2. Hydrogeological survey in 1:50,000 scale was also completed up to 0.6 × 10^6 km^2, covering key areas such as karst area of Southwest China, Erdos Basin, Qaidam Basin, and energy bases like Shanxi and Shananxi. Moreover, the regional groundwater pollution investigation with 4.40 × 10^6 km^2 areas in 1:250,000 scale has been fulfilled with a space database created. Based on the above investigation, the groundwater quantity and quality were evaluated. Special groundwater resource evaluation was conducted between 1980 and 1984, and the second evaluation was conducted between 2000 and 2003. The results show that the whole groundwater resource is 9.235 × 10^{11} m^3/a (Zhang et al., 2004).

Table 1. Natural recharge resources in mountain areas and plains.

Region	Evaluation area		Natural recharge resources	
	Area (million km^2)	Percentage (%)	Quantity (billion m^3/a)	Percentage (%)
Mountain areas	6.8	74.3	698.9	73.1
Plains	2.35	25.7	256.7	26.9
Repeated			32.1	
The whole	9.15	100.0	923.5	100

Since 1950s, China began to conduct the groundwater monitoring. From 2015-2019, China completed the construction of National Groundwater Monitoring Project (NGMP). Countrywide groundwater monitoring network has been built preliminarily in the main plains and basins. These works have played a vital role in supporting national economic and social development.

2. Present status of hydrogeological data in China

Over the past few decades, on the basis of various types of hydrogeological surveys and groundwater monitoring, a large number of relevant data have been obtained. The major data are as follows.

2.1 Hydrogeological mapping

Since 1999, CGS began to construct the national hydrogeological space database which was mainly based on the products of 1:200,000 regional hydrogeological survey. About 1148 sheets of the standard synthetic hydrogeological maps and many other hydrogeological maps were digitized and synthesized in this database. The national hydrogeological space database has provided a great deal of hydrogeological information services for land development, agricultural planning, urban development, water conservancy construction, geological environment protection and new rural construction.

The 1:50,000 hydrogeological survey took groundwater system theory as the guiding ideology, emphasizing the application of new technology and new methods. A series of maps were compiled according to the hydrogeological survey results, which include not only professional maps such as groundwater level contour map, groundwater quality map and three-dimensional hydrogeological structure map, but also applied maps such as groundwater exploitation potential map and groundwater antifouling performance map.

2.2 Groundwater monitoring data

The National Groundwater Monitoring Project (NGMP) was finished just in 2019, totally 20, 469 wells were constructed between 2015 and 2019, of which 10, 171 wells are administrated by Ministry of Natural Resources. The object of NGMP is to construct modern groundwater monitoring network covering the 16 dominant plains/basins in China, effectively improve groundwater monitoring and supervision ability, and provide scientific data for decision makers and researchers.

3. Problems for making groundwater database

So far, the first round of groundwater monitoring data from NGMP have been collected, while the original data need be checked and be synthetically analyzed before use. Also, reasonable methods need be developed to estimate groundwater regime and groundwater quality. These problems lead to difficulty in making groundwater database.

4. Plan and ideas for constructing groundwater database

Groundwater is an important part of water resources for the survival of human beings, is a kind of precious natural resource, and is also one of the important factors that affect the ecological environment. However, groundwater overexploitation has led to some environmental problems such as aquifer depletion, land subsidence and sea water intrusion. At present, China is carrying out a new stage of hydrogeological survey focusing on the ecological environment problems in major river basins. Take land subsidence as an example, it usually bears strong relationship to abstraction of groundwater. The first occurrence of land subsidence in coastal cities of China took place in Shanghai and Tianjin in the 1920s. Then by the 1960s, it became a severe disaster for these two cities. From the 1970s, land subsidence also occurred in major cities along the Yangtze River Delta Plain such as Suzhou, Wuxi, Changzhou, Hangzhou, Jiaxing and Huzhou. Since the 1980s, the area affected by land subsidence extended from cities to rural areas, accompanied with ground fissures, which showed that the disaster of land subsidence had become more serious. The governments have paid much attention to the prevention and control of land subsidence, and great progress has been achieved in investigation, monitoring and groundwater abstraction control. As a result of these efforts, the control of land subsidence has achieved initial success, e.g., the land subsidence has been controlled successfully in regions such as the Yangtze River Delta Plain.

The Chinese government pays much attention to groundwater resources management. The National Groundwater Monitoring Project (NGMP) has been completed, which effectively improves the groundwater monitoring ability and could provide data for monitoring the development of ecological environment problems. CGS plans to improve the density of groundwater wells in order to monitor the groundwater regime more effectively. To meet the need of economic and social development, groundwater resources would be estimated more frequently in the future.

A hydrogeological info-system, called "Geocloud", has been recently developed by CGS, which has been updated to version 2.0. CGS plans that most data of hydrogeological mapping, groundwater monitoring and groundwater-related ecological problems are synthesized into this info-system. Some groundwater data may be provided for conducting groundwater database in the near future. CGS is willing to strengthen international cooperation and jointly promote the technical methods of hydrogeological survey.

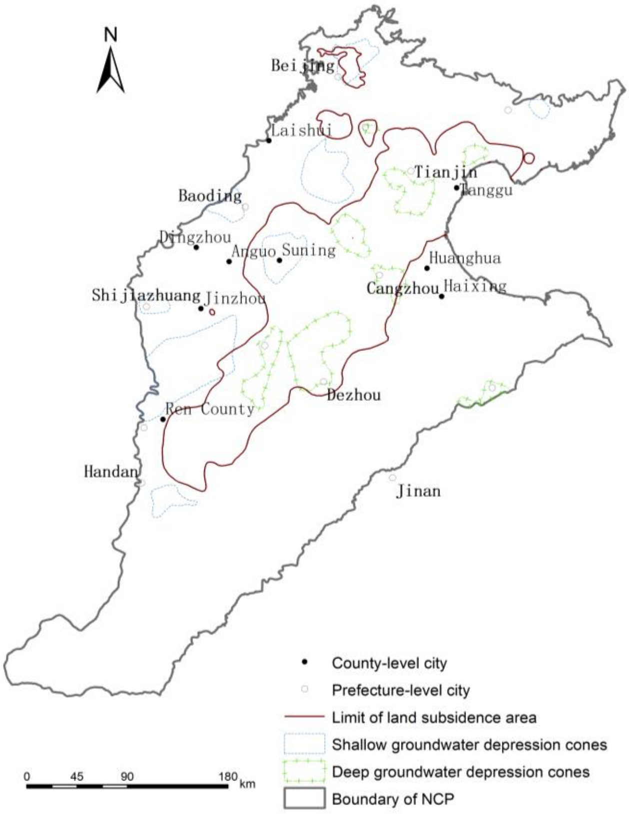

Fig. 1. Distribution of the depression cones of shallow and deep groundwater, and major land subsidence area in the NCP.

References

Cao, J. and Liu, W. (2016) Hydrogeological mapping in China - Present status and future plan, Project Report of the CCOP-GSJ-GA Groundwater Phase III Meeting, CCOP Technical Secretariat.

Guo H. (2015) Groundwater-derived land subsidence in the North China Plain, *Environ Earth Sci* **74**:1415-1427.

James, K. R. (2013) Policy and Planning for Large Water Infrastructure Projects in the People's Republic of China, B. A. thesis, Wesleyan University, Middletown, USA.

Jiang, Z. (2016) Recent Groundwater Issues and Their Action Study in China, Project Report of the CCOP-GSJ/AIST-NAWAPI Groundwater Phase III Meeting, CCOP Technical Secretariat.

Zhang, Z. and Li, L. (2004) *Groundwater Resources of China.* Beijing: China Map Publish House.

Issues and improvement ideas for the Phase III groundwater database of Indonesia

Nofi Muhammad Alfan Asghaf, Budi Joko Purnomo and Akbar Norma Arief

Centre of Groundwater and environmental geology, Geological Agency, Indonesia
e-mail: purnomobudi80@gmail.com, geologialvan@gmail.com

Abstract

Groundwater data as uploaded in the groundwater database phase III CCOP project in Indonesia as the main staple in supporting groundwater management in Indonesia. The main groundwater data are hydrogeological maps containing aquifer types, then developed into a groundwater basin map which can be further developed into a groundwater potential map and groundwater conservation map. The groundwater potential map provides information on the transmissivity (T) value and the hydraulic conductivity (K) value with the output being the optimum discharge value in an aquifer. Meanwhile, the groundwater conservation map contains information on groundwater conservation zones such as safe zones, vulnerable zones, critical zones, and damaged zones. The Indonesian groundwater database status in the Phase III CCOP groundwater database project has now uploaded groundwater data on Java and Sumatra, and will add groundwater data on Kalimantan Island. The idea of improving the groundwater data in this phase III groundwater database project is that CCOP and member countries make a Memorandum of Understanding (MOU) about all member countries required to share data, then add data parameters such as ground water level, transmissivity value, hydraulic conductivity value, and depth of aquifer.

Keywords: Management, groundwater, hydrogeology, groundwater basin

1. Introduction

Indonesia, as a tropical country, has a great water resources, up to 3.9 trillion m^3, a part of the resources is groundwater with potential volume of about 517.123 million m^3 annually. The big potential of the groundwater needs for a correct management based on groundwater conservation. The groundwater management is started by characterization of the groundwater aquifers through hydrogeological mapping. The map then is used as a basic information to roughly estimate the groundwater potential and to configure the boundaries of groundwater basins. The hydrogeology maps are produced by series of activities, including secondary data compilation, field survey, data analysis, and finally map drafting. Despite for groundwater management purpose, the hydrogeology maps are usually applied for regional spatial planning.

The final hydrogeology maps were then used for identification the boundaries of groundwater basins, that will be the basic concept of groundwater basin management. Groundwater basin can be defined as a place underground, in which groundwater recharged, flowing through aquifer, and finally discharged in lowland areas or sea/lakes. The groundwater basins boundaries are typical hydrogeology boundaries in surface and underground. For each groundwater basin, the groundwater potential is then calculated, by basically following the water balance concept, which is presented as Groundwater Potential Map. The information presented by the maps include groundwater quantity (discharge, e.g., m^3 annually) and quality. Other than groundwater management purpose, the groundwater potential maps also can be used for spatial planning and groundwater usage planning.

Groundwater usage for various purposes can causing groundwater degradation, both the quantity and quality, hence needs for conservation to ensure the groundwater can be used sustainably for the next generation. The impact of groundwater usage in a groundwater basin is monitored regularly to produce updated groundwater basin conservation maps, which used for daily operation of groundwater management, i.e., issuing permit of groundwater abstraction by industries and other purposes. The groundwater conservation map is made by considering two main factors, i.e., groundwater table depletion and groundwater quality (seawater intrusion) in every layer aquifer. The maps also present boundaries of groundwater recharge and discharge areas, which is differently treated in the term of groundwater conservation. The discharge area basically is a groundwater protection area, hence the groundwater only permitted to be used for very basic purpose, i.e., for basic human needs. Meanwhile, the groundwater in discharge area can be used for any purposes, including industries. This paper presents discusses the problems of groundwater data management in Indonesia, factors that hinder the management of groundwater data and solutions to overcome these problems.

2. Current status and issues for the Phase III Groundwater Database

There are several problems in managing groundwater data in Indonesia which have resulted in not optimal groundwater data management. Some of the problems that still exist are Don't have a good data management system yet, The area managed is very wide, Differences in the ability of human resources in groundwater management based on Groundwater basin (421 GW Basin in Indonesia) between the Geological Agency (41 GW Basin) and the Local Government (380 GW Basin), Problems with the budget for managing groundwater data, and Uncertainty Regulation for Groundwater.

Groundwater data in Indonesia that has been uploaded in Phase III Groundwater Database are 292 data and are located in Java and Sumatra (Fig. 1). Groundwater data that has been uploaded are in the form of groundwater quantity and quality data from groundwater samples from boreholes and springs in the Cross Provincial Groundwater Basin. Several groundwater basins that have been uploaded in Phase III of the Groundwater Database include the Jakarta Groundwater basin and the Serang-Tangerang Groundwater Basin in Java Island. Groundwater Basin on Sumatra Island that has uploaded data, including the Kutacane Groundwater Basin, Lubuklinggau-Muaraenim Groundwater Basin, Bangko-Sarolangun Groundwater Basin, Gedongmeneng Groundwater Basin, and Ranau Groundwater Basin. Data on boreholes and springs in Phase III Groundwater Database in Java and Sumatra Island consists of physical and chemical data on groundwater including EC; pH; Chlorine; Nitrate; Sulphate; Bicarbonate; Sodium; Ammonium; Potassium; Magnesium; Calcium; Fluorine; Lithium; Nitrite; Phosphate.

There is a slight data error on the island of Sumatra, which is caused by an error in the coordinate data input process in the field, the wrong data will be replaced with new data whose coordinates have been adjusted.

Fig. 1. Groundwater data of Indonesia in the Phase III Groundwater Database

3. Improvement ideas for the Phase III Groundwater Database

Indonesian groundwater data in the CCOP phase III groundwater database project has now uploaded data on Java island and Sumatra island. The idea of improving the groundwater data in this phase III groundwater database project is that CCOP and member countries make a Memorandum of Understanding (MOU) about all member countries required to share data, then Additional data on the Kalimantan island. There are several data parameters of groundwater in boreholes that must be added such as transmissivity value, hydraulic conductivity value, depth of aquifer, screen position, depth of borehole, static groundwater level and dynamic groundwater level. In addition, there will also be additional data isotope Hydrogen Isotope and Oxygen Isotope especially in Java.

4. Conclusions

Various groundwater data in Indonesia such as hydrogeological map data, groundwater basin maps, groundwater potential maps, and groundwater conservation maps are the main ingredients in realizing good groundwater management. In realizing various data in the form of maps, groundwater data are needed in the form of groundwater wells which include the quantity and quality of ground water, as already shared in the phase III CCOP groundwater database project. Groundwater Management in Indonesia is groundwater management based on groundwater basins by prioritizing groundwater conservation, in the context of using groundwater for the welfare of the community.

References

Davis, S.N. and De Wiest, R.J.M., 1967. Hidrogeology, John wiley & Sons, Inc., New York.

Djaeni, A., 1982. Hidrogeological Map of Indonesia Sheet IX Yogyakarta. Directorate of Enviromental Geology, Bandung.

Heath, R.C., 1989. Basic Groundwater Hidrology, United States Geological Survey Water Supply Paper 2220.

Soekiban, S., 2001. Guidelines for Preparation of Hydrogeology Map Scale of 1: 100,000, Geological Agency, Bandung.

Struckmeier, W. and Margat, J., 1995. Hydrogeological Maps A Guide and a Standard Legend. International Association of Hydrogeologists, Hannover.

Sungkawa, W. and Pasaribu, M., 1998. Hydrogeological Map of Indonesia scale 1:100,000 Karawang, Geological Agency, Bandung.

Todd, D. K., 1980. Groundwater Hydrology, Second Edition, University of California, Berkeley, John Wiley & Sons, New York.

U.S. Department of Interior, 1977. Groundwater Manual, First Edition, United States Government Printing Office, Washington.

Issues and improvement ideas for the Phase III groundwater database of Japan

Gaurav Shrestha and Uchida Youhei

Geological Survey of Japan, AIST, Japan
e-mail: shrestha-g@aist.go.jp

Abstract

In Phase III groundwater database of Japan, data of altogether 519 observation wells and sites were uploaded. The database includes data of Ishikari Plain (28 wells), Sendai Plain (78 wells), Yamagata Basin (122 wells), Kanto Plain (155 wells), Nobi Plain (82 wells), Kumamoto Plain (54 wells). For each point, 26 parameters were included. Water quality graphs and vertical temperature profiles were also linked at those observation wells only where these data were monitored. Main issue of Japan's database is with data quality. In database system, well names are case sensitive so there are some problems with misreading and misplacement of data. Other problem is data overlapping of wells close to each other with almost similar coordinates. In order to improve the database, revising and maintaining data quality are very essential for Japan's database at the present context. Other improvement ideas for the whole CCOP groundwater database could be addition of data essential for water resources management and pollution control in each member countries, uploading hydrogeological maps, and addition of surface water quality data.

Keywords: groundwater database, issues, data quality, Japan

1. Introduction

In Phase III groundwater database of Japan, data of altogether 519 observation wells and sites were uploaded in CCOP groundwater portal. The database includes data of Ishikari Plain (28 wells), Sendai Plain (78 wells), Yamagata Basin (122 wells), Kanto Plain (155 wells), Nobi Plain (82 wells), Kumamoto Plain (54 wells) (Fig. 1).

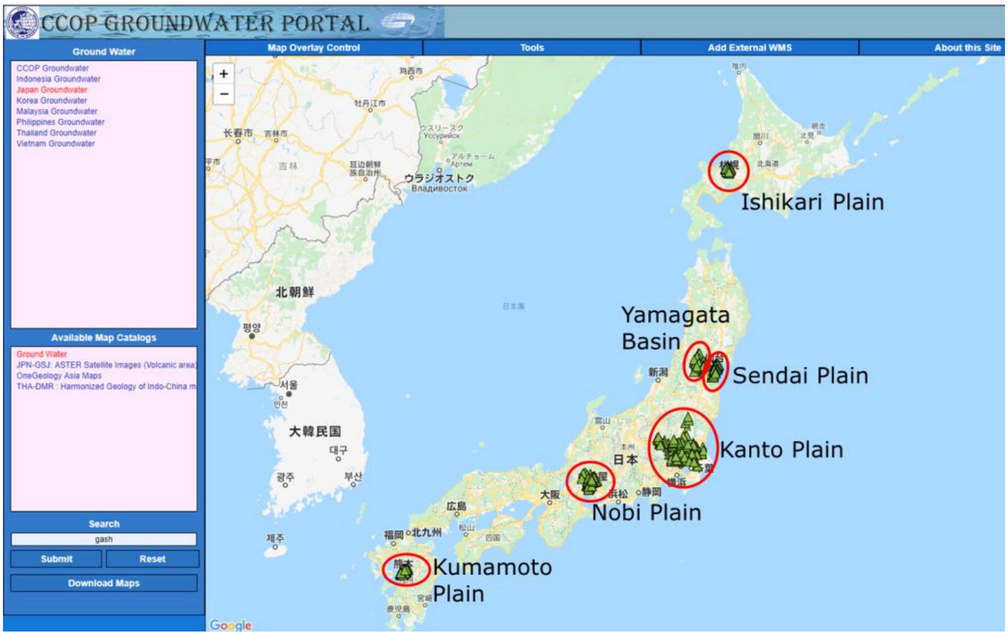

Fig. 1. Area and observation wells in groundwater database of Japan.

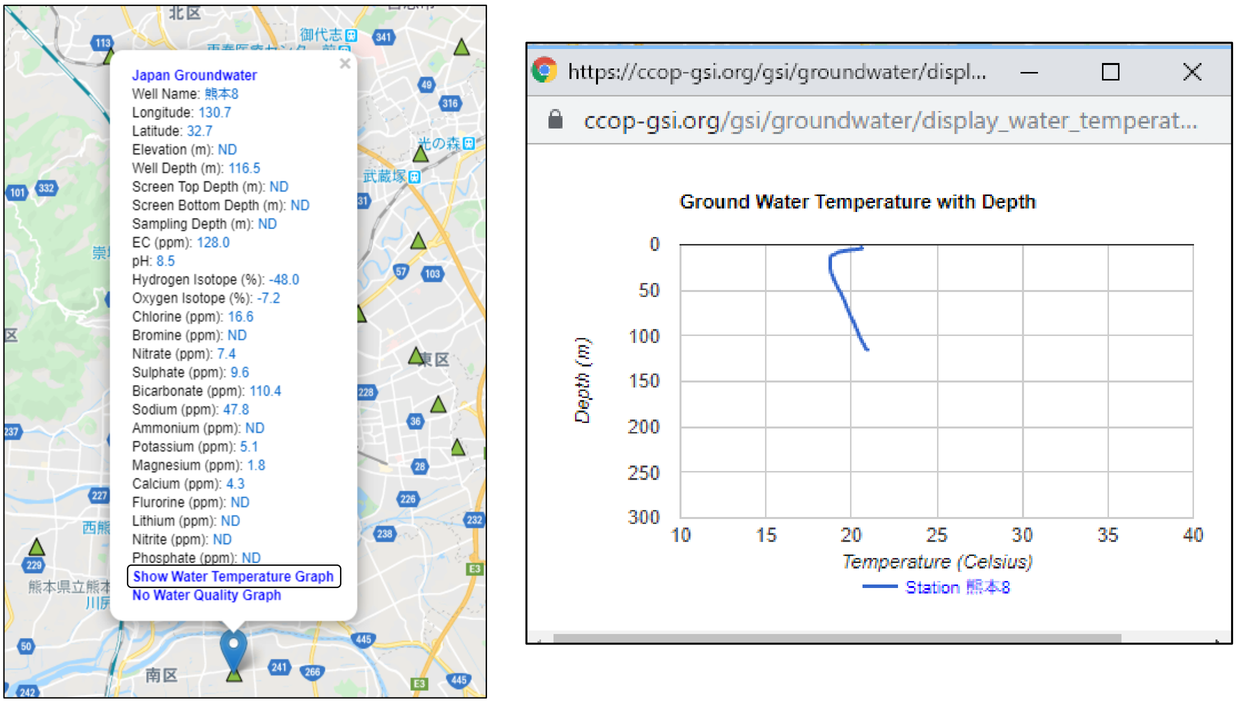

Fig. 2. Groundwater data at each observation point (left), groundwater vertical temperature profile (right).

2. Current status and issues for the Phase III Groundwater Database

At each observation point, 26 parameters were included, however, it is not that all the parameters were available at every point. Parameters without data were written as ND (No Data). Vertical temperature profiles were also included at those observation wells only where these data were monitored (Fig. 2).

Main issue of Japan's groundwater database is with its data quality. In the database system (GSi system), well names are case sensitive. Each and every well name should be unique with that of other wells. If the well name is same, then there will be a problem with data misreading and can be misplaced in other regions. Few cases of data misplacement were found in Japan's database. So, well names had been revised by adding initial letter of each area at the end of well name (Fig. 3).

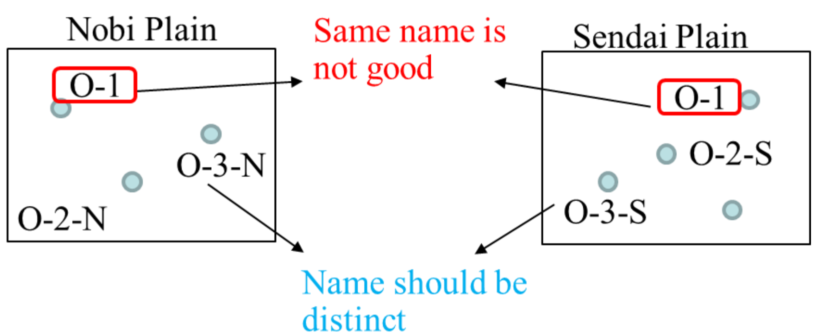

Fig. 3. Issue of groundwater database with same well name.

If there are two wells such as deep and shallow wells close to one another with same coordinates i.e. Latitude and Longitude, then only one well can be displayed because of overlapping. Hence, it should be decided which well to be considered in the database as per the importance of data.

For the temperature profile data of the well, in order to link with its related data in the database system, the well name must be same. If not same, then temperature profile data will not be linked and graph will not be displayed. In Japan's database, there were some cases of temperature data not being linked with groundwater data. It is because Japanese characters are used in well names which were slightly different from the one used in temperature data, for example 沖新 and 沖新（浅）. Second word in the example has some extra character in the bracket due to which two cannot be interlinked.

3. Improvement ideas for the Phase III Groundwater Database

In order to improvise and properly maintain the CCOP groundwater database, increasing the quantity of data is important on one hand, however on the other hand data quality must be constantly checked and corrected for the mistakes by each member countries for their country's respective groundwater database.

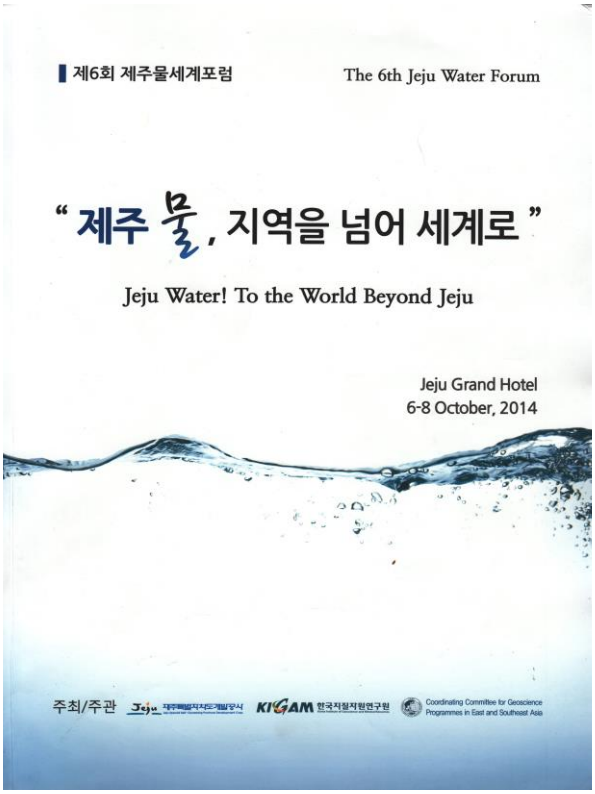

Fig. 4. Cover page of the 6^{th} Jeju Water Forum.
(Reference: www.jwwf.co.kr/forum/eng/history/program.htm)

Phase III groundwater database for all the member countries can be improvised by modifying the current format of database. Additional water quality data or parameters that might be essential for the water resource management in respective member countries can be added so that the database can play a useful role in solving water resource related issues and problems in a near future. In the 6th Jeju Water Forum held in 6^{th} - 8^{th} October 2014 in Jeju, Korea (Fig. 4), CCOP member countries were classified based on their main water resources. Surface water is the main water resource for Malaysia, Japan, Timor Leste, Myanmar, Korea and China (southern area). Groundwater is the main water resource for Thailand, Vietnam, Indonesia, Lao PDR, Cambodia and China (northern area). Hence, addition of surface water quality data can be an option for the countries whose main water resource is surface water. Parameters for drinking water based on WHO guidelines such as total dissolved solids, total coliforms can be useful for drinking water management as well.

Member countries from the Public Policy Group with groundwater or surface water pollution problems can propose for the related additional data. For instance, data of Arsenic concentration in case of Cambodia and also heavy metals like Mercury etc. Further, countries with already published hydrogeological maps (raster data) can be uploaded in the database which can be effectively used together with the data in database.

4. Conclusions

In Phase III groundwater database of Japan, data of altogether 519 observation wells and sites were uploaded in CCOP groundwater portal. The database includes data of Ishikari Plain (28 wells), Sendai Plain (78 wells), Yamagata Basin (122 wells), Kanto Plain (155 wells), Nobi Plain (82 wells), Kumamoto Plain (54 wells). For each point, 26 parameters were included.

Main issue of Japan's groundwater database is with its data quality. Few cases of data misreading and misplacement were found because of same well names for wells in different regions. Other problem is with data overlapping of wells close to each other with almost similar coordinates.

For the improvisation of Phase III groundwater database, it is strongly recommended to revise and maintain the data quality by each member countries, in addition to increase the data quantity. Additional water quality data or parameters that might be essential for the water resource management in respective member countries can be added to the database so that it can play an effective role in solving water resource related issues. Surface water quality data can be added for member countries whose main water resource is a surface water. Also, member countries from the Public Policy group can propose for the addition data related to pollution problems in their respective countries.

References

Jeju Water World Forum homepage, www.jwwf.co.kr/forum/eng/history/program.htm.

Issues and improvement ideas for the Phase III groundwater database of Korea

Seongkyun Kim and Eunhee Lee

Korea Institute of Geoscience and Mineral Resources, Republic of Korea
e-mail: kskinc@kigam.re.kr

Abstract

In South Korea, six main groundwater monitoring networks are operated by different government ministries for different purposes. Their database includes data sets from 442 national groundwater monitoring wells, 3,553 groundwater quality monitoring wells, 181 seawater intrusion monitoring wells, 446 rural groundwater monitoring wells, and 2,451 subsidiary groundwater monitoring wells as of 2018. The database of drinking water monitoring wells is not open to the public.

Each database, however, uses its own specifications, and thus there are difficulties to integrate information from each database. Data errors caused by automatic observation also occur, so data quality needs to be improved.

To improve the utilization and quality of Korea's groundwater database, KIGAM is constructing a new integrated information database for the groundwater and groundwater-dependent ecosystem. It includes both groundwater and surface water information. Using this database, a technique for modeling groundwater flow on a web page is being developed.

Keywords: groundwater, database, Korea

1. Introduction

In Korea, there are six main groundwater monitoring networks (Lee and Kwon, 2016): National Groundwater Monitoring Network (NGMN), Groundwater Quality Monitoring Network (GQMN), Seawater Intrusion Monitoring Network (SIMN), Rural Groundwater Monitoring Network (RGMN), Subsidiary Groundwater Monitoring Network (SGMN), and Drinking Water Monitoring Network (DWMN). They are operated by different government ministries with different purposes.

In connection of these groundwater monitoring networks, KIGAM is currently developing a groundwater database of integrated information system. This new database contains data from the existing monitoring network, as well as a variety of data measured by our researchers.

2. Current status and issues for the Phase III Groundwater Database

The NGMN, the primary groundwater monitoring network in Korea, has completed the establishment of 442 groundwater observation stations throughout the country including Jeju Island from 1995 to 2018 in accordance with Article 17 of the Groundwater Act and the Basic Plan for National Groundwater Management, and plans to install 530 stations by 2021. The monitoring networks are divided by major watershed regions, which are the Han-gang, Nakdong-gang, Geum-gang, Seomjin-gang, Youngsan-gang, and Jeju ('gang' is a Korean word for river). The NGMN aims to provide basic data necessary for the water resources management and pollution control by continuously monitoring groundwater level and quality. Groundwater level, temperature and electrical conductivity (EC) are automatically measured at 1-hour intervals. Groundwater quality is measured twice a year for all monitoring wells. The monitored data sets are managed as a database of the integrated groundwater information service system (www.gims.go.kr) operated by National Groundwater Information Center.

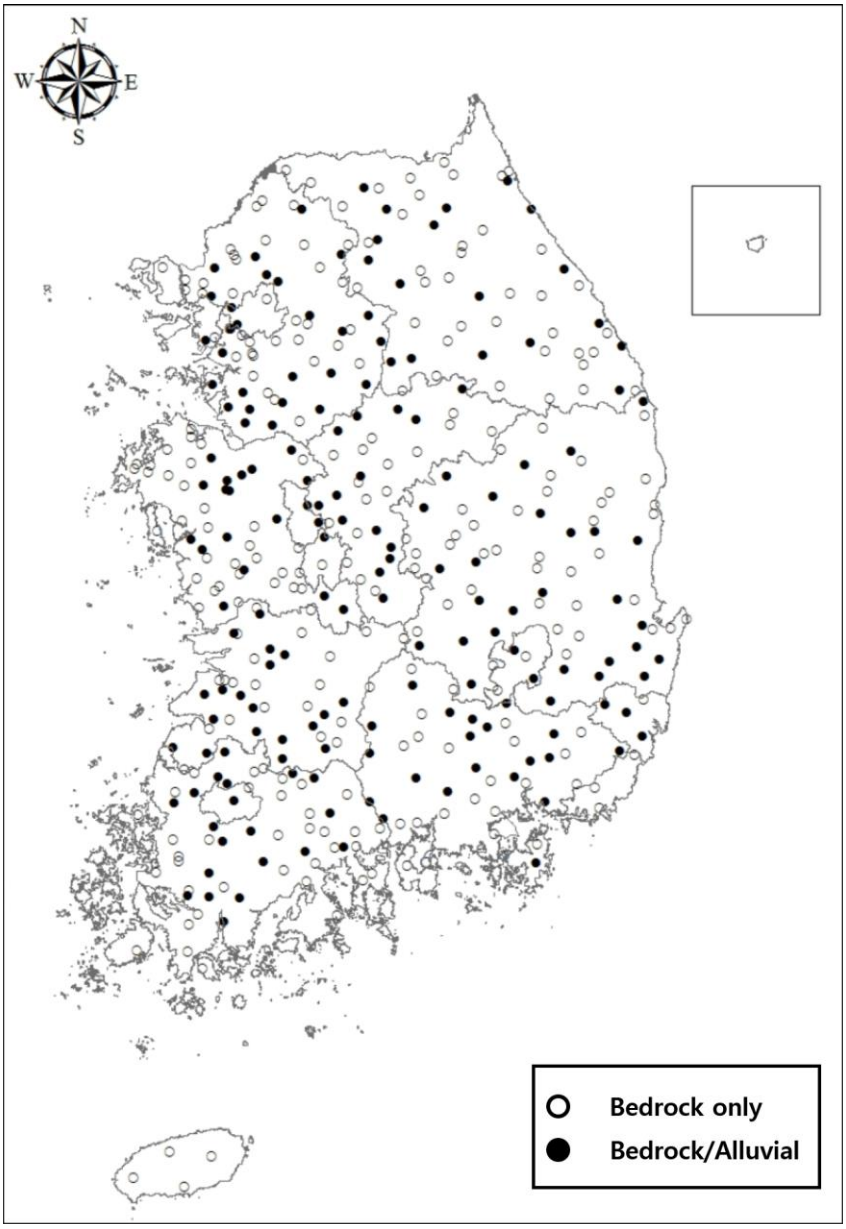

Fig. 1. Location map of 428 groundwater observation stations (MLT, 2018).

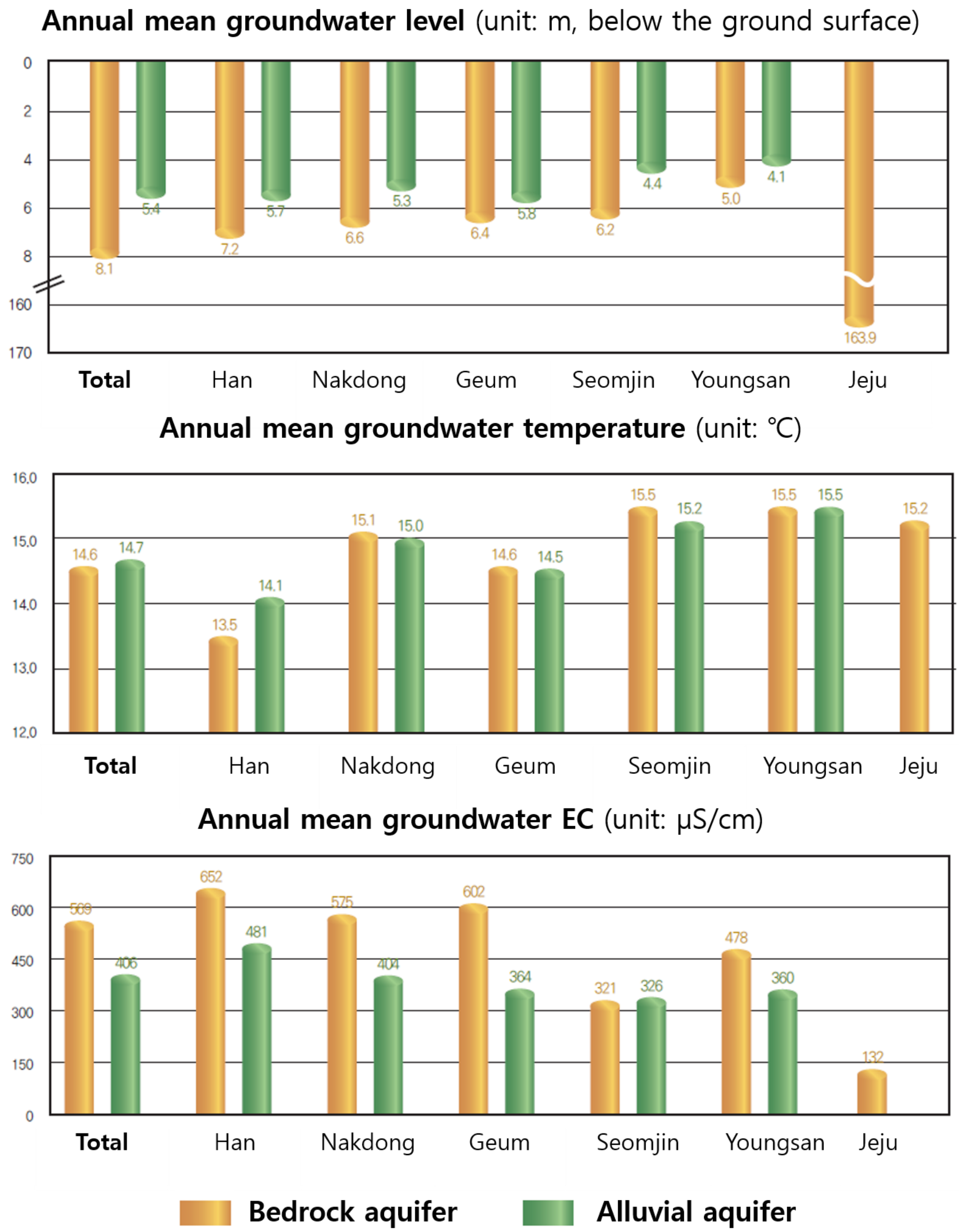

Fig. 2. Overview of groundwater observation data by region (MLT, 2018).

The GQMN is controlled by the Ministry of Environment under Article 18 of the Groundwater Act and Article 9 of Enforcement Rule Regarding Groundwater Quality Conservation. The GQMN had a total of 3,553 monitoring wells in 2017 (ME, 2018a). The data are available to the public via a website (sgis.nier.go.kr) managed by the National Institute of Environmental Research.

Table 1. Number of samples exceeded by contamination standards (ME, 2018a).

Number of samples	7573
Exceeded number of samples	733
Exceeded ratio (%)	9.7
Exceeded number of parameters	773
pH	309
Total coliform group	163
Nitrate	85
Chloride ion	132
Cadmium	3
Arsenic	32
Cyanide	0
Mercury	0
Organophosphorus	0
Phenol	6
Lead	0
Hexavalent chromium	0
TCE	33
PCE	10
Benzene	0
Toluene	0
Ethylbenzene	0
Xylene	0

The SIMN and RGMN have been operated by Korea Rural Community Corporation (KRC) since 1998 and 2002, respectively. As of 2018, a total of 181 monitoring stations were installed for the SIMN (KRC, 2019b) and a total of 105 monitoring stations (446 wells) were installed for the RGMN (KRC, 2019a). Their data sets are disclosed to the public through the website (www.groundwater.or.kr).

The SGMN fills the gaps in the current monitoring wells of the NGMN, which is sparsely distributed over the country. The number of monitoring sites installed by November 2019 for the SGMN is 2451. SGMN data is also available on the NGMN web site (www.gims.go.kr).
According to the Drinking Water Management Act (Article 22.1) and Enforcement Regulation (Article 12.1), the bottled water companies must monitor groundwater level, withdrawal rate, EC, temperature, and pH with automatic sensors every hour for each production well. Currently, 84 companies (ME, 2018b) operate multiple production wells and report the monitoring data to the ME. The DWMN data is not open to the public because the production wells are private property.

Each network, however, uses its own specifications, and thus there are difficulties to integrate information from each network. There is no standardized coordinate system for indicating the position of wells. Abnormal values or outliers often occur due to inherent limitations of automatic monitoring and transmission. The most prominent patterns of the outliers were rapid decline for water level, no variation for temperature and steep decline for electrical conductivity (Yi et al., 2005).

As of 2019, groundwater monitoring data from 221 NGWM were uploaded to CCOP GSi system during Groundwater Project Phase III. Locations of 221 monitoring wells are shown in Fig. 3. The dataset includes annual averages, maximum and minimums of groundwater level, temperature and EC from 2014 to 2016. Figure 3 shows distribution of average groundwater level (left), temperature (middle), and electrical conductivity (right) in 2016.

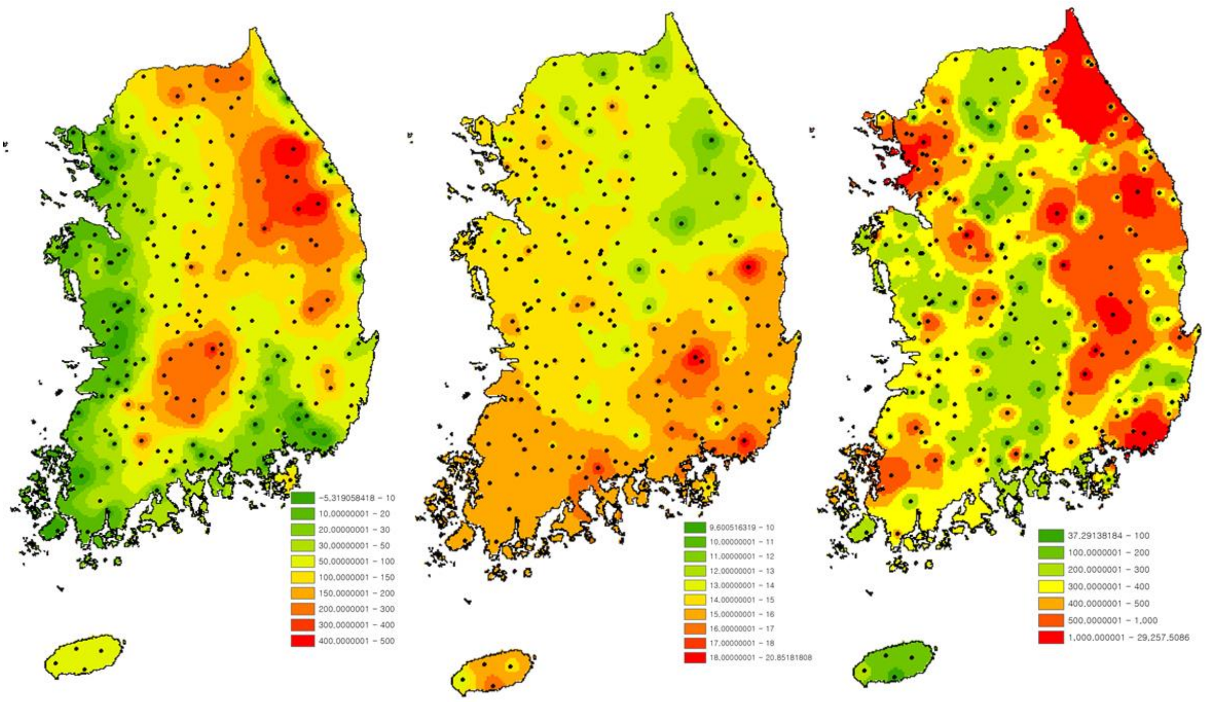

Fig. 3. Locations of 221 NGWN (black dots) used in this study and distribution of the average groundwater level (left), temperature (middle), and electrical conductivity (right) of Korea in 2016.

3. Improvement ideas for the Phase III Groundwater Database

The current CCOP GSi system provides an excellent basis for integrating groundwater monitoring information form CCOP member countries. The system includes user-friendly interface and the DB is being regularly updated to offer the latest information. The collected information through CCOP GSi system is a valuable asset to understand better groundwater status in CCOP regions. Thus, the CCOP GSi system has a greater potential to be expanded to encapsulate linkages between groundwater status and environmental factors in CCOP region if further improvement is given to the systems. Three major recommendation for the system improvement includes (1) to establish long-term operation strategy of CCOP GSi system (2) to increase public awareness and promotion about CCOP GSi to international communities, and (3) to support installation of new groundwater monitoring wells for the member countries who do not possess proper groundwater monitoring system in CCOP region.

References

Lee, J.-Y. and Kwon, K., 2016. Current status of groundwater monitoring networks in Korea, Water, 8:

168.

Korea Rural Community Corporation (KRC), 2019. Annual Report on the Rural Groundwater Monitoring Network in Korea (2018).

Korea Rural Community Corporation (KRC), 2019. Annual report on the Seawater Intrusion Monitoring Network in Korea (2018).

Ministry of Land and Transport (MLT), 2018. Groundwater Monitoring Annual Report.

Ministry of Environment (ME), 2018. Groundwater Quality Monitoring Network Operation Annual Report.

Ministry of Environment (ME), 2018. Water industry statistics survey report.

Yi, M.-J., Lee, J.-Y., Kim, G.-B. and Won, J.-H., 2005. Analysis of Abnormal Values Obtained from National Groundwater Monitoring Stations, *Journal of KoSSGE*, 10 (1), 65-74.

Present hydrogeological data and problem for making groundwater database in Lao PDR

Ounakone Xayviliya[1] and Kuangnuvong Telpvongsa[2]

[1]Groundwater Management Division, Department of Water Resources, MoNRE, Lao PDR
[2]Department of Mineral Resources, Ministry of Mines, Lao PDR
E-mail: ounakone@gmail.com

Abstract

Based on an overview of groundwater in the Lao PDR, with regard to current climate change, groundwater has changed in both quantity and quality. Groundwater management is still inaccessible because of the use of groundwater in the way of the Lao people, especially in areas where groundwater drilling is unsustainable, affecting the use and system of groundwater.

In the past, there were no mechanisms, techniques, and experience in collecting groundwater data, as well as lack of groundwater management bodies, lack of groundwater management tools as regulations for monitoring groundwater use; Data on groundwater (both quantitative and qualitative) is still limited, so monitoring and evaluation activities are not yet implemented.

Keywords: groundwater, climate change, monitoring of groundwater use, data on groundwater limited

1. Introduction

Lao PDR is located in South-East Asia with Area of 236,800 sq. km with 7 million people (2015). 90 % of the country area is in Mekong River Basin. Water resources per capita is around 55,000 m^3 per year. 35 % of annual flow in Mekong is from Lao tributaries. The monthly rivers flow by the pattern of rainfall is around 80 % during the rainy season and 20 % in the dry season. Lao PDR has a tropical climate, which is influenced by the southeast monsoon. There are totally 62 River Basins.

For the groundwater indicated that it is associated with the lower Mekong plain in southern Laos was likely to be associated with the Indosinian sediments geological formation. Eight aquifer units have been described and evaluated in Laos: (i) Basement aquifers (ii) Volcanic aquifers (iii) Schists (iv) Paleozoic sedimentary (v) Karsts (vi) Limestones (vii) Mesozoic sedimentary (viii) Alluvial sediments.

Groundwater resource is accessed through shallow wells and boreholes, and increasingly used for both. 51 % of villages of the country use groundwater resource for their domestic consumption and vegetable gardening in the lowland areas. Since 2012, government of Lao concerned about groundwater resources and several policies, institutional and legal changes have been implemented for better manage and development of groundwater resources. The lack of knowledge and understanding of the resource, and the lack of reliable hydrogeological maps, have been identified as major issues hindering sustainable groundwater development and effective management in Laos.

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Fig. 1. Topography map of Lao PDR

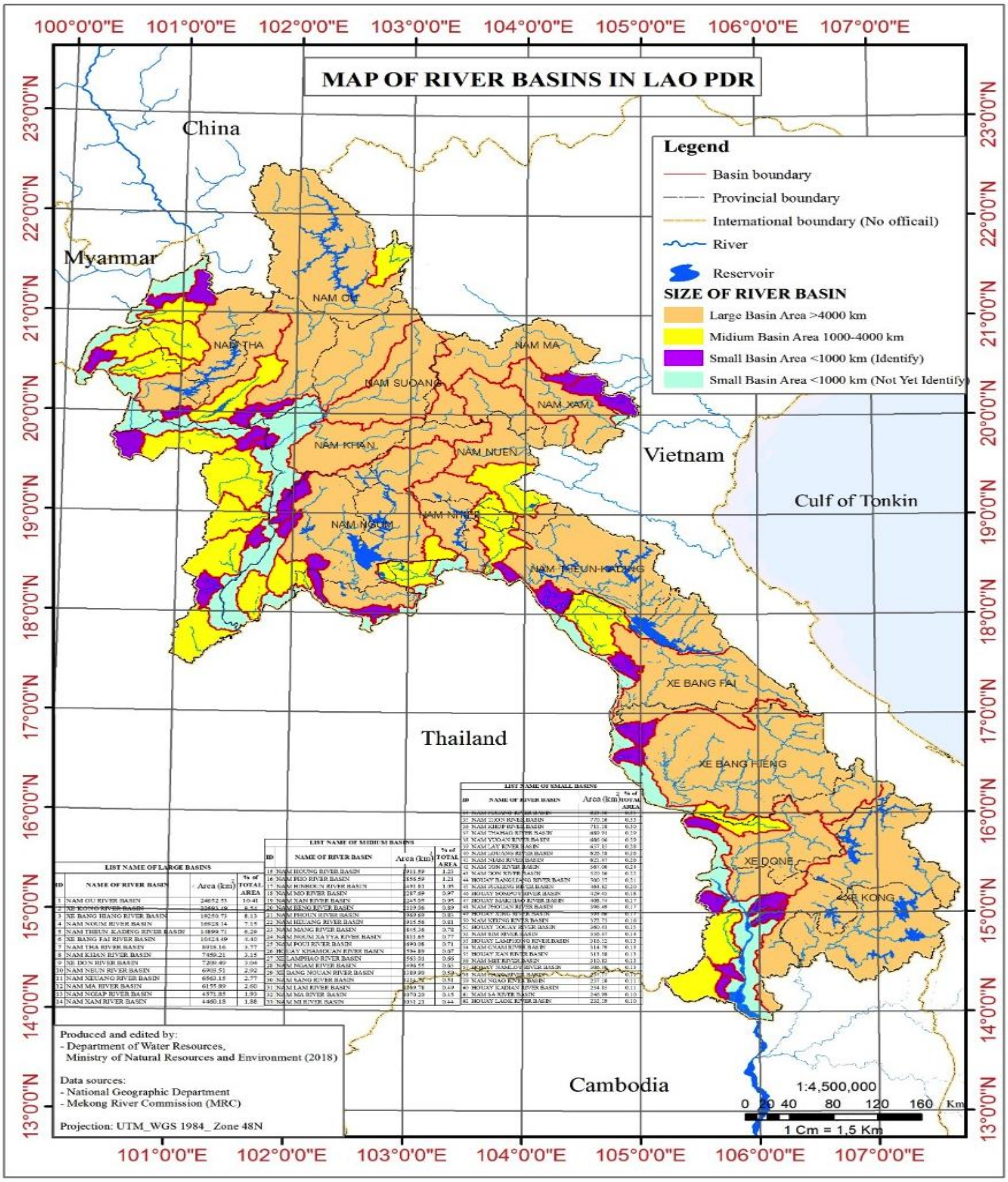


Fig. 2. Map of river basins in Lao PDR

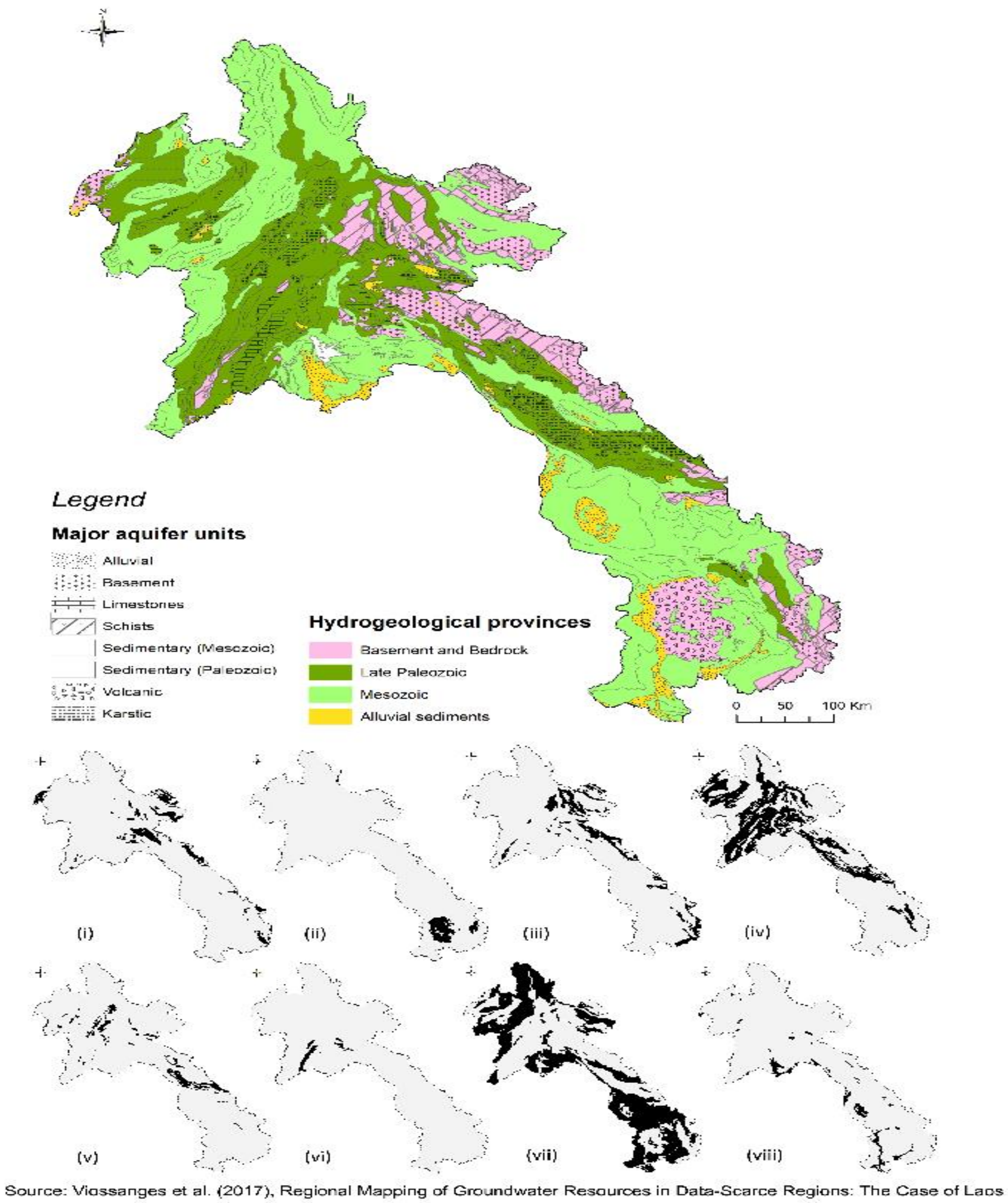


Fig. 3. Map of major aquifer units in Lao PDR

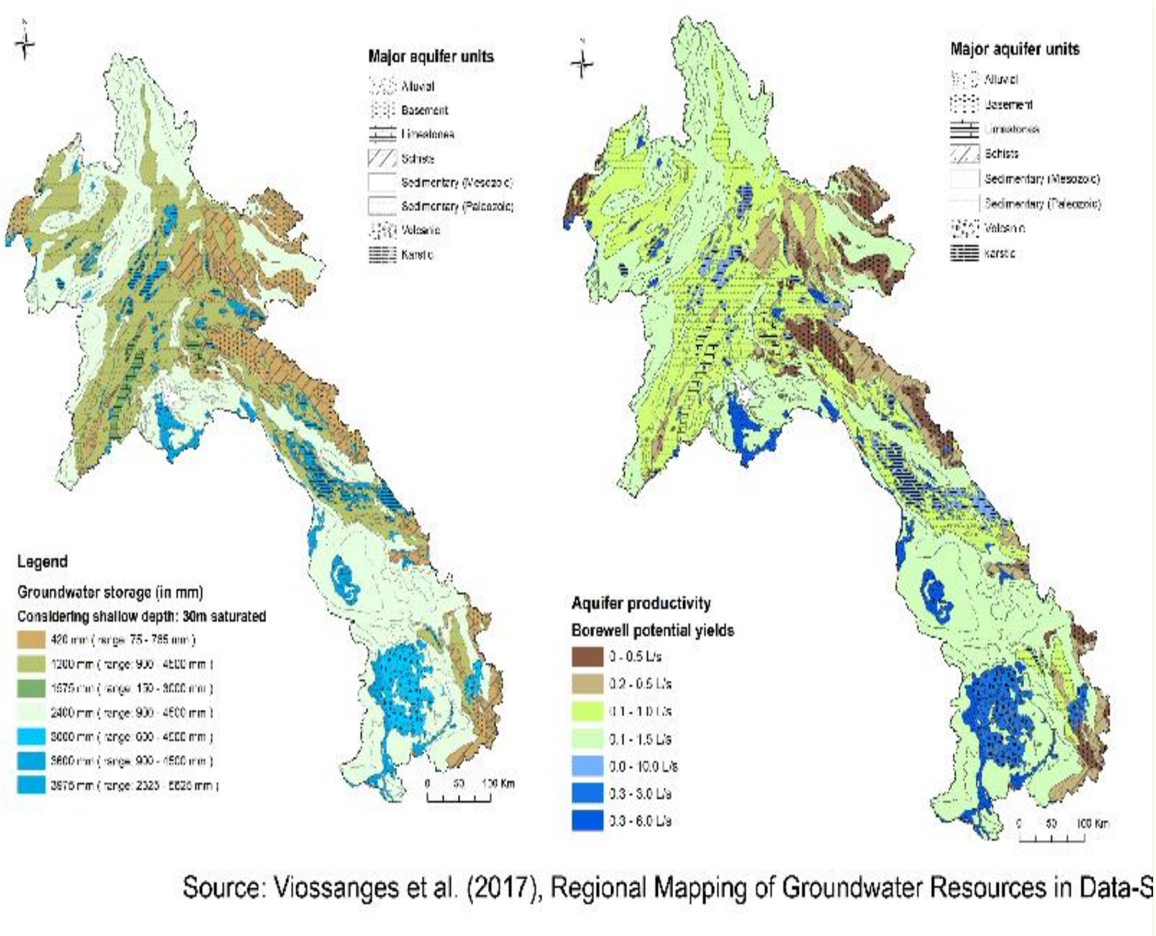


Fig. 4. Map of groundwater storage in Lao PDR

2. Present status of hydrogeological data

Regional mapping of groundwater resources in data-scarce regions in the case of Laos (Research by International Water Management Institute). This paper attempts to address issues on limited data and aims to studies and large-scale regional maps, to provide a country-scale appraisal of the groundwater potential and associated quantitative hydrogeological maps.

Targeting of high quality groundwater in the Province of Vientiane, Laos PDR (By Titus Adewale Olowokudejo, Master of Science Programme, Lulea University of Technology, Sweden) This thesis purpose to contribute to developing method for estimate of the water quality of groundwater using non-destructive geophysical techniques. This method can be an effective method for groundwater investigation and can be integrated with other geophysical methods to fulfill groundwater database in Laos.

Hydrogeological reconnaissance of Sukhuma District, Champasak Province, Southern Laos (Journal of Hydrology (NZ) 56 (2) : 79-96 2017New Zealand Hydrological Society 2017). The objective of this study was to assess the hydrogeology in Sukhuma District of Champasak Province in Southern Laos where such a limitation occurs. A summary of hydrological data availability and improved understanding of hydrogeological conditions in Sukhuma District is presented in this study

We have Diver installed on Groundwater Monitoring System, numbers are 5 Divers for monitoring groundwater-surface water interaction and comparative study of groundwater dependent ecosystems in the Mekong basin level. We have installed diver equipment sites in Vientiane capital, Lao PDR supported by CCOP-KIGAM and, we plan to survey and need to install more on groundwater monitoring system in many basins of Lao PDR.

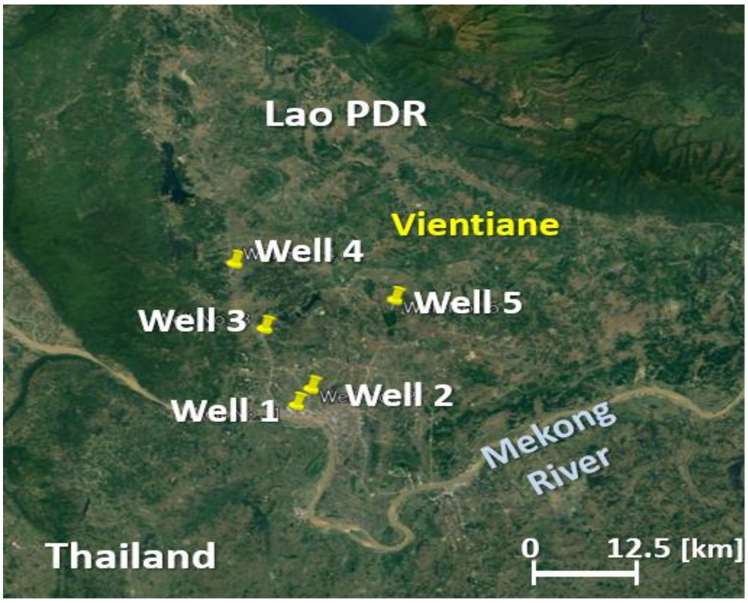


Fig. 5. Location of 5 observation wells

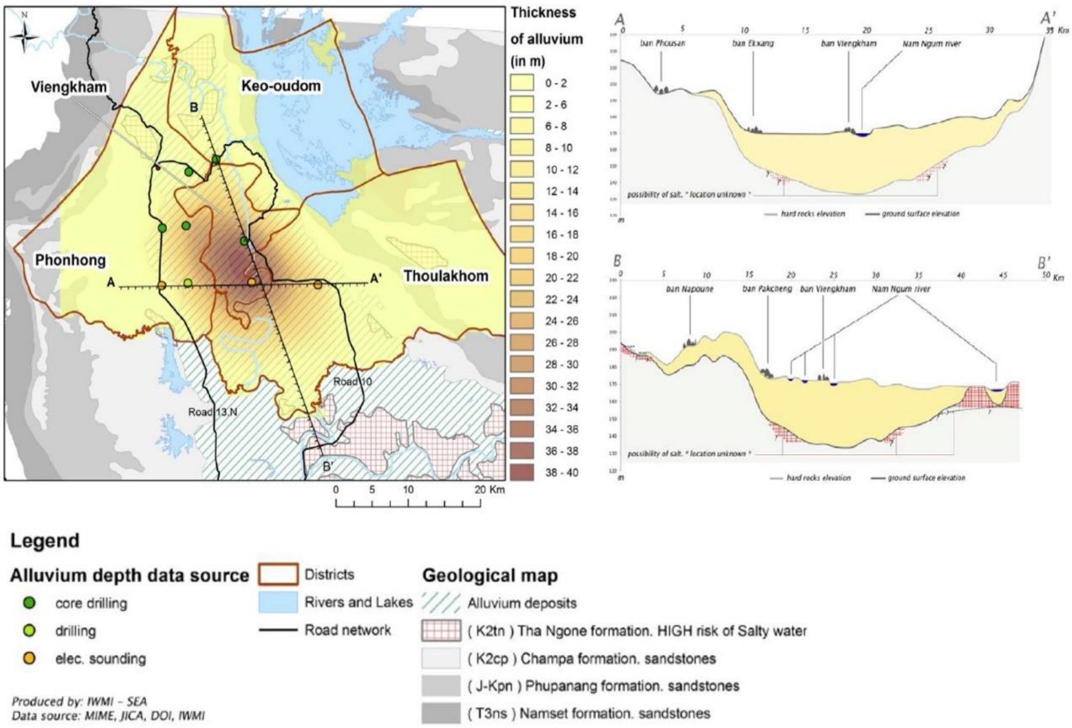


Fig. 6. Alluvium depth data source

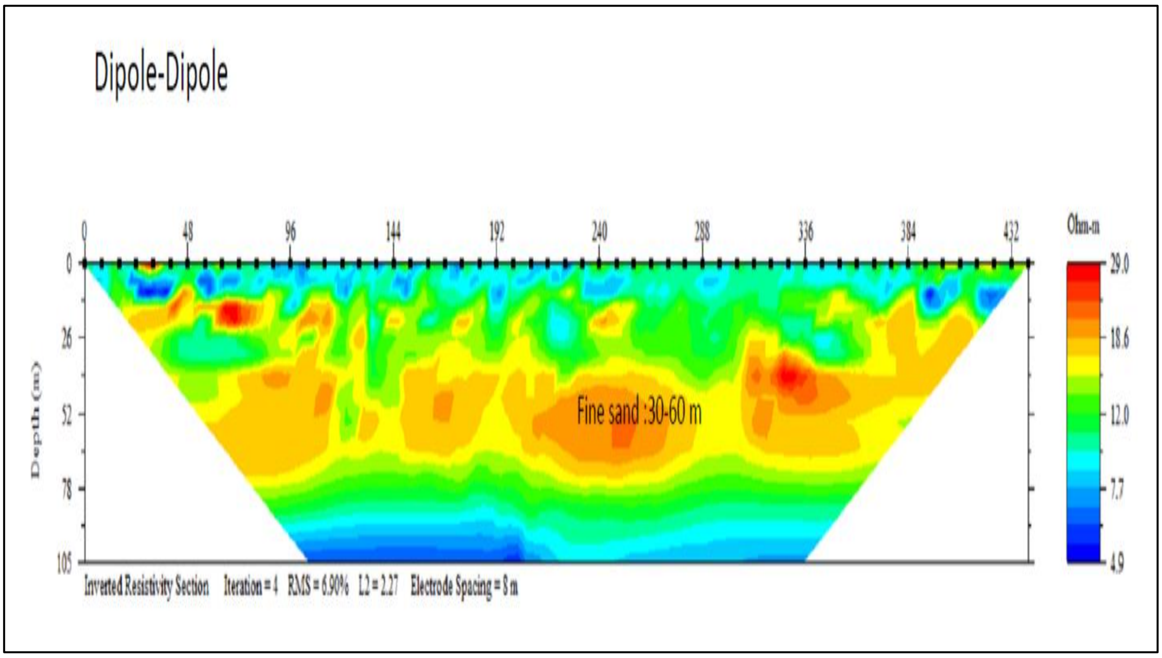


Fig. 7. Depth of aquifer sand in 30-60 m

Table 1. Table showing detail of 5 observation wells

	Well 1	Well 2	Well 3	Well 4	Well 5
Elevation	181 m	170 m	182 m	182 m	177 m
Well depth	20 m	30 m	30 m	30 m	30 m
Well stick up	0.5 m	0.52 m	0.38 m	0.55 m	0.46 m
DTW (measured during diver installation)	9.42 m (from casing top)	3.95 m	2.2 m	-	4.1 m
Diver installation depth	15 m (below from casing top)	17 m	15 m	25 m	25 m
Time of diver installation	10:00 21DEC 2018	11:00 21 DEC 2018	14:00 21DEC 2018	15:00 21DEC 2018	17:00 21DEC 2018
Monitoring interval	1 hour	1 hour	1 hour	1 hour	1 hour

Fig. 8. Picture of field works at 5 observations wells

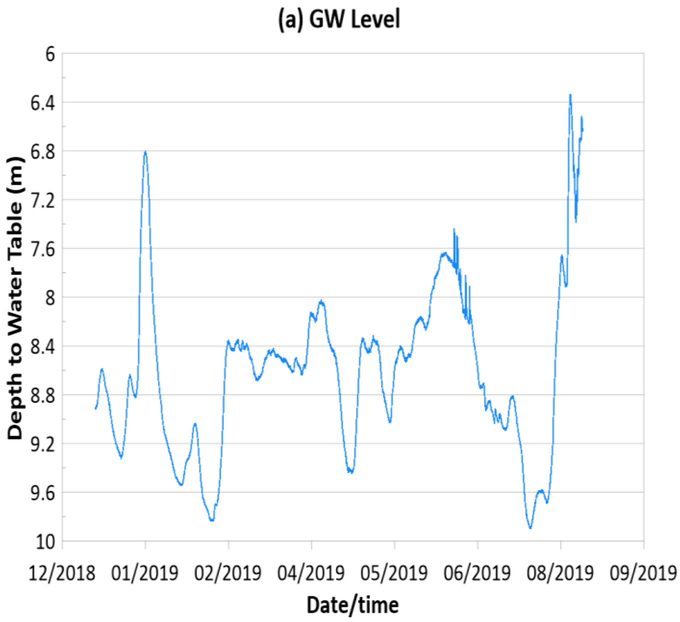


Fig. 9. Showing the groundwater level of observation well

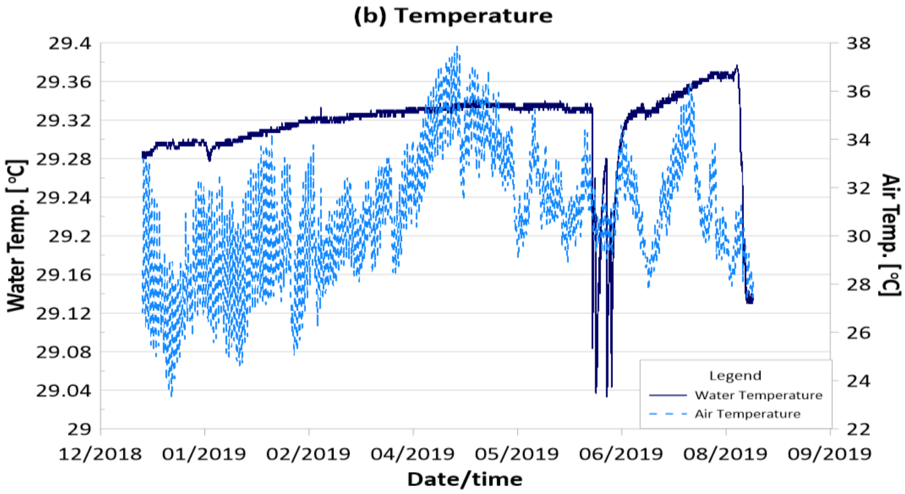


Fig. 10. Showing the temperature of observation well

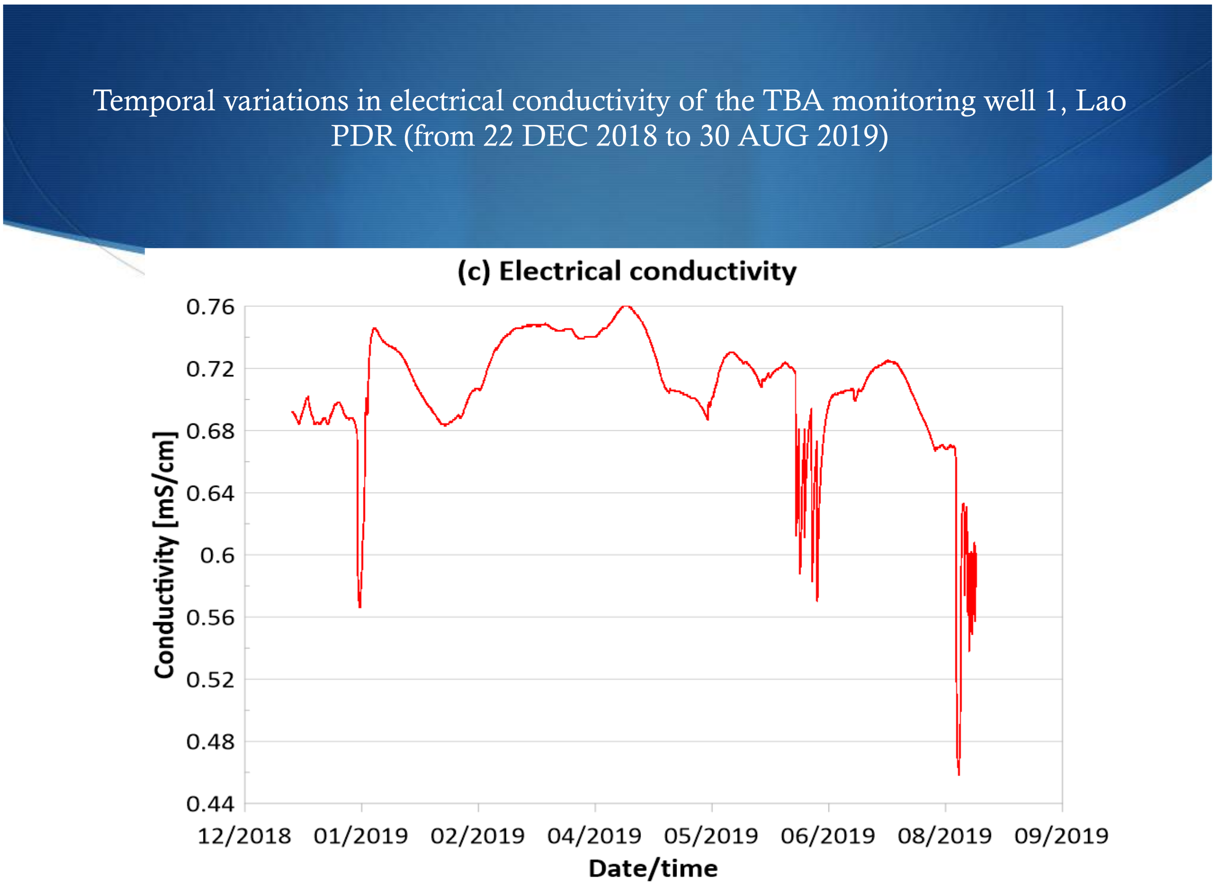


Fig. 11. Showing the electrical conductivity of observation well

Results from monitoring:

- Well 1:

Groundwater level shows temporal variation, mainly affected by river stage. No obvious seasonal trend was observed and the major driving force for groundwater level variation is associated with river stage. Temperature shows increasing trend during the wet season whereas EC shows decreasing pattern during the observation period. Disturbances in groundwater data (level, temperature, EC) was observed during the early June of 2019.

- Well 2

Data shows strong impact of groundwater pumping; groundwater level, temperature and EC showed daily fluctuation due to water pumping from the well. Groundwater level showed slightly increasing pattern during the wet season and groundwater temperature displays increasing trend as it approach hot, summer season

- Well 3

Groundwater level shows generally decreasing trend during the dry season and it started to recover slightly since August 2019. EC displayed increasing pattern. The average ECs for well 1 and well 3 were relatively high compared to well 2, implying that the groundwater system around these wells are possibly influenced by salt rock layer underneath. Further investigation should be carried out to better characterize the spatial pattern of salty groundwater in VP.

- Well 4

Data shows strong impact of groundwater pumping; groundwater level, temperature and EC showed daily fluctuation due to water pumping from the well. Groundwater level showed seasonal variation pattern; the level decreased during the dry season and started to rise as it enters the wet season.

- Well 5

Groundwater level showed falling trend during the dry season and started to recover rapidly during the wet season. Temperature and EC revealed positive and negative correlation with groundwater level, implying that the rainfall (high T, low EC) is the main source of groundwater recharge around the study area. Well no. 5 is located in the hilly terrain and the site was considered as one of the major aquifer recharge zone of the VP plain.

3. Problem and barriers for making Groundwater Database

There are some problems and barriers related to groundwater database making in Lao PDR. First, data and information of groundwater is limited due to the gathering, desk studies and baseline study is at the starting point. The important groundwater potential, groundwater basin, geological, aquifer, groundwater hydrogeology map, groundwater contaminant, water resources usage and groundwater demand all data are important for groundwater management. Also, groundwater database making is lack off, there are some existing data and information related to groundwater. However, it is separately kept. Moreover, the lack of systematic or appropriation tools for groundwater data and information sharing.

Second, non-system and experience for making groundwater database, skills on groundwater database making in both local and national government is in basic level, but there are some groundwater database developed by non-government agencies as JICA, IWMI and others. Secondary data from each agency will be based for groundwater database making in next step.

The water resources related policies and regulation is being developed, since 2017 water and water resources law updated and there are some legislations under this law also developing, the groundwater management agreement is under water and water resources law issued in the March 2019 the objective to modify this law in terms of groundwater management articles. Therefore, this agreement just issued for a year so regards to implementation still in the starting point. It needs the support from related agencies especially government sectors at national and local level to involve to implementation this agreement and it also need the support from NGO in terms of TA or Grant for support the implementation of in agreement.

4. Plan and ideas for constructing groundwater database

Regard to groundwater database constructing, the first activity is continuation to monitor the 5 observation wells that were developed and supported by CCOP, data from recording will submitted to CCOP for setting up the database in the future.

Second activity is developing more observation wells for monitoring water level, water quality and temperature. Based on annual activity for 2020, 8 monitoring wells will be developed in Savannakhet, the activity supported by World Bank under Mekong- Integrated Water Resources Development Program. The idea to develop these observation wells for the basin groundwater database setting up and this data will support DWR for developing the sustainable groundwater management plan for Savannakhet province which will be completed by October 2021.

Other activities are study and survey ground water resources and collect the existing wells and boreholes in priority area as in 4 basins (Nam Ngiep, Sekong, Nam Xam and Xebanghieng River Basin) for groundwater inventory and groundwater database setting up the objective for developing groundwater management plan.

References

Viossanges et al., 2017. Regional Mapping of Groundwater Resources in data _ sources.

Issues and improvement ideas for the Phase III groundwater database of Malaysia

Alvyn Clancey Mickey

Department of Mineral and Geoscience Malaysia
e-mail: alvyn@jmg.gov.my

Abstract

Department of Mineral and Geoscience Malaysia (JMG) is the lead agency that responsible for matters related to groundwater in Malaysia. JMG actively participate and committed in fulfilling international cooperation and obligation set by global frameworks such as CCOP Geoinformation Sharing Infrastructure for East and Southeast Asia; namely CCOP-GSJ GSi Groundwater Project Phase III. To date, JMG has compiled a total of 345 tube wells (TW) data for updating the GSi Project database on groundwater and maintaining the data quality; Selangor (21 TW), Sabah (10 TW), Kedah (58 TW), Johor (48 TW), N.Sembilan/Melaka (50 TW), Pahang (50 TW) and Perak (108 TW). There are three main internal issues which prohibiting the project progress namely; (i) *Enabling Constraint*, (ii) *Fragmented Tools* and (iii) *Fund Limitation*. Therefore, JMG has outlined few new initiatives to resolve the issues which also in line with the 12th Malaysia Plan; in pursuant to the water sector transformation through mainstreaming groundwater usage for water security and economic growth. Four main key advantages of API usage were identified namely fully automated, high efficiency, better integration and well adaptation. Bridging API to all CCOP MC groundwater database and CCOP GSi database will definitely an idea to consider. "*Real time"* database management will be an advantage by fully utilise API advantages into CCOP GSi database and others MC database respectively.

Keywords: groundwater, hydrogeological map, Malaysia, Asia

1. Introduction

Department of Mineral and Geoscience Malaysia (JMG) is the lead agency that responsible for matters related to groundwater in Malaysia. However, it is limited to groundwater exploration, tube well development and groundwater data inventory. Since 5th Malaysia Plan (1986), a total of 4,758 tube wells (Fig. 1) were developed by JMG (Peninsular Malaysia 4,218, Sabah 293 & Sarawak 247) for various purposes which benefited 1.5 million people nationwide. Apart from that, JMG has developed a groundwater GIS database; known as HYDROdat, for planning, assessing and monitoring of groundwater activities to safeguard and maintain the quality and potential reserve. Fig. 2 simplified the groundwater current status in Malaysia.

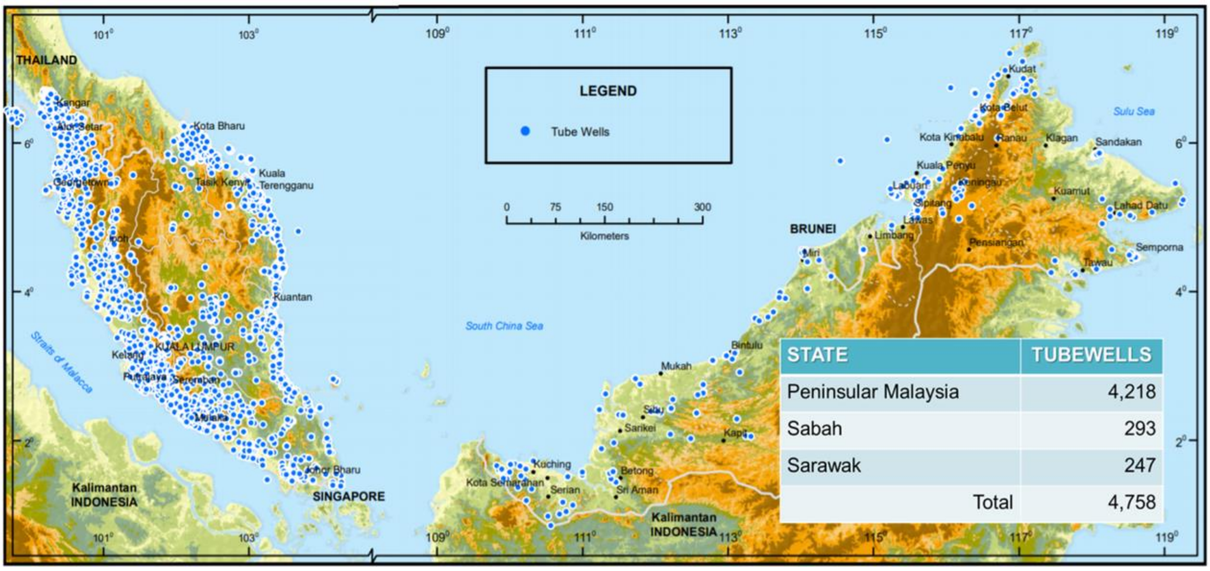


Fig. 1. Tube well location map in Malaysia (JMG HYDROdat, 2018).

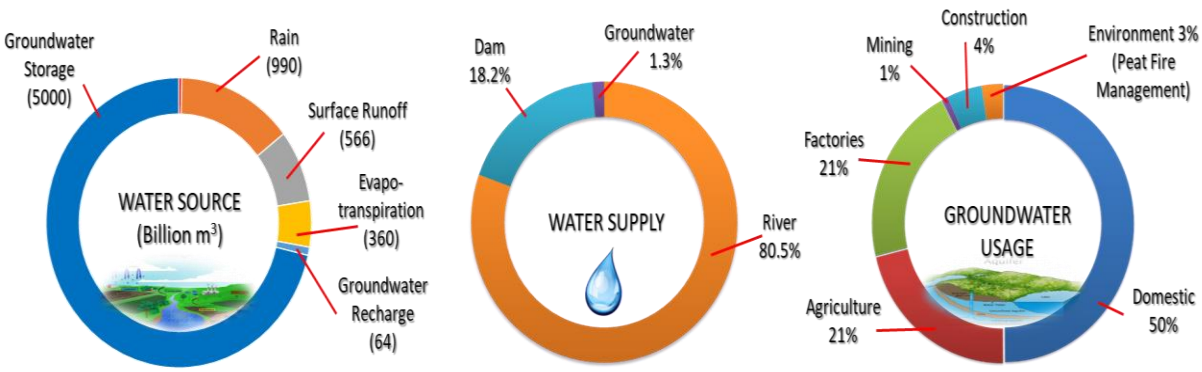


Fig. 2. Groundwater status in Malaysia (National Water Resources Study (NWRS), 2012).

JMG actively participate and committed in fulfilling international cooperation and obligation set by global frameworks such as CCOP Geoinformation Sharing Infrastructure for East and Southeast Asia; namely CCOP-GSJ GSi Groundwater Project Phase III. The Geological Survey of Japan (GSJ) initiated the project in year 2005 and plays a vital role which progressively lead the project into three phases; Phase I (2005-2008), Phase II (2009-2013) and Phase III (2014-2020). During the Phase I (2005-2008), selected CCOP Member Countries (MC) were involved the project which mainly focus on database of groundwater management and control. As for Phase II progress (2009-2013), the project expands its scope into constructing and designing of groundwater database and establish Asian Standard for Hydrogeological map. In the midst of Phase II, some issues had been addressed regard on the project and new objectives were outlined as project scope for Phase III; the expansion of database area (member countries) and promotes CCOP open source groundwater database. Fig. 3 show the project scope for Phase III.

Fig. 3. CCOP-GSJ GSi Groundwater Project Scope for Phase III.

CCOP-GSJ GSi Groundwater Project Phase III again expands its scope to 13 CCOP Member Countries namely Cambodia, China, Indonesia, Japan, Korea, Lao DPR, Thailand, Malaysia, Myanmar, Philippines, Vietnam and recently joint Mongolia and Papua New Guinea. Since the current status on the groundwater database management system varies from one CCOP member country to another, three groups have been formed namely DB Group 1, DB Group II and Public Policy Group. JMG were in DB group II along with Indonesia (Group Leader), Philippines and Vietnam.

2. Current status and issues for the Phase III Groundwater Database

To date, JMG has compiled a total of 345 tube wells (TW) data for updating the GSi Project database on groundwater and maintaining the data quality (Table 1). Out of the 345 TWs data were collected, 21 TWs data (Selangor) has successfully up load into the database, 10 TWs data (Sabah) need some amendments on its location and 58 TWs data (Kedah) submitted to the National Compiler (NC) for data entry.

A total of 256 tube wells (TW) data has been compiled; Johor (48 TWs data), N.Sembilan/Melaka (50 TWs data), Pahang (50 TWs data) and Perak (108 TWs data), which submitted to the National Compiler for verification and data entry.

JMG has been actively involved in this project and yet to find a good progress. There are three main internal issues which prohibiting the project progress namely; (i) Enabling Constraint, (ii) Fragmented Tools and (iii) Fund Limitation (Fig. 4).

(i) *Enabling Constraint*

Inconsistent representative personal; changes of National Compiler (NC) or Person in Charge (PIC), unable the data compilation and data entry progress constantly as plan.

(ii) *Fragmented Tools*

Outdated database system and lack of data maintenances were identified as disintegrate tools that slow down the project progress.

(iii) *Fund Limitation*

Lack of fund for monitoring, data inventory, lab work and tube well maintenance work unable to achieve a good quality and continuous data; leads to inadequate data collection. Most funding is for new development projects and less priority on monitoring and maintenance work.

Table 1. GSi Database Current Status for Groundwater.

No.	STATE	STATUS	TUBE WELL DATA
1	Selangor	Completed	21
2	Sabah	Amendment	10
3	Kedah	Submitted	58
4	Johor	Compilation	48
5	N.Sembilan/Melaka	Compilation	50
6	Pahang	Compilation	50
7	Perak	Compilation	108
		Total	345

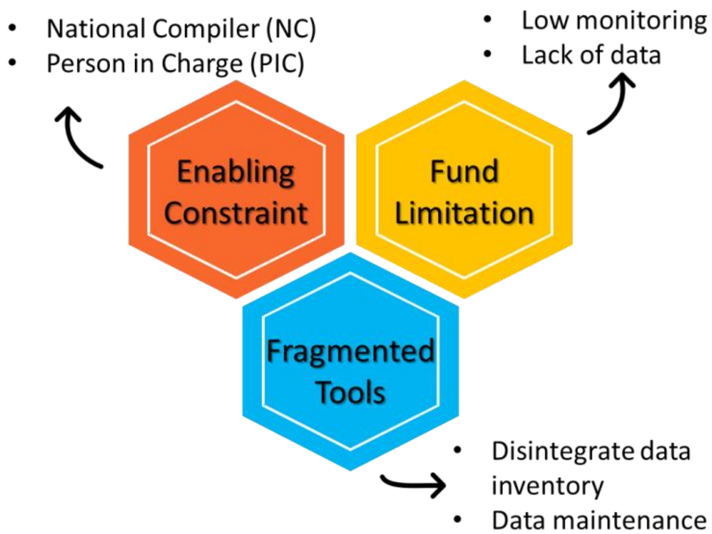


Fig. 4. Project Issues; Enabling Constraint, Fragmented Tools and Fund Limitation.

3. Improvement ideas for the Phase III Groundwater Database

JMG understands that there is a need to overcome the issues and to ensure the project progress a successful one which will benefit to all. Therefore, JMG has outlined few new initiatives to resolve the issues which also in line with the 12th Malaysia Plan; in pursuant to the water sector transformation through mainstreaming groundwater usage for water security and economic growth. Recommendations of improvement illustrated in Fig. 5.

Improve Groundwater Data Inventory Tools (framework and network)
Good and comprehensive groundwater data inventory leads to an effective groundwater management and water security sustainability. JMG's current groundwater database and monitoring network is fragmented and poorly structured. The current database framework (i.e. attributes) is varies from CCOP GSi database framework and need more improvements for better. Hence, JMG will propose to set up a National Groundwater Monitoring System (NaGMiS); an integrated groundwater monitoring network collaborate with relevant agencies which will provide more groundwater data collection and enhance the data coverage comprehensively. Apart from that, an upgrading of the current groundwater database system (HYDROdat) will be carry out for an integrated groundwater evaluation and management for risk assessment. These efforts and initiatives definitely will strengthen and enhance the disintegrated tools to be more effective and efficient subsequently in line with CCOP GSi Groundwater Phase III project scope.

Promotes Enabling Personal/Representative Approach
Proactive commitment and constant support from permanent representative are essential to ensure the project progress and effectiveness. Frequent changes in NC and PIC prevent good progress in project and result poor outcome.

Diversification of Fund
Water sector transformation is part of the 12th Malaysia Plan and JMG is in the progress on finalise the fund proposal allocation not only for new development project but as well for data inventory dan monitoring works that need the same attention.

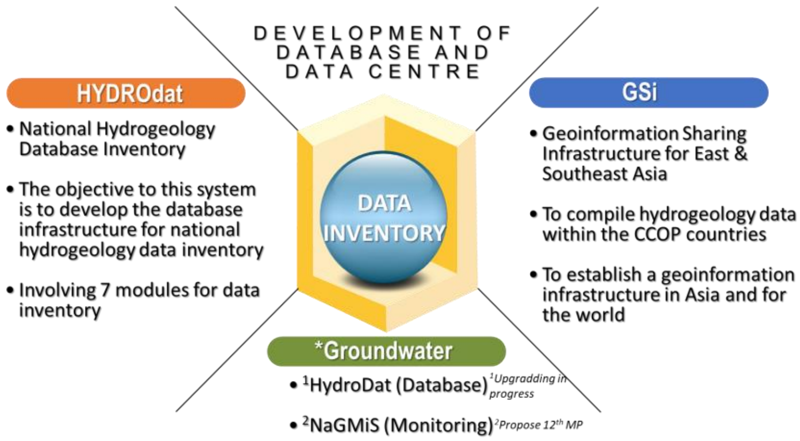


Fig. 5. Recommendations on tool framework and network improvement.

4. Conclusions

An application programming interface (API) is a computing interface which defines interactions between multiple database framework intermediaries. An API can be entirely custom, specific to a component, or it can be designed based on certain standard requirements to ensure interoperability between various database system. Four main key advantages of API usage were identified namely fully automated, high efficiency, better integration and well adaptation. Bridging API to all CCOP MC groundwater database and CCOP GSi database will definitely an idea to be consider. Fig. 6 show illustrate API will benefit CCOP GSi database with various database from other member countries.

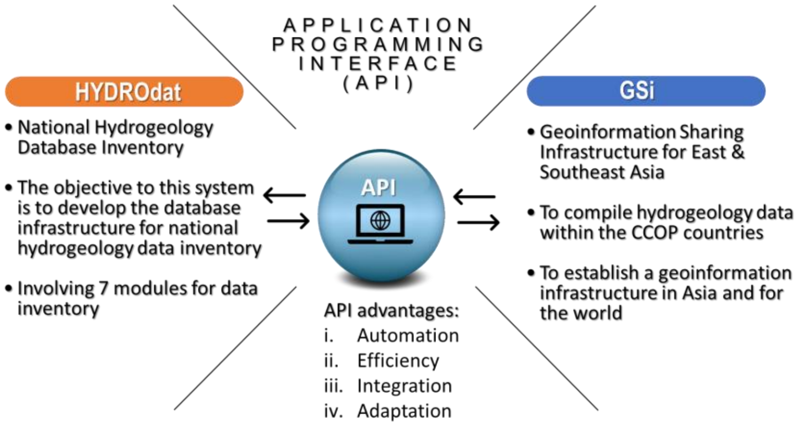


Fig. 6. Illustrate API benefit CCOP GSi database to MC database as *real-time* intermediaries.

JMG believe with all the efforts and initiatives mentioned above take place, better improvement on project progress will be definitely achieve. Subsequently, the newly propose database system and monitoring network will be more comprehensive and equip good quality data into the CCOP GSi Groundwater Project and benefit for all. "*Real time*" database management will be an advantage by fully utilise API advantages into CCOP GSi database and others MC database respectively.

References

Department of Irrigation and Drainage Malaysia, 2011, Review of The National Water Resources Study (2000-2050) and Formulation of National Water Resources Policy.

Department of Mineral and Geoscience Malaysia, 2018, Annual Report 2018.

Shahar Effendi bin Abdullah Azizi, 2019, Keynote Speech: Malaysia International Water Convention 2019, Department of Mineral and Geoscience Malaysia.

Issues and improvement ideas for the groundwater database in Mongolia

Purevsuren Santiv and Odontuya Dugerjav

Geology and Exploration Division, Mineral Resources and Petroleum Authority of Mongolia
e-mail: purevsuren.s@mrpam.gov.mn

Abstract

Mongolia is a landlocked country in Central Asia 1.56 $\times 10^6$ km^2. The size of the territory is 19th in the world. It has a population of 3 $\times 10^6$, with a population of 135th in the world. Population density is 1.8 people per sq. km, the world's most sparsely populated country. The country is divided into four seasons which are winter (December to February), spring (March to May), summer (July to August) and autumn (September to November). Summer and autumn are rainy season. More than 70 % of the rivers' water resources are composed of over 30 % of the highest altitude or area of the Altai, Khangai, Khentii and Khuvsgul mountains. This is due to the rainfall at altitude of 250 mm in the high mountain zone. Groundwater resources in the Gobi region are poorly replenished, and if water resources are depleted over time, water levels may be decreased, depleted and higher evaporation of water.

The groundwater is the most important source in Mongolia. All socio-economic activities are directly dependent on the groundwater resources and their potential. The widespread use of groundwater for herders from wells as well as for agricultural irrigation, mining and factories use groundwater for their operations in areas where there is no surface water. For most cases groundwater is a reliable source of drinking water. 95 % of the population uses groundwater and 5 % use surface water. Groundwater is used from wells and in some areas spring water is also being used.

Keywords: groundwater, hydrogeological map, Mongolia

1. Introduction

The Ministry of Nature, Environment and Tourism and its affiliated agencies are responsible for water resources, reserves and database according to the Water Law. Mineral Resources and Petroleum Authority of Mongolia is responsible for hydrogeological research and mapping under the Minerals Law.

Currently, the Environmental Information Center under jurisdiction of Ministry of Nature, Environment and Tourism compiles the water database in Mongolia. The Mineral Resources and Petroleum Authority of Mongolia is developing a database on hydrogeological research in access format.

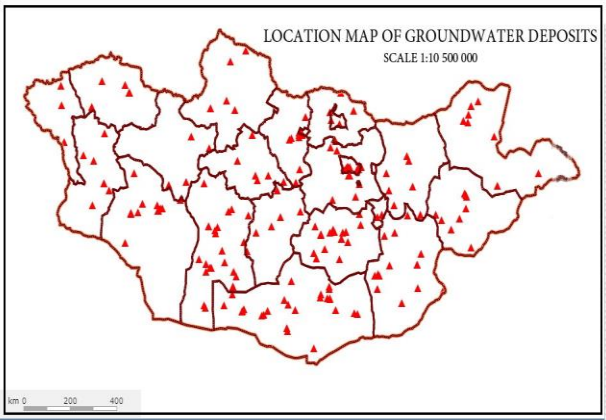


Fig. 1. Location map of groundwater deposits.

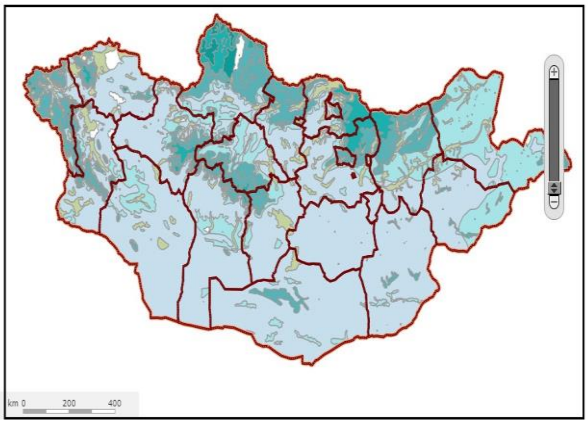


Fig. 2. Groundwater renewable reserve map.

Hydro-geological Mapping

Regional hydro-geological survey and mapping, and published hydro-geological maps are hydro-geological map of MPR at scale 1:1,500,000 (1973), hydro-geological map of Mongolia 1:1,000,000 (1996) and at scale 1:3,000,000, 1:500,000 and 1:200,000 for choosing territory of Mongolia (1981-1997), and also a new hydrogeological map at scale 1:500, 000 for all territory of Mongolia (2014-2017).

- Complex geological-hydro-geological survey at scale 1:500,000 on the area 340,000 km^2
- Hydro-geological survey at scale 1:100,000 - 1:200,000 on some desert parts of the country with total area of 210,946 km^2

Fig. 3. Map of water basin in Mongolia.

2. Current status and issues for the groundwater database

The following documents are available at the Mineral Resource Information and Technology Center, Minerals and Petroleum Authority of Mongolia.

1. A total of 358 hydrogeological research reports from 1935 to 2004 and the annex maps in paper forms
2. Registration of 194 deposits of underground water reserves, 29,700 boreholes, 20,628 wells and 2,997 spring water in the e-database

Hydrogeological reports stored in paper form in geological archives

The 358 hydrogeological research reports from 1935 to 2008 within the territory of Mongolia are stored in paper form in the archives of the State Geological Information Center:

1. 1:500,000 scale, 1:200,000 scale and 1:100,000 scale geological-hydrogeological mapping 31 reports
2. 212 reports on water exploration in provinces from 1969-1992
3. 146 reports on groundwater exploration
4. 13 reports on spring water
5. 31 reports related to water (commentary, observation results), it is comprised of 5 parts

In addition, 490 geological engineering reports from 1937 to 1980 are stored as well.

Hydrological registration database

The Geological and Information Center has established 1,022 research registration databases in relation to hydrogeological research reports which is stored in archives. The advantage of this database is that all the reports concluded within the territory of Mongolia connected to topographic map (cartogram). In other words anyone can view the integrated hydrogeological research reports of Mongolia from 1935 to 2008. This registration directory is filled with 14 basic questions for the purpose of including the general research data.

Water point database

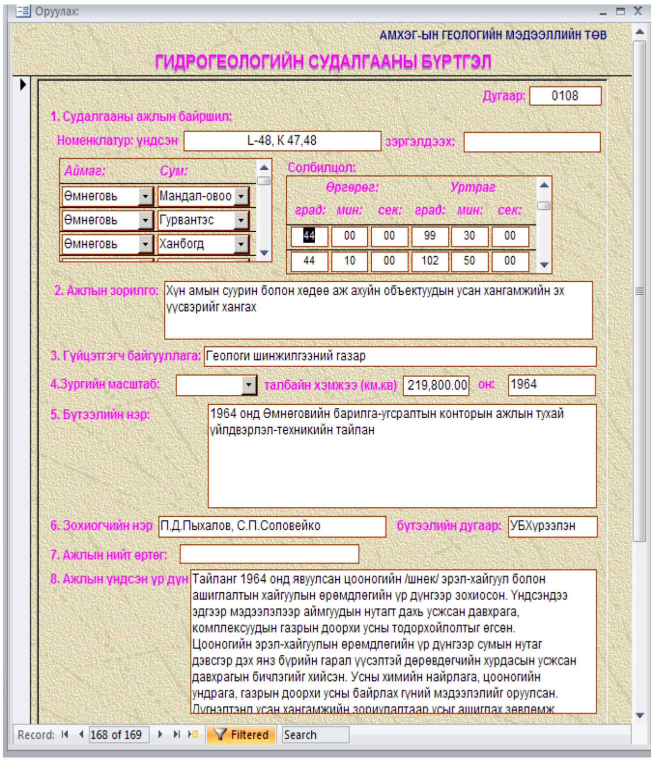
This database is created by the water point source information in geological and hydrogeological research reports stored in the Geological Information Center archives. In total, this account contains 53,325 water points and comprised of 3 main parts:

1. 29,700 borehole registries
2. 20,628 spring water registries
3. 2,997 well registries

In addition, the program provides options for re-entering, registering, and viewing templates as these data are further enhanced by new research materials.

Water point registry

This database like hydro-geological reference directory using Microsoft Office Access software for text data and ArcMap-Arcinfo program for image data to digitize these data, and location of water points within the territory of Mongolia linked to the reports and topographic map data for viewing. In order to include the general information for each section, 19 for borehole, 24 for well and 23 for spring water section grouped together for registration.



Basic questions of hydrogeological research registry:

1. Number
2. Location of research work (nomenclature, adjacent nomenclature, province, provincial districts, coordinates)
3. Purpose
4. Contractor
5. Map scale
6. Size of area
7. Date
8. Registry name
9. Authors name
10. Registry number
11. Total cost
12. Result
13. Additional appriasal

Fig. 4. Hydrogeological research database.

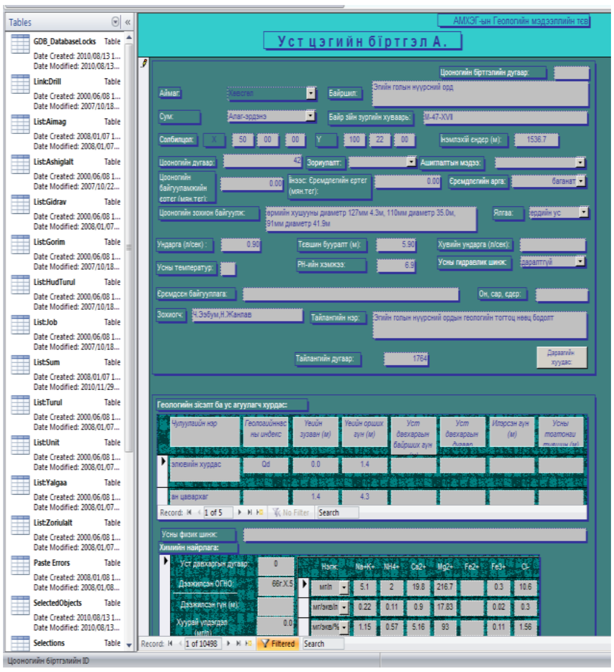


Fig. 5. Water point database.

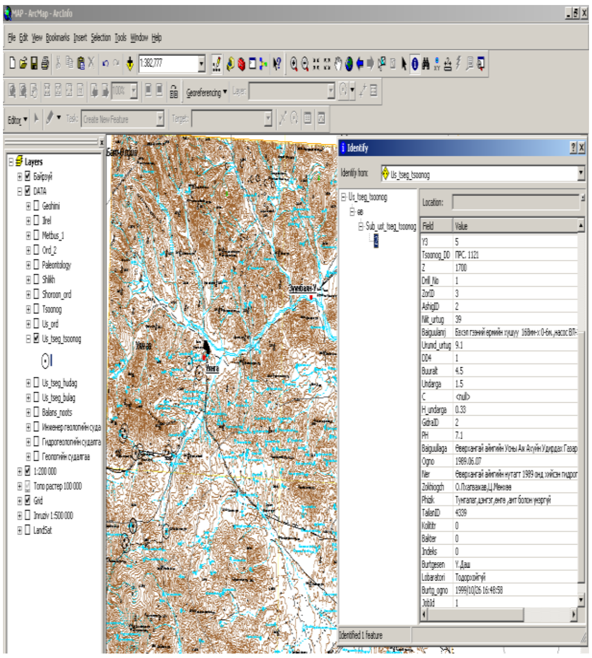


Fig. 6. Topography of Mongolia.

Database information registry

1. Number
2. Location (province, provincial district, coordinate, location, nomenclature)
3. Well number, purpose
4. Well construction cost
5. Well design
6. Distinctions of common and spring water
7. Well yield (liter per sec)
8. Depletion level
9. Yield percentage
10. Water temperature
11. PH level
12. Water hydraulics
13. Drilling company
14. Report author, name, date, number
15. Lithology and aquifer formation
16. Water properties
17. Chemical composition
18. Bacterial analysis
19. Laboratory

Depending on the research the baseline information on each well is filled differently.

Groundwater registry information

A total of 194 registry have been filled and 21 basic questions is included in the general information for each deposit.

Registry basic information:

1. Regisrty number
2. Deposit name
3. Mineral resource
4. Deposit type
5. Discovery (Year, authors name, company name, discovery information)
6. Geographical location (province, provincial district, location, coordinates, elevation)
7. Geographical economic position
8. Regional geology mapping, geophysics
9. Exploration work method
10. Geology data (folding area, structure, formation region, area, sub-region)
11. Water bearing structure
12. Geomorphology
13. Geo-structure
14. Weather information
15. Reserve calculation method
16. Hygiene recommendations
17. Other, prospecting
18. Water reserve

19. Result of operation
20. Mapping code
21. Hydrogeology reports

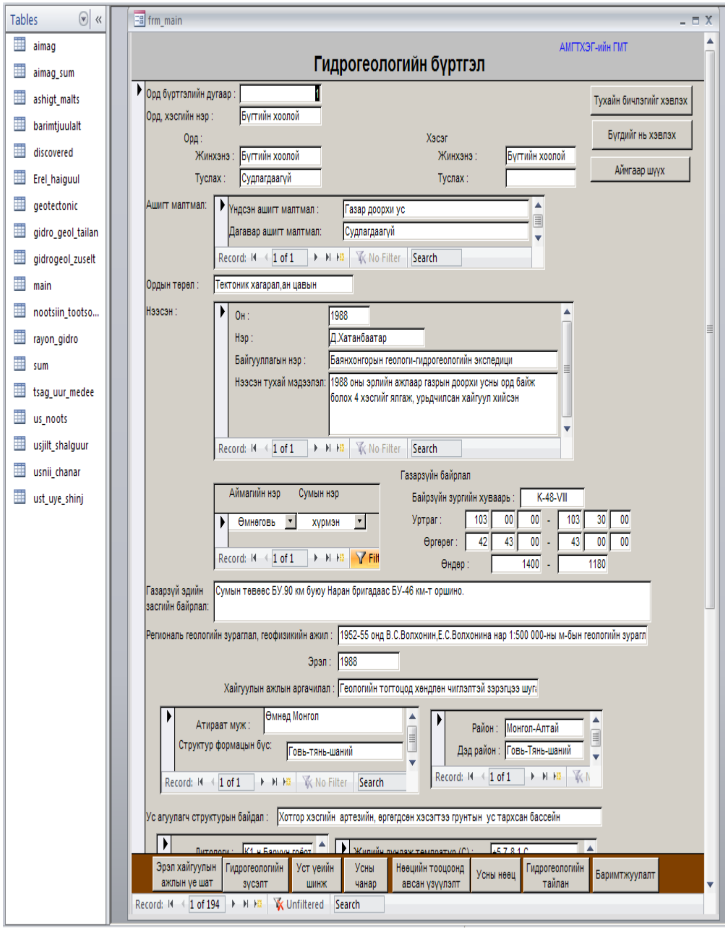


Fig. 7. Groundwater registry information.

3. Improvement ideas for the groundwater database

- Comprehensively plan for water-related legislation and implement measures to improve the legislation
- Renew the water resource, conduct science-based research studies by the government and develop policy papers for water resources
- There is no monitoring for use of groundwater and natural resources in Mongolia that is why we would make a clear conclusion on resource composition, reclamation, depletion and pollution and defining future trends
- Development of new program software
- Improve quality of data
- Constantly enrich the database

4. Conclusion

The key importance of the geology and electronic database is to provide fast efficient way the general information required by professional staff, and to obtain more detailed information on the information provided by the paper.

At present, a major undertaking on groundwater resources is being conducted by state budget funding of 1:200,000 scale geo-ecological and hydrogeological mapping works in the South Gobi region, and hydrogeological research works in accordance with geological study guidelines. 1:50,000 hydrogeological card is being drawn up with the results of the chemical analysis. These data are registered into the database according to the annual plan.

In 2004, the Water Law was approved and groundwater related activities were transferred to the Ministry of Nature and Environment (former name) and because of this the groundwater-related reports submitted at very low numbers at the Geological Central Archives. Our geological archives is aiming to develop groundwater data, add additional data, enrich and update groundwater data in the archives for each year plan.

References

Jadambaa, N., Nyamaa, B., Munkhtuya, L. and Uugankhuu, B., 2014-2017, Geodatabase-2013 project, *Explanation to Hydrogeology map at scale 1:500,000 of Mongolia*, **No. 8481**.

Battumur, R. and Bat-Ulzii, SH., 2003-2004, Groundwater exploration for additional water supply in Ulaanbaatar city, **No. 5593**.

Kolidisheva, R.Ya., Efimova, D.B. and Grishina, A.P., 1986, *Explanation to Hydrogeology map at scale 1:500,000 on SE part of Mongolia*, **No. 4028**.

Ministry of Nature, Environment and Tourism, Environment Information Center, https://eic.mn/groundwater/.

Present hydrogeological data and problem for making groundwater database in Myanmar

Than Oo

Department of Geological Survey and Mineral Exploration
Ministry of Natural Resource and Environmental Conservation, Myanmar

Abstract

Water is essential for mankind and the largest available source of water lies in the underground. The Dry Zone is a part of the Central Inner Burman (Myanmar) Basin located between 19 ° to 23 °N and between 94 ° to 96 ° E. It covers an area of 67,700 km^2, 10 % of country, partially over Sagaing, Magway and Mandalay Regions. It is 403 km. north-south while 120 km. east-west. Based on the stratigraphy, there are eleven different types of aquifers in Myanmar. The water use in Myanmar is appreciably increased, especially in agriculture. Seawater intrusion is a common problem in the coastal zones, especially in the delta areas of Myanmar. There are seven other outlets and deep water along the river side. So, the aquifers in Ayeyarwaddy Delta are endangered by the seawater intrusion. Myanmar is also affected by the change of abnormal condition such as climate change. The urban population is growing around country and groundwater demand is being needed year by year. The awareness distribution will be needed among public for the knowledge in water. These plots have been prepared by compiling available geological and hydrogeological reports, field observations, water sampling and tube well data inventories. The hydrogeological mapping for the coastal and delta areas are still remain and it is also planning stage.

Keywords: groundwater, aquifers, Myanmar

1. Introduction

Water is essential for mankind and the largest available source of water lies in the underground. Extended irrigated lands, industrialization and increasing population will demand both underground and surface water. The Dry Zone is a part of the Central Inner Burman (Myanmar) Basin located between 19 ° to 23 °N and between 94 ° to 96 ° E. It covers an area of 67,700 km^2, 10 % of country, partially over Sagaing, Magway and Mandalay Regions. It is 403 km. north-south while 120 km. east-west. The dry zone is surrounded on three sides by mountain ranges and opens towards South. It consists of undulating plateau with elevation of 150-200 m and a number of steep hilly chains rise above the plateau with peaks of hill reaching altitude of 300-400 m.

2. Present status of hydrogeological data

2.1 Groundwater resources in Myanmar

Based on the stratigraphy, there are eleven different types of aquifers in Myanmar. Depending on their lithology and depositional environment, groundwater from those aquifers varies in quality and quantity. Of these, groundwater from alluvial and Irrawaddian aquifers is more potable for both irrigation and domestic uses. Groundwater extracted from Peguan, Eocene and Plateau limestone aquifers for domestic use in water sacred areas, even though these are not totally suitable for drinking purposes. The groundwater resources of Myanmar could be summarized as below.

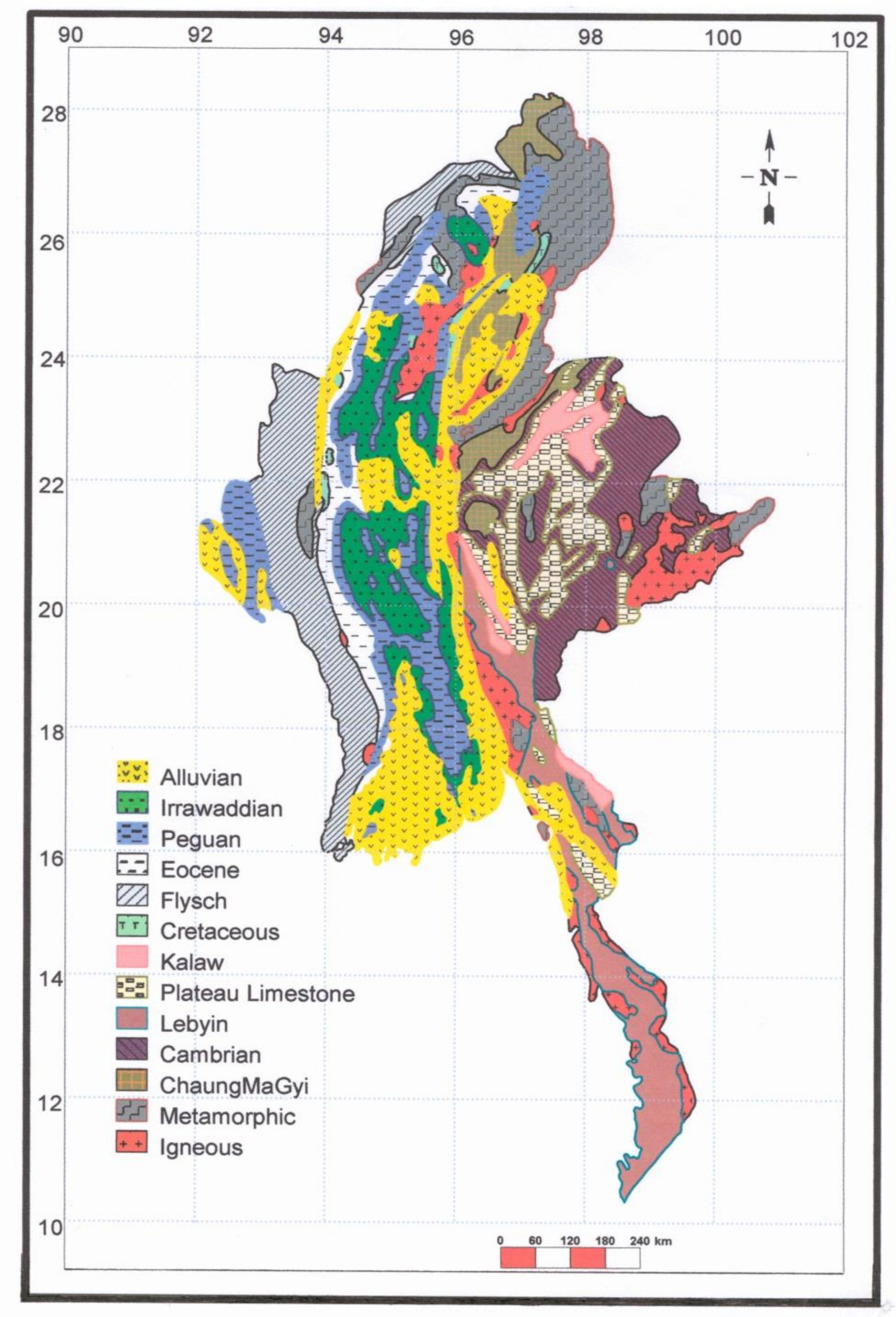


Fig. 1. Aquifers in Myanmar.

Table 1. Description of aquifers in Myanmar.

Sr.	Name of Aquifer	Major rock units	Area of occurrences	Remark
1.	Chaung magyi Aquifer	Low grade metamorphic rocks	Eastern Highland	To be studied in detail
2.	Cambrian-Silurian Aquifer	Molohein, Pindaya & Mibayataung Group	Eastern Highland	To be studied in detail
3.	Lebyin-Mergui Aquifer	Greywacke, quartzite, argillite, slate, mudstone, gravel, etc;	Western boundary of Eastern Highland and Taninthari Ranges	To be studied in detail
4.	Plateau Limestone Aquifer	Limestone & dolomite	Eastern Highland, Western boundary of Eastern Highland and Taninthari ranges	GW is being extracted in some places
5.	Kalaw-Pinlaung-Lashio Aquifer	Loi-an Group & Kalaw Red Beds	Eastern Highland	To be studied in detail
6.	Cretaceous Aquifer	Flysch units and limestone units	Northern Kachin, Western Ranges	To be studied in detail
7.	Flysch Aquifer	Inter-bedded units of sand, siltstones, shale and mudstone	Western Ranges	Probable GW source area
8.	Eocene Aquifer	Sandstones, siltstones and shale	Periphery of Central Lowland	Probable GW source area
9.	Pegu Group Aquifer	Sandstone, siltstones and shale	Central Lowland and Rakhine Coastal Plain	Mostly saline & brackish water, some fresh water in recharged areas
10.	Irrawaddian Aquifer	Mainly sands, sandstones with gravels, grits, siltstones and mudstones	Central Lowland and Rakhine Coastal Plain	Thick aquifer fresh GW with iron contents
11.	Alluvial Aquifer	Sands, gravels and mud	River basins and its tributaries, base of mountains and ranges	Fresh GW, seasonal water table changes

2.2 Groundwater usage

The water use in Myanmar is appreciably increased, especially in agriculture. Other water use such as domestic and industrial sectors are very small compared with agriculture water use. Surface and groundwater use are mentioned separately as follows.

Table 2. Water uses in Myanmar.

Sr.	Use	Surface Water	Ground Water	Total
1.	Domestic	1.15 (3 %)	2.55 (68 %)	3.70 (8 %)
2.	Industrial	1.17 (3 %)	0.33 (9 %)	1.50 (3 %)
3.	Irrigation	41.97 (94 %)	0.85 (23 %)	42.82 (89 %)
	Total	**44.29**	**3.73**	**48.02**

(Unit in million acre-feet)

3. Problem and barriers for making groundwater database

3.1 Seawater intrusion

Seawater intrusion is a common problem in the coastal zones, especially in the delta areas of Myanmar. There are seven other outlets and deep water along the river side. The salt intrusion starts from October to April, during cold and dry seasons, and it propagates toward upstream. The distance of salt intrusion to upstream is different due to the discharge of outlets. So, the aquifers in Ayeyarwaddy Delta are endangered by the seawater intrusion.

3.2 Impacts of climate change

Myanmar is also affected by the change of abnormal condition such as climate change. The Cyclone Mala (2006), Cyclone Nargis (2008), and Cyclone Giri (2010) are alarming signal of climate change in Myanmar. The Cyclone Nargis, the worst natural disaster in the history of Myanmar, struck Ayeyarwaddy Delta and Yangon Region in the year 2008. Currently, the groundwater tables are being decreased around country, especially in central dry zone by rainfall pattern of climate change.

3.3 Increasing of urban people & needs of awareness distribution

The urban population is growing around country and groundwater demand is being needed year by year. The awareness distribution will be needed among public for the knowledge in water.

The 'Dry Zone' is situated in Central Myanmar. It is the country's most economically deficient region with 43 percent of households living under conditions of poverty1. Some 80 percent of the regional population live in rural villages. The lack of access to a reliable water source and the variability in yield and quality constrains livelihood and agricultural development, contributing to the prevailing poverty and food insecurity. The Myanmar Government as a matter of national policy, ranks improved drinking water supply and sanitation, farming strategies and socio-economic development as major priorities. Detailed 1:500,000 geological map of Central Myanmar as well as regional hydrogeological and hydro geochemical drawings.

These plots have been prepared by compiling available geological and hydrogeological reports, field observations, water sampling and tube well data inventories. The detail of this report is governed by the data available which is still largely qualitative. Generalizations have been necessary in preparing the maps and notes. More detailed site-specific information may be obtained from sources listed in the bibliography and relevant government authorities.

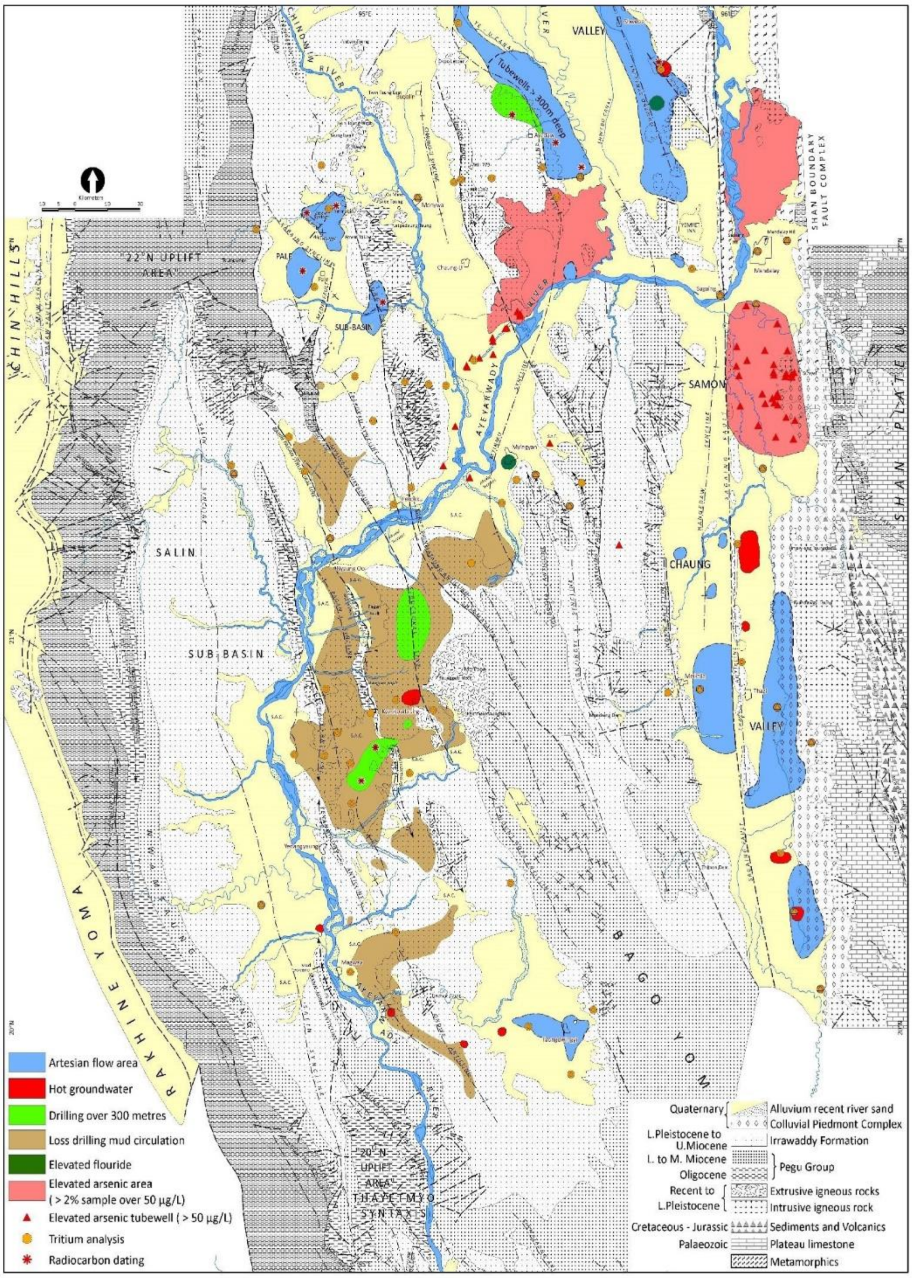


Fig. 2. Hydrological Map of Central Dry Zone.

Table 3. Hydrochemical characteristics of representative water samples from 3 main aquifers.

Division	Aquifer	Type of water						Total no. of representative sample
		$HC0_3$ - $S0_4$	Cl - $HC0_3$	$HC0_3$ - Cl	$S0_4$ - $HC0_3$	Cl - $S0_4$	$S0_4$ - Cl	
Magway	Alluvial	-	-	-	-	-	-	149
	Irrawaddian	63	36	50	10	18	7	184
	Peguan	10	6	8	1	8	1	34
					Sub total			367
Mandalay	Alluvial	42	20	45	9		-	116
	Irrawaddian	17	8	11	12	2	-	50
	Peguan	4	1	7	4	3	-	19
					Sub total			185
Sagaing	Alluvial	7	10	32	-	1	1	51
	Irrawaddian	12	10	28	16	1	3	70
	Peguan	2	-	-	-	-	-	5
					Sub total			126
Ayeyarwaddy	Alluvial	-	18	2	-	4	-	24
	Irrawaddian	1	13	-	-	3	-	17
	Peguan	-	6	-	1		7	
					Sub total			48
Yangon	Alluvial	6	2	5	5	-	4	22
	Irrawaddian	-	15	1	7	6	3	32
	Peguan	-	4	1	2	1	-	8
					Sub total			62
Bago	Alluvial	29	1	-	-	-	-	30
	Irrawaddian	6	-	1	4	-	2	13
	Peguan		1	-	-	-	-	1
					Sub total			44
	TOTAL	199	154	191	70	48	21	683

3.4. Water quality of three major aquifers

According to the hydrogeological studies quoted in the previous sections, water chemistry of three major aquifers from Sagaing, Mandalay, Magway, Bago, Yangon and Ayeyarwady Divisions can be identified and mentioned in Table 3.

4. Plan and ideas for construction of groundwater database

The total of 3,000 water well spatial database has been constructed in the GIS platform at Irrigation and Water Utilization (IWUN) Myanmar. First, the spread sheet format for the groundwater well attribute table were constructed by state and region in Myanmar (i.e. MS Excel work sheet) and then link to GIS platform by the fourth purpose of getting spatial database system. Recently the constructed database has inertial the specific area, which is the Central Part of Myanmar including Sagaing, Mandalay and Magway Regions. The groundwater information is representation depth to aquifer, static water level, pumping water level and yield for particular diameter of borehole size etc. are included in the database.

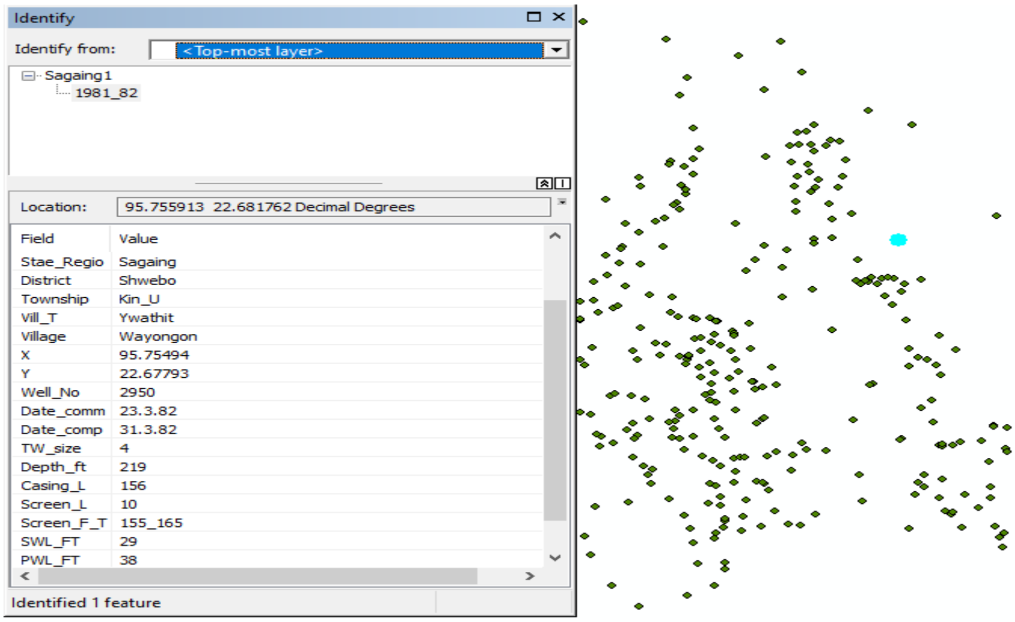


Fig. 3. Water well spatial database in GIS platform.

In 2016, the Government of Australia supported for the "Hydrogeological Mapping of the Dry Zone-Central Myanmar". The Hydrogeological mapping was completed in September 2017 and provides insight into the hydrogeology within the Dry Zone. The map describes the current knowledge of the groundwater systems and indicates the areal spread of Hydrogeological features (high aquifer yields, low and high salinity, artesian pressure, elevated temperatures, contaminants (arsenic, fluoride) and age. Now the Hydrogeological Mapping for the Eastern Highland (it is covering the Kachin State, Shan State, Kayah State, Kayin State, Mon State and Tanintharyi Region) is ongoing stage with the assistant from the Australia Water Partnership (Australian Government Assistance). The hydrogeological mapping for the coastal and delta areas are still remain and it is also planning stage.

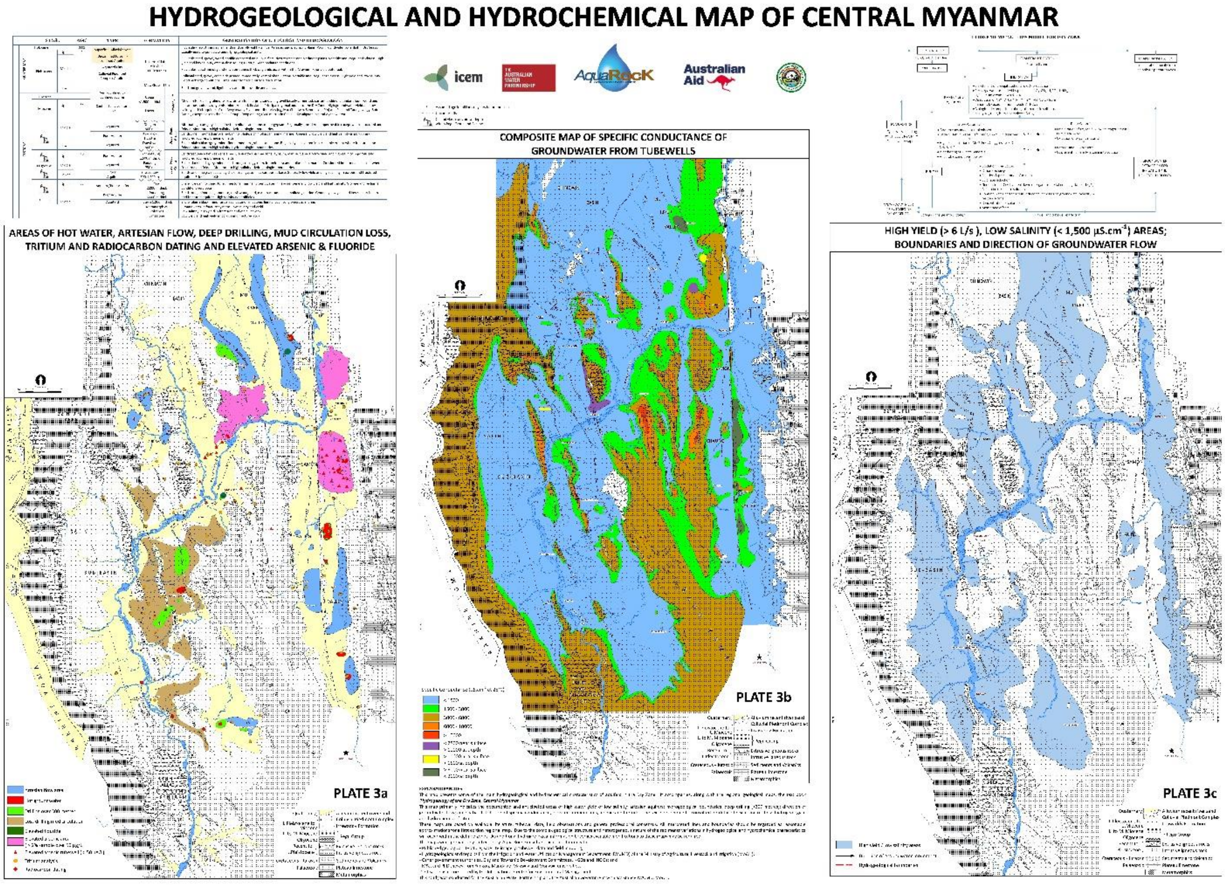


Fig. 4. Hydrogeological and hydrochemical maps of central Myanmar

5. The State Management of Water Resources Organization

National Apex Body for Water Resources Management is National Water Resources Committee (NWRC) and it was formed in 2013. It is on the highest level and the most responsible committee in the water sector.

The objectives of the committee are:

- To harmonize the relationship among water related agencies,
- To establish rules foe water resources management,
- To enhance the participation of all stakeholders,
- To establish relationships with international organizations, and
- To review existing water laws and regulations for development of the water sector

The committee adopted Myanmar Water Resources Policy in February, 2014.

5.1 Suggestions

- Groundwater recharge and storage reservoirs in the river basins
- Mangrove replanting for shoreline protection
- Flood walls and storm surge barriers
- Preparation of hazard maps
- Capacity building for adaptation to all stakeholders
- Need to more technical training

6. Conclusions

The proposed future activities will be carried out such as Country level, basin wise estimation for groundwater potential, Volume estimation for country level groundwater extraction, Water quality monitoring in heavy groundwater extracted areas, Preparation of Hydrogeological Maps for the whole country, Searching the new groundwater prospect areas, Preparation of hazard maps, Establishment of Groundwater Database Management System using Geospatial Technology by the cooperation of International Organization.

This area is located in Bagan-Nyaung U Township, Mandalay Region. It is situated in Central part of Dry Zone of Central Myanmar and located between North Latitude 21º 00’ 00” to 21º 15’ 00” and East Longitude 94º 50’ 00” to 95º 12’00”. Its elevation is about 282 feet above sea level. The stratigraphic units exposed in this area are Pegu Group, Irrawaddy Formation, Alluvium and Igneous rocks. The groundwater in alluvial deposits is suitable for drinking and agricultural use. The groundwater yield from this unit is about 4,000 gph from 6 inch diameter tube well. The groundwater in Irrawaddy Formation is groundwater yield-3,000 gph from 4 in diameter tube well. In our study area pumping test for 3 hours and recovery test of 3 hours duration were performed at 4 inches diameter tube well at Nyaung-U (Department of Rural Development). The aquifer is located at the depth of (600-650 feet) and so its thickness is (50 feet).

Myanmar would like to request to CCOP for capacity building program in Groundwater and Geosciences, and we have great expectation for the improvement of cooperation and coordination with CCOP Member Countries in future activities.

References

Department of Geological Survey and Mineral Exploration (D.G.S.E), Ministry of Mines, Myanmar

The Water Resources Utilization Department (WRUD), Ministry of Agriculture and Irrigation, Myanmar, 2016

Present hydrogeological data and problem for making groundwater database in Papua New Guinea

Dorcas Fabila

Geological Survey Division,
Mineral Resources Authority, Papua New Guinea
e-mail: dfabila@mra.gov.pg

Abstract

Initially, the groundwater database was established in the year 2015, of which the data parameters to be collected were defined. Main type of data collected include general information of boreholes/ shallow wells, borehole construction details, lithological logs, pump test data, and water quality (lab test) data.

Data collection began with the capital city of Papua New Guinea, Port Moresby, and has since then, continued on to two other provinces, East New Britain and Morobe Province. A good amount of data has been gathered from existing reports and it is proposed that a next phase of site visits should be carried out to confirm status of the boreholes and collect information on new boreholes where necessary.

Data collection on the desktop level is sufficient; however, few obstacles may be faced when continuing on the project to the second phase of field engagement to confirm borehole status. Customary land owner issues are among one of the main challenges, along with other factors such as funding.

Groundwater data collected is very essential as all data sets will go towards building a revised groundwater potential map and borehole location map of each province, and eventually, a national map.

Keywords: PNG, groundwater, borehole, groundwater potential map

1. Introduction

In the year 2015, a groundwater database was established in order to collect all necessary groundwater data to be recorded into this database. Data collection began with Port Moresby, the National Capital District (NCD) of Papua New Guinea (PNG), and has since then, continued on to two other provinces, namely the East New Britain and Morobe Provinces.

All data collected would aid in generating a revised groundwater potential map of each province, and eventually, of the country. Groundwater data is important in order to monitor the quality and quantity of this important resource; hence, database management is important. Presented in this report are the current status of the database project and the challenges faced therein.

2. Present status of hydrogeological data

Initially, the hydrogeological data collection project began with data collection of the capital city of Papua New Guinea (PNG), Port Moresby. The approach taken to collect data was mainly through existing reports and borehole construction templates which were used to record borehole data during construction of any borehole. Data collection of the Port Moresby boreholes was successfully completed, and a city-wide survey was also carried out in 2017 to confirm the status of each borehole registered in the database. From this project, a borehole location map was created for Port Moresby, indicating current status of the boreholes (Fig. 1).

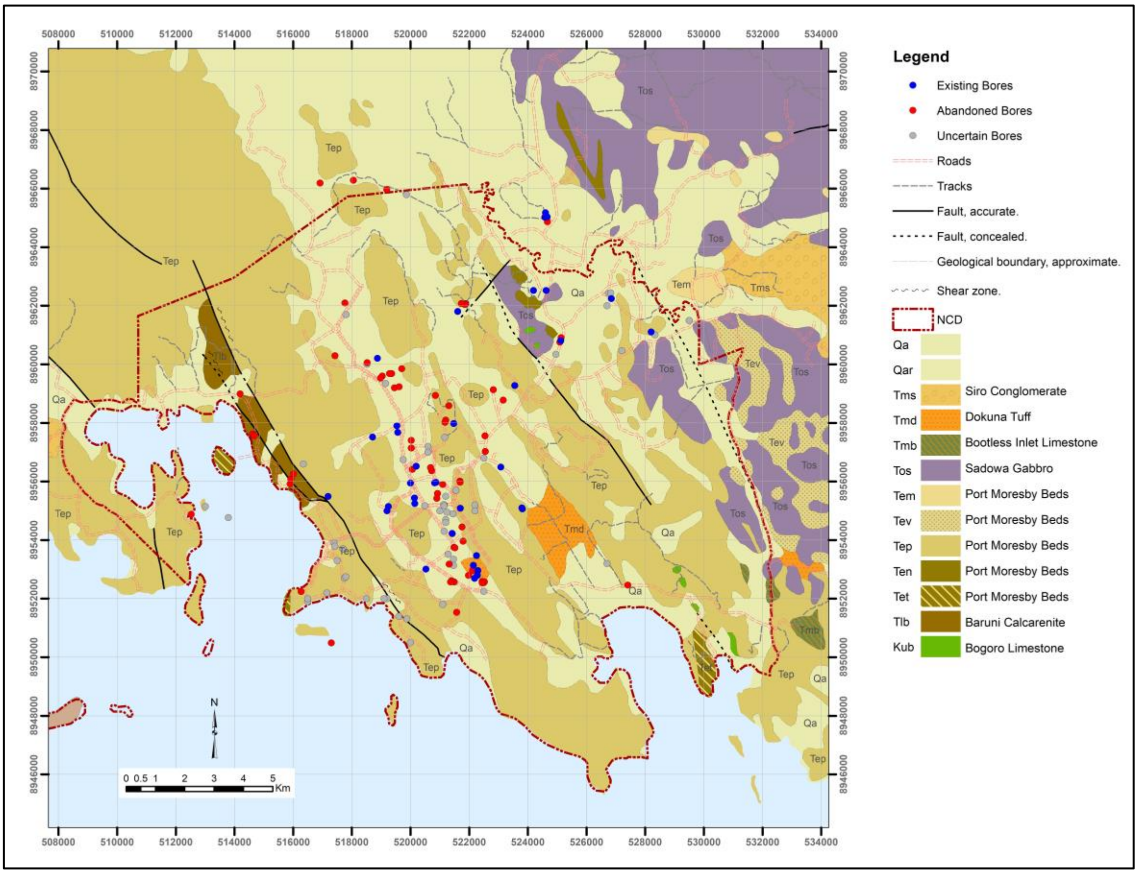


Fig. 1. Geological map of Port Moresby, indicating borehole locations.

Data collection for other provinces have already commenced, which include Rabaul and Kokopo Towns of East New Britain Province, and certain areas of the Morobe Province. A similar approach was taken for data collection as done for Port Moresby, where most data was sourced from existing reports of the area of interest. Data collection for Kokopo and Rabaul were successful, and the data was represented on separate borehole location maps (Fig. 2 and Fig. 3). The maps indicate the status of the boreholes at the time of reporting from the existing reports; hence, these data need to be updated.

Currently, the Mineral Resources Authority (MRA) have requested collaborative efforts from other state entities, namely the Water PNG Limited and the Conservation & Environment Protection Authority (CEPA) to share groundwater data in order to build a good database and monitor the groundwater resource. CEPA responded favorably to this request, however, Water PNG are yet to respond. MRA have also established a good working relationship with a private drilling company, Central Drillers, whom have agreed to share drilling data for any borehole drilled within PNG. Central Drillers usually engage in water supply drilling programs for areas within Port Moresby, Central Province, and other nearby provinces.

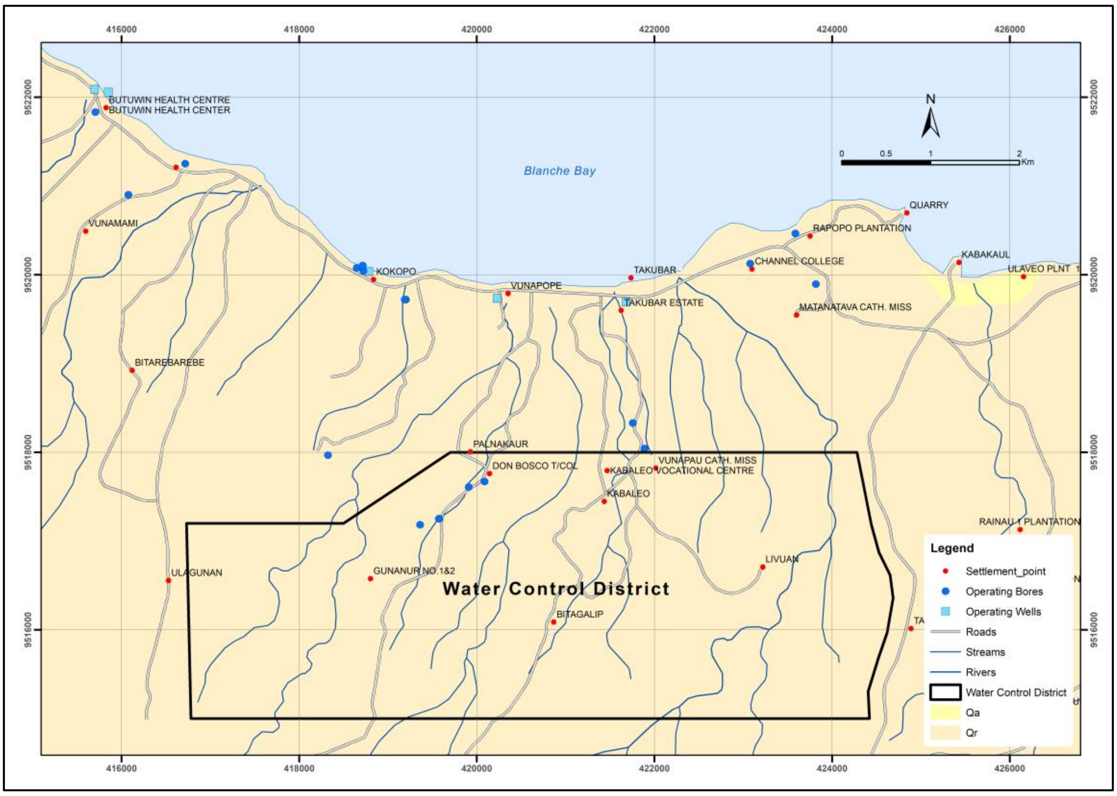


Fig. 2. Geological map of Kokopo, indicating borehole locations.

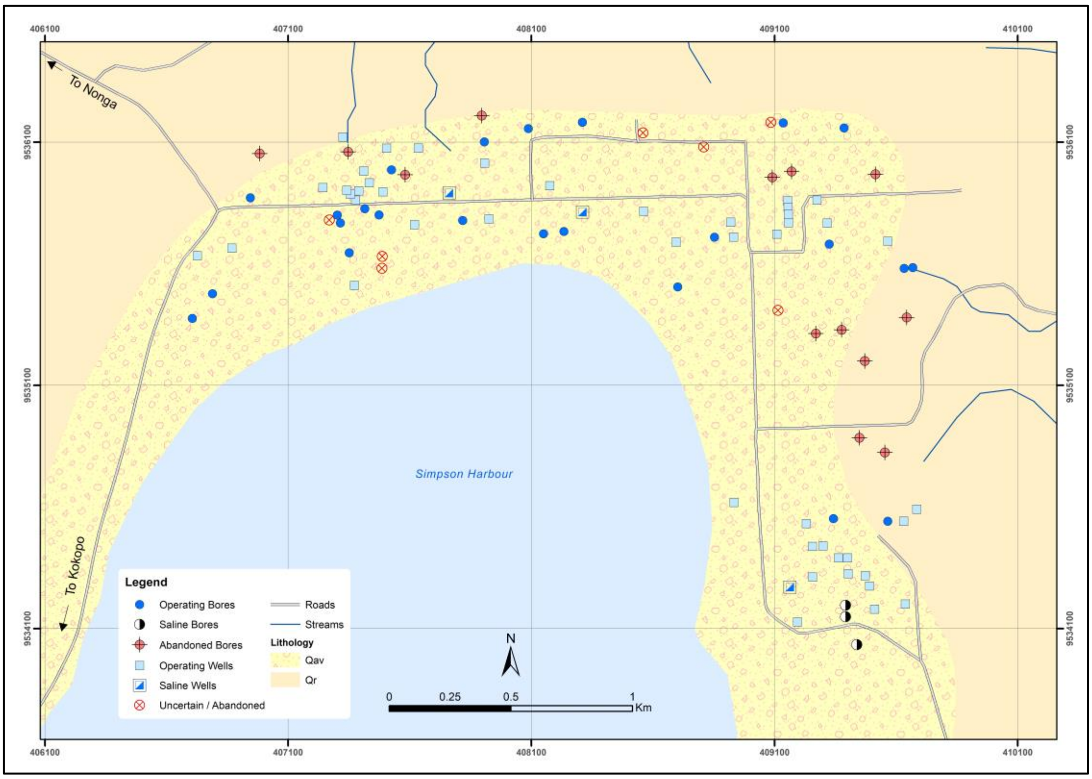
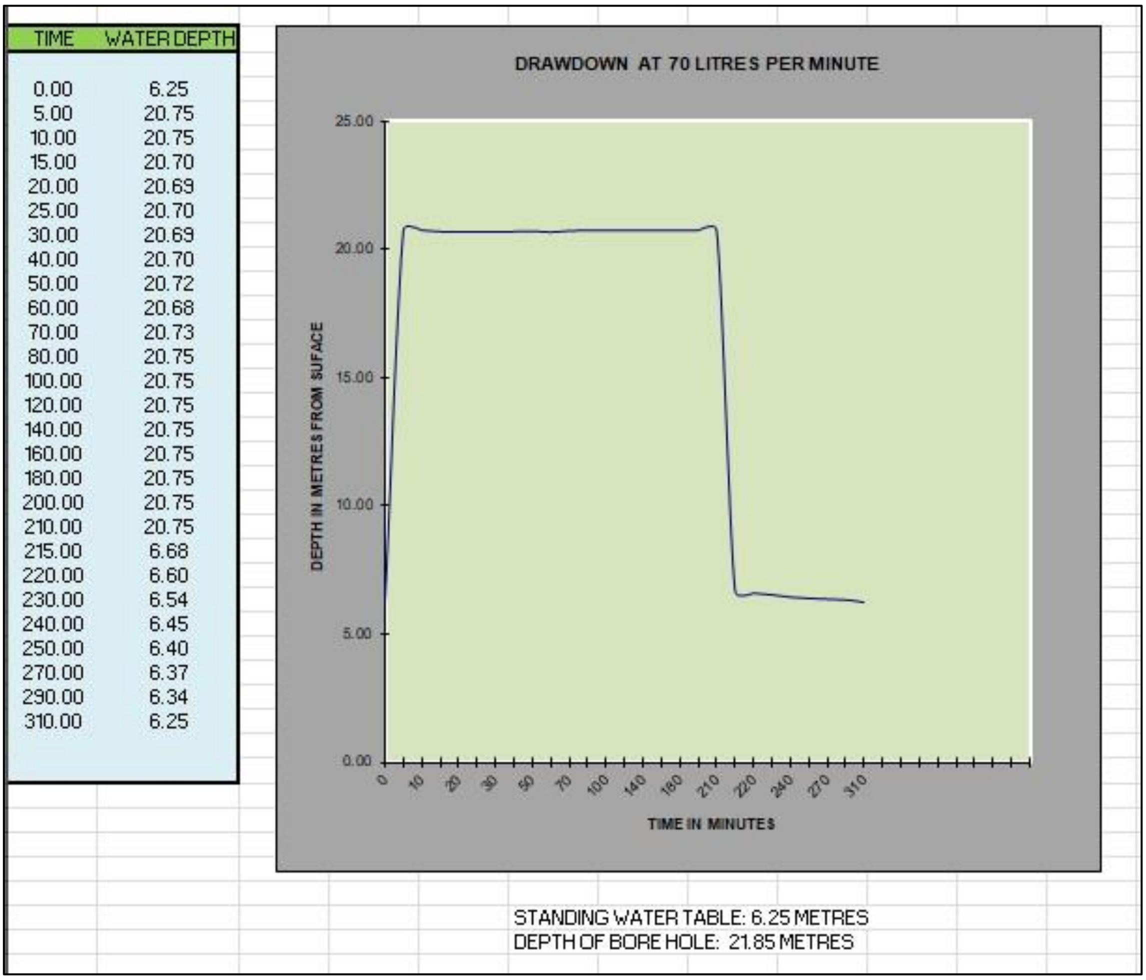


Fig. 3. Geological map of Rabaul, indicating borehole locations.

3. Problem and barriers for making groundwater database

The data provided by Central Drillers mostly contain general information such as groundwater level and aquifer performance such as pump test data; however, these data sets do not indicate any geographic location or GPS coordinates. This may be a challenge for the Hydrogeology team to go on site and confirm location of these bores. A similar obstacle was encountered with data collected from existing reports of Morobe Province, where geographic locations of the boreholes were not recorded. Without proper information on location of the boreholes, the spatial relationship of the various aquifers within the study site and how they relate to the local geology may not be well established. The type of data shared by Central Drillers is shown in Fig. 4.



TIME	WATER DEPTH
0.00	6.25
5.00	20.75
10.00	20.75
15.00	20.70
20.00	20.69
25.00	20.70
30.00	20.69
40.00	20.70
50.00	20.72
60.00	20.68
70.00	20.73
80.00	20.75
100.00	20.75
120.00	20.75
140.00	20.75
160.00	20.75
180.00	20.75
200.00	20.75
210.00	20.75
215.00	6.68
220.00	6.60
230.00	6.54
240.00	6.45
250.00	6.40
270.00	6.37
290.00	6.34
310.00	6.25

Fig. 4. Type of groundwater data provided by Central Drillers.

From the current data that were collected, it was noted that some information was duplicated in more than one report. This gives rise to the need for proper observation of data in order to avoid discrepancies and duplication of data, more importantly, considering, the accuracy of the data entered into the database.

In any project, funding is necessary in order to bring the project to completion. While data can be collected directly from existing reports, Hydrogeologists of MRA would need to be present on the site in order to confirm status of the boreholes, and to collect water samples in order to have updated water quality data. Due to this reason, the groundwater database project would depend largely on the availability of funding; hence, at present, more time is given to desktop data collection.

In order to collect good updated groundwater data, there needs to be a good collaboration between state entities, as well as private companies, mainly drilling companies. This approach may make way for easy access to good groundwater data and aid in monitoring the groundwater resource. Attempts have been made to contact other state entities in order to work in collaboration in sharing groundwater data, however, this may depend on the response of other state entities and the respective drilling companies engaged in water supply projects within PNG.

Although collection of data at the desktop level is reasonable, the second phase of data collection with field engagement may present challenges, especially due to land owner issues. A vast amount of land within Papua New Guinea is under the ownership of customary landowners, hence, in order to access any boreholes/ shallow wells within such areas, proper permission needs to be sought from the customary land owners in order to access the boreholes and collect updated data. This is one of the major setbacks experienced in PNG for any field hydrogeological work, as well as other programs involving geological and environmental work. This is a common situation that is encountered; hence, a proper solution needs to be devised in order to counteract such obstacle.

4. Plan and ideas for constructing groundwater database

Adding onto the data already collected for Port Moresby, Kokopo, Rabaul and Morobe Province, it is proposed that more data collection will continue for other provinces within PNG. Of the other provinces, Central Province has been selected as the next target province for data collection, as this province is the closest to Port Moresby, hence, access to these areas for second phase of data collection (field engagement) will be more suitable (Fig. 5).

Since data for Kokopo and Rabaul have already been collected, it is proposed that a next phase of field visit will be carried out to confirm status of the boreholes and collect water samples where necessary, for updated water quality data.

The involvement of other state entities and private drilling companies is very essential in collecting good, up to date groundwater data. Hence, for this project, the MRA Hydrogeology section aims to establish more ties with other state entities and private drilling companies who are directly engaged in groundwater and water supply operations within PNG to be able to share groundwater data efficiently. At present, CEPA and Central Drillers have agreed to share any groundwater data they may have with the MRA Hydrogeology team.

Data collected for Port Moresby is been reviewed at present, and it is planned that a final report will be written to present all the data collected. Once the report is finalized, the data sets will be submitted to our GIS team to be uploaded onto the MRA and GSi CCOP portal.

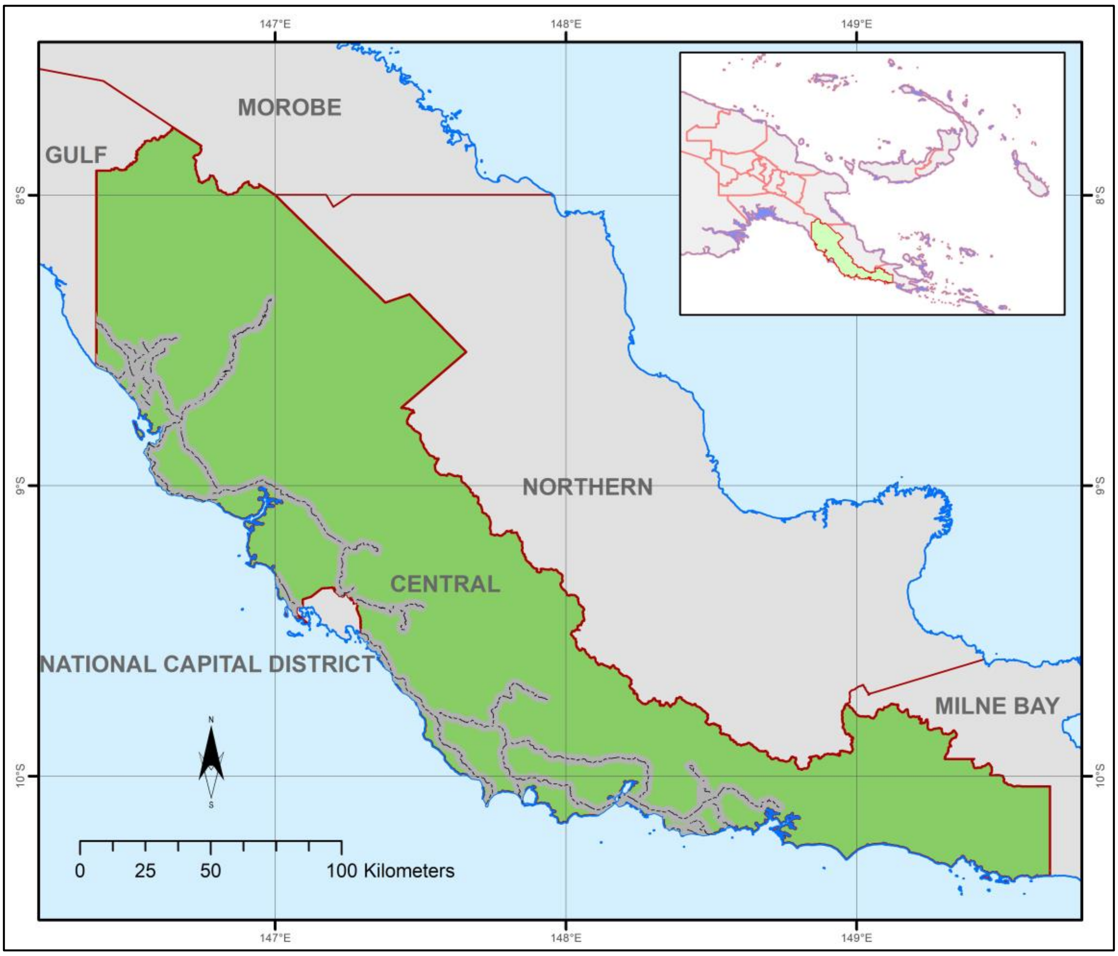


Fig. 5. Location of Central Province (green shaded) with reference to NCD-Port Moresby.

4. Conclusion

Since the commencement of the groundwater database project, a good amount of data has been recorded for the capital city of PNG, Port Moresby, with other Towns such as Rabaul and Kokopo of East New Britain Province, and areas of Morobe Province. Continuation of data collection is essential in order to have a more improved record system and monitoring system for the groundwater resource of Papua New Guinea.

Data collected will aid in creating a revised groundwater potential map and borehole location map for each province in PNG, and eventually a national groundwater map. A work plan for 2020 is aimed at collecting data for the Central Province, and to continue to phase two for confirmation of bores within East New Britain Towns of Kokopo and Rabaul. With the help of CCOP funded workshops, this project may continue successfully.

References

Birrell, J. P., 1971, Rotary boreholes at Coral Sea Hotel site-Port Moresby, James Birrell & Partners, Pty Ltd, 13p.

Harris, J. and Jacobson, G., 1972, Port Moresby Urban Geology, Geological Survey of Papua New Guinea, 69p.

Pounder, J. M., 1972, Summary of groundwater data, Rabaul, East New Britain, Geological Survey of

Papua New Guinea, 54p.

The Waterboard, 1995, Third Urban water supply project, Kokopo water supply predesign inception report, The Waterboard, 34p.

The Waterboard, 1996, Third Urban water supply project, Kokopo water supply, Report on hydrogeological investigations under Contract TCWB 07/95 Stage 1: Groundwater feasibility study, The Waterboard, 111p.

Thompson, J. E., 1955, Preliminary Report on Test Bore for water on Boroko Hockey Ground, Department of Minerals and Energy, Geological Survey, 2p.

Thompson, J. E., 1955, Report on Test Bore for underground water at Boroko Recreation Reserve, Department of Minerals and Energy, Geological Survey, 3p.

Thompson, J. E., 1955, Report on Test Bore for water at Boroko Hotel, Department of Minerals and Energy, Geological Survey, 2p.

Issues and improvement ideas for the Phase III groundwater database of Thailand

Phuengchat Chantawongso

Bureau of Groundwater Exploration and Potential Assessment
Department of Groundwater Resources
Ministry of Natural Resources and Environment, Royal Thai Government
e-mail: chantawongsop@gmail.com

Abstract

The Department of Groundwater Resources (DGR), the Ministry of Natural Resources and Environment, The Royal Thai Government, has been developing concepts and designing up to date database systems, and accurate data information to support effective decision making of the groundwater management plan. Groundwater potential assessment for each groundwater basin both as qualitative and quantitative aspects should be explored.

Concepts and database design can be supported by the stakeholder to use groundwater data, which has an important role in many sustainable groundwater development goals. In the future, DGR will plan to develop a smart groundwater database system. The first stage is to survey and collect data requirements. DGR must know the expectation of the users and the planning of structure that represents a real-world object of the database as much detail as possible. The next step is to find out the groundwater database system which can make easily and provide facilities for the organization.

The database development process includes data and information gathering, a variety of techniques have been developed and powerful modeling capabilities. Moreover, the complete groundwater database system must give time to it for developing and upgrading. In the future, the groundwater database needs to be improved to serve new growing demand for data requirements and to support database services.

Keywords: groundwater, hydrogeological map, Asia

1. Introduction

DGR's role is generally responsible for providing unified groundwater resources management. The mission is to manage the optimal efficiency of exploration, assessment, development, conservation, restoration, and control of groundwater resources. Groundwater information technology is developed to enhance sustainable groundwater resources management by the user participation approach. To develop groundwater resources organization, human resources, and implementation of technology transfer to the public for sustainable and integrated groundwater resources management.

DGR is a core agency duty to prepare information needs creating a groundwater resources database including preparation, compilation, and up to date groundwater database. Hydrogeological maps are ensured accurately and always up to date for publication. Now a day, Thailand's water consumption is increasing rapidly because of population and economic growth. As a result of these, the groundwater database is also important to support groundwater management planning as well as groundwater potential exploration for any groundwater basins in terms of qualitative and quantitative aspects.

The groundwater database collects groundwater information such as well number, well location, static water level, and well chemical properties. It describes characteristics of hydrogeological data for example sedimentary basins, unconsolidated and consolidated rocks, etc.

In the year 2015, DGR was established to share the groundwater database to all the participants of the meeting and upload it to the CCOP website, the host of www.ccop-gsj.org/main/. The CCOP Geoinformation Sharing Infrastructure for East and Southeast Asia (GSi Project) portal is under development and accessible by the members. DGR presented a groundwater data of Thailand, the status of hydrogeological data, Hydrogeological map, Groundwater map of Thailand, and the step of development of the groundwater database.

The discussion of the project of the CCOP-GSJ groundwater project is designed by two groups. DGR was a DB1 Group that shared groundwater data in excel format and provided by the end of the CCOP-GSJ/AIST-NAWAPI Groundwater Project Phase III Meeting in Hanoi, Vietnam, adding to the groundwater data of the Upper Chaophraya (Sukothai, Phitsanulok, and Pichit Provinces)

Also, DGR exchanged the plan of the detailed hydrogeological map and the groundwater map on a scale of 1:50,000. DGR collected the data catalogue including layer names, type of data, data characteristics, and source of data. Both spatial and attribute data were input to the Hydrogeological Information System and performed a spatial analysis by using GIS.

Until 2019, DGR shared a groundwater data and hydrogeological map in the part of the area of the Upper Chaophraya and Khon Kaen Province to the GSi Groundwater Portal.

2. Current status and issues for the Phase III Groundwater Database

2.1 The status of groundwater database of the Department of Groundwater Resources in Thailand

Groundwater database is a key resource for all stakeholder development and has an important role in many groundwater sustainable development goals. DGR provides mainly functions for special data collection management. Previously, DGR developed groundwater resources water demand expansion as a result of population growth for drinking, household use, agriculture use, industries use, and other activities. Necessary data collection is useful to develop new groundwater resources.

In 2002, DGR established Thailand's hydrogeological and groundwater databases named "The PASUTARA Database". The PASUTARA Database has been continuously added the information of soil and rock layer, groundwater well location, and depth, drilled log, geophysical log, casing program, static water level, and groundwater quality, etc. DGR used the PASUTARA Database and groundwater paper and digital maps at a scale of 1:100,000 to create Hydrogeological Geographic Information System (HYGIS). The HYGIS combines with the geographic program for inputting data, displaying maps, and storing data. It is easy to install and use. Also, the HYGIS contains more kinds of hydrogeological and groundwater data than the PASUTARA database, for example, aquifer type, geological structure, and hydrogeological cross-section, which are the data integration and interpretation for effective decision making.

Currently, the groundwater management of DGR can be divided into the function of many sectors to manage special data. Groundwater Exploration and Potential Assessment can handle the survey and inventory data, resistivity data, hydraulic data, pumping test data, and to collect database about the HYGIS layer. Also, the assessment data is carried out by the Bureau of Groundwater Exploration and Potential Assessment. It confirms challenges in the region being the state of groundwater data collection and data management. The objective is to provide hydrogeological and groundwater map, and the regional groundwater potential assessment. It is also to prepare an advanced geophysical survey and set up a geophysical database system.

The groundwater development roles are the standards of groundwater drilling, the technical well drilling, and installation. In this part, the organization is improving the data storage system. Then, it has a target to develop standards and makes a new edition of the handbook regarding groundwater development and management for keeping up on changes in innovation and technology in the future and solving the problem area, and water shortage areas in our country.

Fig. 1. The sector of the Department of Groundwater Resources of Thailand.

The groundwater conservation and restoration roles are to analyze, to conduct research, to set up a groundwater monitoring network, to monitor groundwater level and quality, to evaluate the declining of groundwater level situation due to the development of groundwater usage, and to evaluate the effect of groundwater contamination by analyzing the water quality. The project on information technology development project was established in 2018 for the surveillance and monitoring of groundwater operation. The objectives are to create a centralized database system, to design implement surveillance, and to monitor the groundwater operation system by constructing the master station. The database construction collects and stores the water level data for monitoring the static water level declination as well as changing water quality from routine work and putting into the geographic information system. It is to design and to develop automatic real-time surveillance, and to monitor the groundwater operation system network with the data from the observation wells.

This database is called "TGMS" which represents the monitoring wells database system in Thailand. The organization can collect the data location of monitoring stations and information of monitoring stations e.g. static water level, and groundwater quality such as EC, temperature, total dissolved solids, and salinity, etc. Then, DGR users can analyze data and forecast the groundwater situation for supporting groundwater management. As a result of the TGMS which displays to distribute monitoring wells and data on a web-based application. It can be able to use the functionality of the online presentation system and to deal with an efficient database system. Besides, to implement a groundwater situation database and Geological Information System (GIS), they can work well together including information dissemination systems and information exchange via a web-based application or mobile device to allow public, private sectors, and related government agencies to quickly and accurately access groundwater information. The database system supports the future mathematic computation model for assessment of groundwater situation that can be used to apply in groundwater management in any area.

The part of the groundwater quality analysis group focuses on the quality of groundwater utilization for the public and household. To service and support groundwater samples analysis from all stakeholders need the results of the quality of groundwater used. The main purpose is to evaluate, change, and collect groundwater quality data for all groundwater resources development. Nowadays, we are improving a groundwater quality database, so-called the "E-lab" database. It combines groundwater quality data collected in each groundwater basins in Thailand and provides a summary of groundwater quality in selected aquifers for groundwater development and management.

The E-lab database consists of two types of data: general and specific, which are as follow:
1. To calculate raw data for groundwater quality information.
2. To produce a groundwater quality report in excel, pdf, and graph, etc.

DGR plans to design a network of groundwater quality databases that are related to water sampling and based on specific hydrogeological conditions, the activity of land use, or others. However, these are linking to the main groundwater database for mass storage of relevant data that the PASATARA database reaches the data access which the users are easy to understand.

The Groundwater Control and Legislation System (GCL) is a tool for the function of groundwater usage control. The GCL, concerning the data, is used by the DGR's staff and local authorities. The GCL is an application for drilling and groundwater abstraction as a target to collect private wells data including the groundwater licenses, invoices, groundwater usage of all private wells, and improvement to the application for licensing. Presently, DGR can be designed the GCL application to help and report the groundwater operation licenses which manage to groundwater tax payment e.g. groundwater-charging rates, penalties, and fees for groundwater activities.

The Groundwater Information Technology Center (GITC) is the importance of data storage and sharing data groundwater database system for groundwater development and groundwater management in the organization. The main objective is to accurate reliable data for effective decision making. Furthermore, the GITC handles the "PASUTARA database" or the groundwater database system is designed for the database structure which is performed under the DGR’s standards. It provides a convenient environment to retrieve and collect database information which supports groundwater database to all user and participants. The general user needs to make information access being easy, quick, inexpensive, and flexible.

The GITC improves the database development according to the purpose of the database design, consultation of group storage data into the database. Implementing a database system development includes analysis, design, and development of database systems. About the groundwater database network, the GITC has launched a mobile application named the "Badan4thai". This application is a tool for disseminating groundwater information to the public including application widespread use. It will result in good access to groundwater information. Also, it can be shown groundwater wells, groundwater availability maps, etc.

As mentioned above, there are many database sets to each function of the groundwater database management under the framework that are targeted for DGR officials. They have a coordinating role in groundwater storage and shared data management. To analysis data and information needs to find out a suitable area for groundwater resources development.

Then, the groundwater database is still improving the each of database functions to manage data because all the users cannot know a characteristic feature as well. They discussed in detail the complete definition and description of these data. Normally, if the users know and understand the objective of each function database, the users can handle and apply to facilitate quick development information and to find a suitable area for groundwater resources development. Thus, the organization has to focus on groundwater database management which brings to accurate and reliable data for successful decision making.

Moreover, the current situation of the Groundwater database management in Thailand consists of more than 300,500 records of wells including the government and private sector data. In summary, groundwater resources in Thailand can be calculated as the total groundwater storage in Thailand figured out at $1{,}137{,}174 \times 10^6$ m^3 in 6 geographic regions. For sustainable groundwater development, DGR allows annual groundwater consumption at approximately 60 % of annual groundwater recharge, which is called “safe yield”.

Groundwater utilization information in Thailand can be categorized into three main groups that groundwater annual recharge is about $72{,}967 \times 10^6$ m^3 so that annual groundwater availability (safe yield) is $45{,}385 \times 10^6$ m^3.The estimation of groundwater utilization in Thailand is about $14{,}741 \times 10^6$ m^3, which is separated as $1{,}223 \times 10^6$ m^3 for household, 777×10^6 m^3 for industries, and $12{,}741 \times 10^6$ m^3 for agricultures. Fig. 2 illustrates the approximated groundwater utilization of each of the groups.

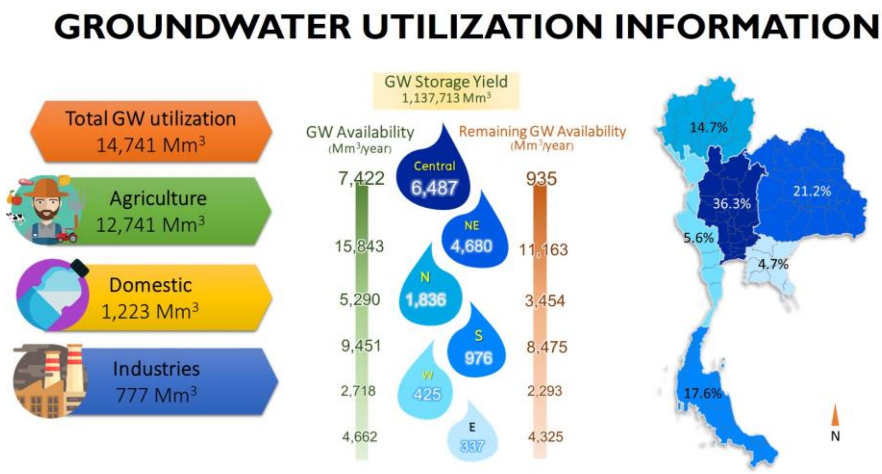


Fig. 2. Groundwater Utilization Information of Thailand in 2019.

2.2 Current status and issues for the Phase III Groundwater Database

DGR as the member participant in the CCOP-GSJ Groundwater Project Phase III shared a groundwater data and hydrogeological map in the part of the area of the Upper Chaophraya and the Khon Kaen Province to the GSi Groundwater Portal in the figure as shown below.

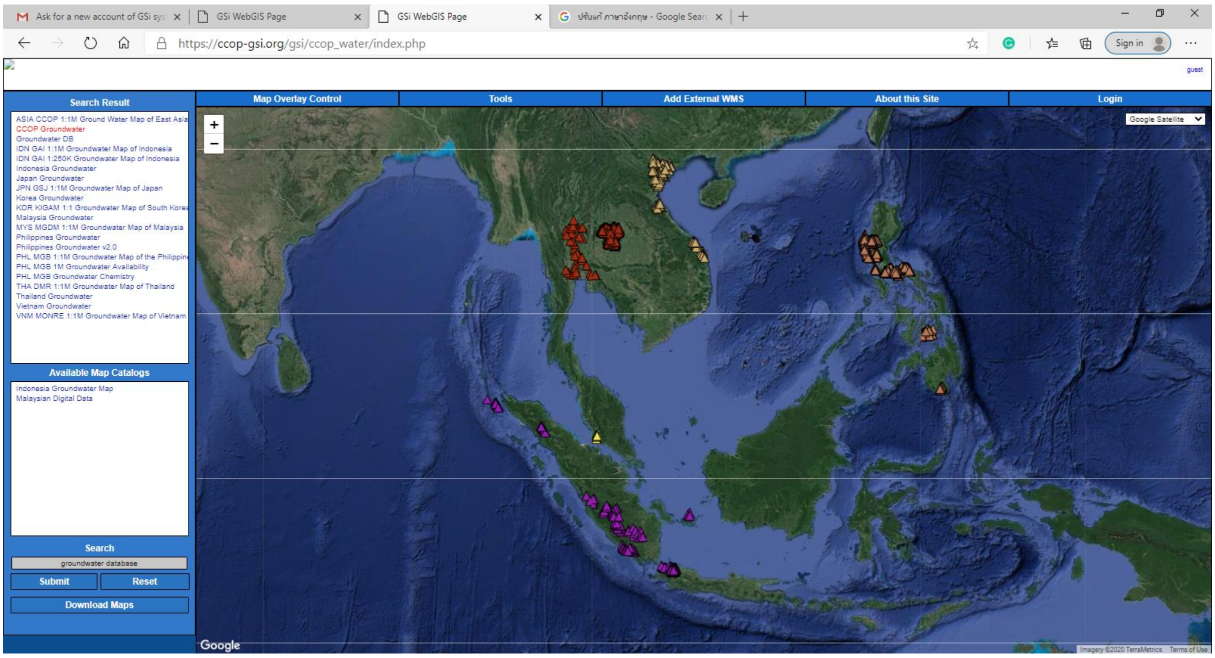


Fig. 3. The whole of groundwater data of the member participants input to the website.

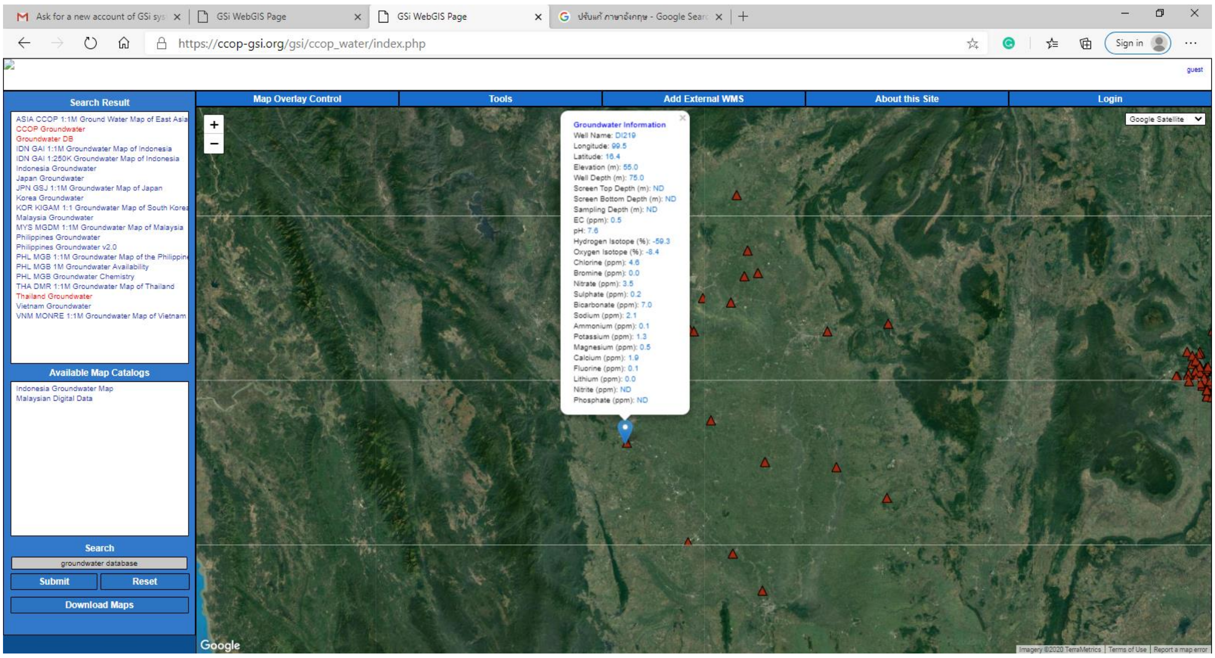


Fig. 4. Some groundwater data of the part of the area of the Upper Chaophraya, Thailand.

Up to date, the following data are available from the GSi Groundwater Portal, DGR had some problems because some groundwater data on the part of the area of the Upper Chaophraya, Thailand was collected the survey data by the other subject. Also, the other groundwater data of the Khon Kaen Province was not available data from the field at the same time. Therefore, some data was out to date.

By the way, the discussion topics are planned to update, data review, and revised the plans with the groundwater data in Khon Kean Province, Thailand. Now, DGR still is revising groundwater data in this area for the compilers' data.

Additionally, DGR exchanges some ideas to discuss how to utilize the DB group data to complier in the interesting areas, the cooperation of CCOP countries, and the implementation of the GSi system.

3. Implement to groundwater database of DGR and improvement ideas for the Phase III Groundwater Database

3.1 Implement to groundwater database of DGR

In the current, for a well-groundwater database system, DGR can design the groundwater database management to improve the PUSATARA database in the next step. It is called as "the SMART Pusutara database" to be kind to the user.

The SMART DGR data management accordance with an organization, the new demand is growing for database services. Including the DGR has planned to be Groundwater 4.0. At that time, it is improved to be a multi-application for support to the users when they search for groundwater wells, groundwater maps, information on groundwater. In 2017, DGR provides "Badan4thai" which is a mobile application. “The Nagaraj center"; the groundwater war room was built in 2018. It has been displayed on the monitors to enable decision making on groundwater resources management.

At present, DGR has launched the smart of DGR projects about 4 sections that are Smart ERP, Smart Planning, The Smart Pasutara, and Smart GIS as shown in Fig. 5.

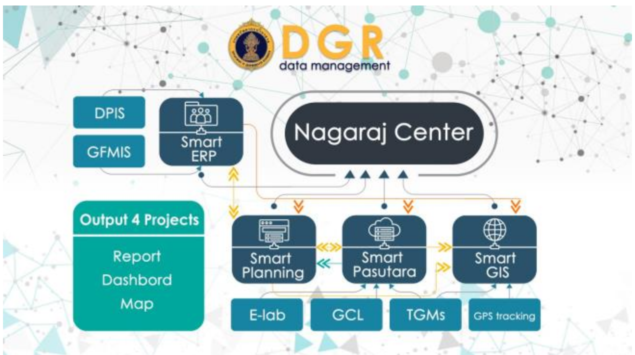


Fig. 5. Flowchart of data management under the DGR’s Nagaraj Center.

In the part of the SMART Pasutara and the Smart GIS is the application being the tool for disseminating groundwater information. It includes a function of searching for groundwater wells, groundwater maps, information on groundwater, etc. This system can be an interaction between user and administrator that reduce the time for data survey and search data of groundwater resource management.

Then, the subject of issues and the improvement of the groundwater database management is the importance of reliable and up-to-date groundwater data as the only way to develop a good conceptual understanding of aquifer systems and groundwater resource development. This is a key concept of data storage and sharing to all participants required for integrated groundwater resource assessments and the development.

However, the development of groundwater database management has been found some issues for database design on the state of groundwater data collection and data management in the organization. It is insisted on data structure and compilation into a database format, data entry, and edition, updating, quality control at all levels, and maintenance. Moreover, under the condition of general database management includes limited human resources, equipment, and financial capacity.

The estimate of collection analysis, manage, retrieval, and sharing of data should be aware in data storage and control standards in a different format of the activity of conceptual design about the data requirements. The conceptual of groundwater database design is important to all data requirements from users and all participants.

3.2 Improvement ideas for the next phase groundwater database

The objective of the project is important to the mission, and to implement for the next phase because a hydrogeological condition is different from each member country, and the readiness of each country is not equal. The host of the project and the team of the CCOP Technical Secretariat should support the participating of the standard hydrological data and database metadata or groundwater data structure which input to the platform.

In some cases, the issues and the groundwater database improvement should be draft the workshop in some areas being corporations for groundwater monitoring and groundwater management. The project should be set the main objective of the standard formats for collecting data from each country. It can be shared the maintain of data quality and updated the database of the basic geo-information infrastructure in Asia. There is the improvement of CCOP member countries in the groundwater database project both DB1 groups and DB2 groups, share the groundwater data, and go to implement the groundwater database development.

Developing a database among members is important to consider and to understand the purpose who will use this groundwater database for any benefit from the groundwater database and have a plan to implement in any information pattern. They need to design a database structure that will be useful to meet the purpose of data exchange, and convenient for the data recorder to be able to search the data for further analysis as well. There is a plan to implement data in any format. Besides, it must be emphasized on the availability of member states that are ready to implement or performance in the database, and storage technology or a storage structure due to there are different concepts of the groundwater database management in many countries. However, all member states have to benefit from the creation of the groundwater database with confidence in the information exchange. This will benefit every country in knowing the changing of the environment that represents the quantity and quality of groundwater and other related information.

4. Conclusions

The groundwater database management can be classified by each function of the Bureaus of DGR that depend on the characteristic feature data. Our organization maintains records on the various data which goes to a unique groundwater database system. It can handle, integration of the related data collection with any details of the analysis and interpretation of suitable groundwater resources. The importance of groundwater database system brings to the advantage of good groundwater management for sustainable groundwater management. Furthermore, DGR concentrates on the conceptual of groundwater database design and plan to optimize database system implement.

References

CCOP-GSJ Groundwater Project Report GW-9, 2019, Report of the CCOP-GSJ-DGR Groundwater Project Phase III Meeing: Technial Report of the CCOP-GSJ Groundwater Project Phase III.

Bhojaraju, G. and Koganurmath, M. M., 2003, Database Management: Concepts and Design, publication at www.researchdate.net/publication.

Groundwater monitoring system in Mekong River Delta and improvement ideas for the Phase III groundwater database of Vietnam

Hoang Van Hoan and Tong Ngoc Thanh

National Center for Water Resources Planning and Investigation, Vietnam
e-mail: hoanghoandctv@gmail.com

Abstract

The groundwater data compiled under CCOP-GSJ Groundwater Project of Vietnam has already been uploaded in the GSi system in Phase III Groundwater Database including: Red River Delta, and some provinces in the center part like Thanh Hoa, Ha Tinh, Quang Nam, Quang Ngai. The main issues and improvement ideas for the Phase III Groundwater Database as following: CCOP country's groundwater database in GSi system (DB1 & DB2) continue sharing monitoring data from other areas, groundwater database and groundwater issues as well as groundwater database management and development. In the CCOP-GSJ Groundwater Project Phase IV, Vietnam continues upload data base and monitoring data in Mekong River Delta and sharing the groundwater database management of Vietnam for the question "How to manage groundwater resources database, to use, to share etc. for sustainable development."

Keywords: groundwater, monitoring, Vietnam

1. Introduction

Monitoring, forecasting and warning of water resources in order to promptly detect the quantity and quality of water sources to manage and protect water resources. Recognizing the importance of water resources monitoring, supervision, and forecasting. Vietnamese government is constantly trying to improve the effectiveness of monitoring. Monitoring, forecasting and warning of water resources in general and the Mekong River Delta in particular, which are heavily affected by climate change, sea level rise, and mining activities. Human use cascade.

2. Current status and issues for the Phase III Groundwater Database

2.1. Situation of management, operation and development of monitoring network

Activities of monitoring, warning and forecasting water resources have been implemented for nearly 40 years (from 1980 to present). Water monitoring network includes surface water monitoring network and groundwater monitoring network. In the Mekong River Delta region, the network of water resources monitoring has been built and operated quite methodically, especially with the surface water monitoring network, it is currently building transboundary stations adjacent to Cambodia but has not yet been synchronized operation.

Up to now, there are 12 groundwater monitoring stations in the Mekong River Delta region with 37 points including 124 works, distributed in 12 provinces and cities including Long An, Dong Thap, Ben Tre, Vinh Long, Tra Vinh and An. Giang, Can Tho, Hau Giang, Soc Trang, Kien Giang, Bac Lieu and Ca Mau. Particularly Tien Giang province has no monitoring works put into operation.

The goal of building a national system of natural resources and environment monitoring in general and the water resources monitoring network in particular, unified, synchronous and modern, reaching the region's leading level; meeting the needs of basic survey information in service of state management; in service of forecasting, warning, preventing, mitigating damage caused by natural disasters and environmental pollution, responding to climate change.

Implementing the planning and monitoring work in the Mekong River Delta region has been gradually improved in the direction of modernization. Up to now, the semi-automatic recording monitoring equipment has been installed in 88/124 works and there will be 123 works with fully automatic monitoring installed, real-time data directly transmitted to the Center.

2.2. Monitoring, editing and editing documents

Monitoring is carried out as follows: Automatic monitoring: Data collected from monitoring works will be transmitted directly to the collection system at the Center; with semi-automatic monitoring: data collection mode at the recording device is set 12 times per day, particularly in the affected area 24 times per day. Every month, observers come to take the monitoring data from the machine to the computer twice in the middle of the month and at the end of the holy month, and there are 2 checks between the two times to get data to ensure the data collection process. smoothly, uninterrupted. For Manual Monitoring: carried out by portable power cord and slow thermometer.

Sampling and analyzing of water samples: samples are taken periodically in 2 seasons, the dry season is conducted in March and April, the rainy season in September and October. Types of analysis include iron samples, contaminated samples and trace samples.

Every month, the units collect and update monitoring data to be performed monthly at the federations for each monitoring area assigned to operate and manage. This database has been upgraded and developed into an organic system. General water database for the whole country as well as Mekong River Delta in particular. With this system of water resources database, data of monitoring and supervision of water resources in the whole country as well as those of the Mekong river delta are stored and managed in a synchronous manner at the Quick Service Center. promptly and promptly for the state management of water resources.

This monitoring database software supports tools to help professional staff manage groundwater monitoring data such as water level, temperature, quality in a synchronized and uniform manner. Based on managed monitoring data, operational system software supports data mining tools such as extracting water table data, charts based on monitoring indicators and other information as a report. The monitoring data has been promptly adjusted to better serve the management of water resources and social requirements

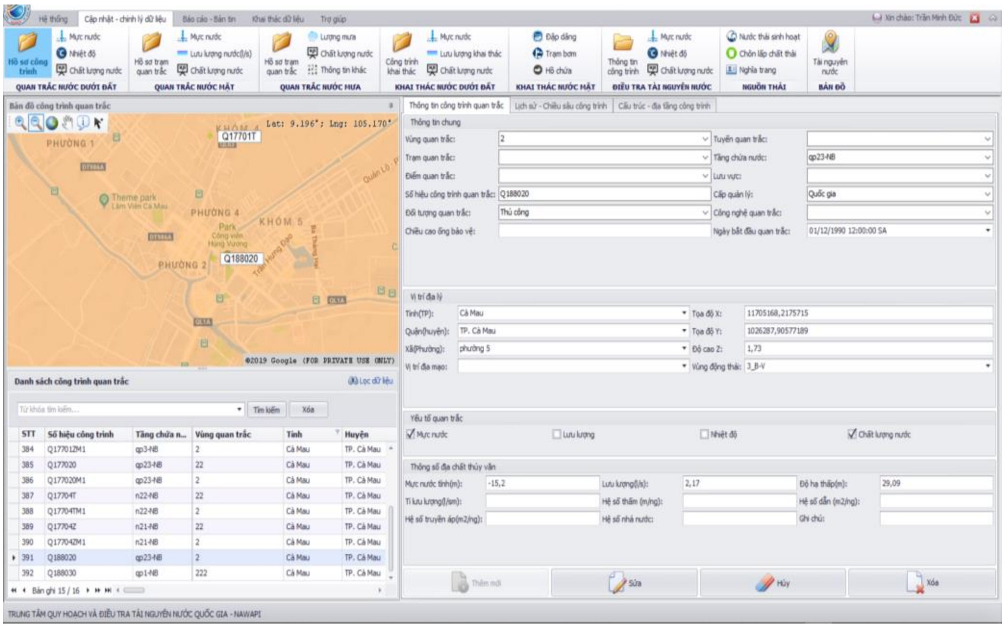


Fig. 1. Interface of water resource database management software.

2.3. Warning work forecasts of water resources in the Mekong River Delta

The work of forecasting and warning water resources is carried out synchronously with the work of foreign affairs and continuously improving to improve the quality and increasingly meet the data requirements for state management of water resources. raw water. Hardware and software systems for operational management, forecast and warning of water resources have been invested by the state, and the server system ensures the collection of online data, online updates. from three federations, forecasting water resources warnings using specialized and advanced software. The surface water forecast models are used as MIKE, HYPE, SWAT sets of groundwater forecast models such as MODFLOW, GMS, FEFLOW. Currently, the integrated system Mike Operation software and decision support is being built and expected to be completed in the fourth quarter of 2019 to serve the task of forecasting and warning water resources.

Groundwater resources in river basins in Vietnam has been implemented step by step, warning notices and forecasts are conducted for 5 regions in the North, North Central Coast, South Central Coast, Central Highlands and Southern region. In the monthly notices, forecasts and warnings of groundwater resources: to assess the trend of monthly, quarterly water level changes for main aquifers, to assess monthly water change This is compared to the previous month, compared to the same period last year, compared to the same period last year and compared to the same period with 10 years ago. Forecast of daily average water level for monitoring works in the next two months. In the quarterly newsletter, there are 2 parts, Part 1 gives a general assessment of changes in water levels and water quality for the main aquifers of the current quarter compared to the previous quarter.

Especially, with the current urgent situation of the Mekong River Delta region, every year, a special newsletter forecasting the risk of water level reduction and salinity intrusion in groundwater has been implemented, contributing to the work. water resource management as well as socio-economic development. In the bulletin, there are two parts: Part 1 evaluates the current situation of water level decline for 5 years, 10 years and 10 years compared to the current year and predicts the rate of water level decline for the next 5 years for 5 years. main aquifer. Which divides the regions with different lowering rates, the area of distribution of geographical names. Part 2 describes the current situation of light saline distribution and predicts the risk of saline intrusion for the next 5 years. In which identifying areas at risk of saline intrusion, places of distribution.

2.4. Solutions and orientations for development of water resources monitoring and supervision

Regarding the management and operation of the monitoring network, to continue upgrading and completely covering the network of monitoring points, especially for a number of high mountain areas, border areas, islands and a number of provinces and cities which have no monitoring works yet. such as Phu Quoc island, Tien Giang province. By 2025, the total number of water resources monitoring and supervision works will be increased to 84 points with 340 works. The manual monitoring works are gradually replaced with semi-automatic and automatic ones, with the goal of achieving synchronous and automation throughout the monitoring network by 2030.

In terms of forecasting of water resources, we have achieved advanced science and technology level, capable of forecasting water resources, serving allocation of water resources, economical exploitation and use, effective, rational and sustainable water resources, socio-economic development.

Development will focus on thematic forecasts, especially in areas at risk of degradation, depletion of water sources, forecasting risks of water pollution such as saline intrusion, increasing levels of toxic substances in groundwater, assessing the impact of natural disasters on groundwater resources such as climate change and sea level rise, ground subsidence caused by lowering water levels.

3. Issues and improvement ideas for the Phase III Groundwater Database

The function of management of groundwater resources in Vietnam currently includes the ministries: Natural Resources and Environment, Agriculture and Rural Development, and Construction. Groundwater resources management overview in Vietnam as following:

3.1. Legal documents for water resources:

+ Law on water resources;

+ National strategy on water resources;

+ Decree stipulating the licensing of exploration, exploitation and use of water resources;

+ Decree on sanctioning of administrative violations in the field of water resources;

+ Decree regulating the management and use of data and information on natural resources and the environment;

+ Regulations on groundwater drilling;

+ Regulations on the protection of groundwater resources;

+ Provisions on investigation and assessment of groundwater resources;

+ Regulations on the treatment and filling of unused wells;

+ The Circular prescribes economic-technical norms in surveys and surveys.

3.2. Management and law enforcement situation

The management of groundwater is implemented in all provinces with the following contents:

- Dissemination of law dissemination;

- Investigating and making statistics on exploitation status; investigating and assessing water sources;

- Licensing groundwater exploration and exploitation;

- Licensing water drilling practice;

- Making planning for exploitation, use, protection and zoning of exploitation restriction;

- Establish monitoring network;

- Handling and filling damaged or unused wells.

3.3. Main problems and challenges

- The investigation and evaluation of groundwater resources have not been closely linked with the socio-economic development planning, and have not yet met the requirements of the planning for exploitation of water resources;

- In groundwater search and assessment, the factors between surface water and groundwater and environmental factors have not been studied comprehensively; mainly studying pale aquifers, not interested in studying saline aquifers. Therefore, there is a lack of data to assess water resources when using the model method;

- There still exist many issues of hydrogeology, which have not been clarified, including the hydrogeological structure and sources of forming groundwater reserves;

- The groundwater monitoring network is still sparse, broken, moving a lot. Therefore, the monitoring of changes in quantity and quality of groundwater, forecasting depletion, saline intrusion and environmental change is very limited;

- So far, there is almost no reliable data on the figures of dynamic and static reserves of aquifers;

- Lack of many standards, procedures and technical regulations for groundwater investigation and assessment;

- Lack of documents on water resources and current situation of water exploitation is a major difficulty in the management of groundwater resources.

3.4. Some key solutions

- Continuing propaganda to raise community awareness in exploiting, using and protecting groundwater resources;

- Strengthening law enforcement (strengthening the management apparatus, implementing the legal system);

- Strengthening capacity to investigate, research, and assess water resources;

- Deploying and upgrading the groundwater monitoring and supervision system;

- To step by step make plans for groundwater protection and exploitation, first of all in delta areas, areas with great potential of groundwater sources and highly concentrated exploitation.

4. Conclusions

Vietnamese government is improving groundwater monitoring system in Mekong River Delta in particular and all over country in general. The main contents of forecasting and warning include: forecasting the total volume of water and assessing the capacity of the water supply to meet water exploitation and use demands; determining the threshold of water exploitation and use; forecast of water quality; improve the forecasting of water resources; diversify forecasting products; modernize and automate the entire collection, inspection, revision, and adjustment of the water resources data; forecast of groundwater level in hot spot areas and water level decrease (center of funnel) even in places where monitoring data is not available. Regarding to groundwater database in GSi system, Vietnam continues upload database, monitoring data as well as other activities.