Ground Water Contamination in Cambodia

Country paper prepared by
Pan Peng MSc, Ngo Pin MSc

Introduction

Cambodia borders on Thailand in the northwest and the west, Lao PRD in the northeast, Vietnam in the southeast and the east and the Gulf of Thailand in the southwest. Its total area is 181,035 km^2 with a population of about 11,437,000, according to the 1998 census. Agricultural land accounts for about 20% of the total area. Approximately 67% of the total land area remains forested. About 2 million hectares are used for rice cultivation. Cambodia is an agricultural country. Approximately 84% of the total population lives in rural areas of which 80% are farmers.

The country has abundant water resources and possesses a huge potential for the development of multipurpose water resources projects, covering irrigation, water supply, hydropower production, navigation, and tourism. The exploitation of these water resources however requires an improved institutional capacity as well as adequate financial support. About 82% of the total cultivated area in Cambodia is rainfed. Deforestation, erosion and sedimentation in the Tonle Sap Lake, in the rivers and in other lakes are at the origin of changes in the hydrological regime that cause floods, droughts, the shifting of the stream courses of rivers and changes in rain patterns.

In Cambodia large quantities of water are contained in the Mekong and other rivers and streams, in lakes and in groundwater resources. The latter are estimated at close to 17.6 billion m^3. The exploitation of these resources is very limited at present and large financial allocations are needed in order to properly develop the national water infrastructure in line with the national policies.

Surface Water

The Mekong River originates in the Tay Tang Mountains in Tibet, it has a length of 4800 km and a catchment area of 795,000 km^2. The Mekong River passes through China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam before entering the South China Sea.

At its confluence with the Tonle Sap River near Phnom Penh, the Mekong River receives a considerable discharge from the Tonle Sap Lake during the dry season (November to March.). Here, the river is divided into four branches: the upstream and downstream Mekong River branches, the Tonle Sap River and the Bassac River.

The Mekong River flows through Cambodia, over a distance of about 480 km. Its total drainage covers about 86% of the land area of the country and brings annual floodwaters of about 475,000 million m^3. These floodwaters enter partially into the Great Lake and inundate both sides of the Mekong and Bassac Rivers. This plays an important role in the maintenance of soil fertility. The Mekong River has a suspended silt load of between 300 to 600 g m^3, resulting in the sedimentation of several mm of silt per year.

The Mekong water is rich in lime and potash; its neutrality (pH 6.3-7.4) helps in reducing to some extent the acidity of the Cambodian soils. The mean annual discharge entering Cambodia exceeds 300 billion m^3 and it is estimated that with the contribution of downstream tributaries, some 500 billion m^3 are discharged into the sea annually. At Kratie Province, the peak discharge occurs during the August/October monsoon when it may reach 70,000 $m^3 s^{-1}$.

A particular aspect of the Mekong system in Cambodia is Tonle Sap Lake. The lake functions as a natural flood stabilizer in which some 20% of whole Mekong River floods are regulated by reverse flows into the lake mainly between June and September. The remaining 80% floods the lowlands of the country as well as the delta in Viet Nam.

During the monsoon flood season the overflow from the Mekong is diverted, expanding the size of Tonle Sap Lake area many times, flooding and fertilizing the surrounding rice plains and providing abundant supplies of fish. By September/October, the volume of water in Tonle Sap Lake may increase to 72 billion m^3 and the lake area may expand to 16,000 km^2.

The flow of Mekong River is closely linked to the rainfall pattern. Large areas of Cambodia around the Tonle Sap, Tonle Bassac and Mekong Rivers are flooded during the rainy season. Pollution generated along the rivers may be transported during the rainy season to the Tonle Sap Lake. The rich natural resources of the Mekong River and its tributaries contribute not only to Cambodia, but also to the neighboring riparian countries, playing an important role in socio-economic development.

Groundwater

Groundwater is used in Cambodia for both community and town water supply and for irrigation. To date, there has been no comprehensive investigation of the national groundwater resources. However, there have been two studies, both under the auspices of the US Geological Survey. The first (Cushman, 1958) was a reconnaissance of the lowland area to determine the availability of groundwater for dry season irrigation. The second was a general description of groundwater availability based on test drilling data and well records obtained in the course of a USAID rural development program between 1960 and 1963. The program drilled 1100 wells, of which some 800 were productive. Depths ranged from 2m to 209 m, with an average of 23 m. Information is also available from well drilling programs undertaken since the 1980s by NGOs and international organizations, particularly by OXFAM and UNICEF who have drilled more than 5000 wells throughout the country. These wells were generally to depths of 20 m to 50 m. The most recent information on these wells however, mainly relates to their location and characteristics.

The Mekong lowlands consist broadly of alluvial material overlying shale, slate and sandstone bedrock. The low hills and plateau areas are mostly underlain by igneous rocks and limestone. The depth of alluvium is 70 m or more. The alluvium consists of sandy silt in the upper part and of clayey silt in the lower. There are occasional sand beds of up 1 m thickness. Two types of alluvium are recognized, an older one and a younger one. The younger alluvium is situated under the Mekong and Tonle Sap Lake flood plain. Except for the occasional thin sandy beds and lenses, the alluvium has a low hydraulic conductivity and the yield is very low, typically 0.2 $l s^{-1}$. Yields from the sandy layer are higher, typically of the order of 1 $l s^{-1}$. For those UNICEF wells for which records are available, many have a yield of more than 3 $l s^{-1}$, while less than 3% are reported as having yields in excess of 10 $m^3 hr^{-1}$ (2.7 $l s^{-1}$).

In January 1996, the Government of Japan signed an agreement to fund a project for the supply of clean water to the Phnom Penh municipality and rural areas by using groundwater. About 30% of this groundwater was to be obtained around Phnom Penh. No artesian aquifers were found, the area being underlain at depths ranging from 18 m to 80 m by hard crystalline rock. The best well yielded 3.3 $l\ s^{-1}$, and the average of seven production wells was 1.33 $l\ s^{-1}$.

Ground water levels

In Cambodia the productivity of aquifers in the eastern part of the country is high, whereas the aquifer productivity in the western part is low. Groundwater levels of existing wells have been surveyed since February 1997. These monthly base measurements continued until November 1997. Twenty-six wells were selected for monthly monitoring. Most of these are dug wells or combined wells. The results of these groundwater level measurements show values of 1.7 to 2.25 meters for dug wells and 4.75 to 5.5 meters for drilled wells. The lowest groundwater levels were observed in January to July 1997 while maximum levels occurred between October-November 1997. The groundwater levels along the Mekong and Bassac River show a steep rise from June-July, 1997. It is presumed that those groundwater levels are influenced by the water level changes of the rivers.

Groundwater Contamination

Groundwater in Cambodia is generally good quality, but high iron contents and increasing salinity levels have been noted in Svay Rieng and Prey Veng Provinces. Also, water sampling in four provinces in northwestern and southern Cambodia indicate high levels of iron, TDS and fluoride in groundwater. Many shallow wells are contaminated by fecal coliforms. All water samples in Battambang failed to meet WHO water quality guidelines. Contamination of water resources has led to frequent outbreaks of cholera.

Groundwater samples for chemical analysis were collected from 54 existing wells and 24 newly drilled wells (test wells) in May-June 1997. The following are some of the results within different provinces:

- In Svay Rieng Province the trace element chemistry, is dominated by Na, HCO_3 and Cl.
- In Phnom Penh $NaHCO_3$ is dominant along with Ca and Mg.
- In Prey Veng, Na, Ca and Mg dominate along with HCO_3 and Cl.
- In Kompong Speu, most samples contain Ca and HCO_3.

When the results are compared with the guideline values for drinking water issued by the WHO, many of wells have higher values than the WHO standards.

Geology and the occurrence of groundwater

On the basis of landforms, geology and occurrence of groundwater, Cambodia can be divided into three main regions namely, the Mekong Lowlands, the Southwestern Highlands and the Coastal Plain of Southwestern Cambodia.

The bedrock underlying the Mekong Lowlands consists predominately of a series of consolidated sediments of shale, slate, sandstone and limestone of Triassic and older age. The Southwestern Highlands consist of several massive mountain ranges. These ranges commonly have relatively steep sides and flat tops. The main mass of the Highlands is formed by the Cardamoms and Elephant mountains. The Highlands are made up of a series of metamorphosed sandstone, slate, schist and quartzite units. In the vicinity of the city of Pailin these are associated with a large mass of gabbro and rhyolite.

Alluvium

In Cambodia, the alluvial units constitute some of the most important sources of groundwater. The alluvium, whether it is older alluvium or young alluvium, may be composed of sand, silt and clay and mixtures of these constituents. The clay portions have a low permeability and may yield water at very slow rates. The sandy beds and lenses of the alluvium are some of the best water-producing horizons. Their average yield is about 16 m^3 h^{-1} in drilled wells. Groundwater from alluvium is generally believed to be of good chemical quality and suitable for most purposes in Cambodia. In many areas, dug wells are important as sources of domestic water supply.

Basalt and other igneous rocks

Data available on the water-yielding capacity of basalt quote yields of 30-50 m^3 h^{-1}. A large area of the country in Kompong Charm Province in the northeast is underlain by basalt. The quality of water from basalt is good and suitable for most purposes. Other igneous rocks occurring in the country are gabbro, rhyolite, diorite, and granite. The water-yielding capacity of these rocks, either fresh or weathered, is believed to be similar to basalt.

Post-Triassic Sandstone and Conglomerate

A large part of the highland area and a large area between Kompong Cham and Pursat Province are underlain by these rock types. The original porosity and openings along joints and bedding planes make these rocks somewhat permeable. No deep wells are known to penetrate the sandstone and conglomerate beds. The groundwater from sandstone and conglomerate should contain little mineral matter as the rock consists mostly of silica.

Limestone

Limestone has limited distribution in surface exposures. Almost no data are available on the water-bearing capacity of limestone, but it is believed that limestone could yield substantial water.

Triassic Metamorphic rocks

Triassic rock units consisting of sandstone, shale, slate, quartzite, and schist appear to underlie a large portion of the Mekong Lowlands. The yields are considered to be low.

Conclusions and Recommendations

- In conclusion, surface water will probably always be the predominant source of water supply for all purposes, particularly for irrigated agriculture. Groundwater could provide an important source of supplemental water during the dry season. It could also be a principal source of water for small industries, minor irrigation and domestic use.
- No hydro-chemical or hydrological evaluation has been done for many groundwater sources. At the same time, in many instances data available have not been fully utilized and interpreted. In addition, Water quality standards have not been established.
- Elevated arsenic values have been found in some areas but systematic testing has not been done. No facilities are available in the country for arsenic analysis and samples have to be sent abroad.
- A national focal point is needed for hydrogeological assessment and groundwater monitoring and evaluation.
- An (inter-ministerial) arsenic/groundwater task force is needed to bring together available groundwater management and expertise, to evaluate existing groundwater/geology data for a better understanding of the groundwater system and its main hydro geological process, to use existing/new groundwater data for evaluation of water contamination and other groundwater management issues and to coordinate the collection, storage and exchange of data among others to advise the government on laboratory facilities, quality standards and future groundwater management issues.

References

CARD: National Seminar on Food Security and Nutrition, April 1999.

JICA & MRD: The Study on Groundwater Development in Southern Cambodia, July 1999.

MOWRAM with Sir M. MacDonald and BCEOM Société Française d'Ingénierie, March 2001: National Water Sector Profile, Kingdom of Cambodia.

MOE, UNDP/ETAP, February 2000. Environment: Concepts and Issues, A Focus on Cambodia.

MRC & UNEP, Bangkok, Thailand, May 1997: Mekong River Basin Diagnostic Study Final Report.

MRC & GDIMH, Mr. Pang Peng: The Review on Groundwater Investigation Activities in Cambodia, February 1998.

Nippon Kei Co., Ltd, Hokkaido Engineering Consultants Co., Ltd, March 2001 : The Study on The Rehabilitation and Reconstruction of Agricultural Production System in Slakou River Basin, Kingdom of Cambodia.

WHO, Peter R. Feldman: Drinking Water Quality Assessment in Cambodia, January 2001.