Bangkok's deteriorating groundwater

by Chandran Nair

The depletion and contamination of Bangkok's groundwater sources has had serious environmental effects, including pollution, subsidence and flooding. The author outlines the position and proposes control measures.

GROUNDWATER RESOURCES in the Bangkok metropolitan area and the surrounding provinces are being depleted and contaminated at alarming rates. They are highly vulnerable to the excessive exploitation and quality deterioration associated with rapid industrial development and the resultant population growth. The pace of industrial decentralization into regional centres has been slow, and there has been inadequate creation of industrial zones and estates where the integration of reuse reclamation schemes into comprehensive water resources planning could be done with economic benefits.

These factors, coupled with a lack of effective controls, has led to the serious depletion of aquifers and the subsequent environmental implications. Quality deterioration has its roots both in over-abstraction and in the lack of adequate pollution abatement measures. Both depletion and quality deterioration can be linked to the failure of the major industrial water users to apply water conservation and reuse strategies.

Water levels in observation wells dropped 10 to 12m between 1985 and 1989. Although a Groundwater Act passed in 1978 restricted the digging of wells, it did not cover areas without municipal water supplies, and enforcement was difficult. In some parts of the municipal area there has been no development of surface resources and all water is still obtained only from the ground.

Groundwater in Bangkok

The Bangkok area consists of the city of Bangkok and the surrounding districts of Thon Buri, Nonthaburi and Samut Prakarn. The area is about 750 square kilometres and the population is estimated to be between seven and eight million. To serve this large population and the expanding industrial sector, water is drawn from the Chao Phraya River and, increasingly since about 1970, from groundwater reserves. There is a lack of adequate alternative surface water sources, partly because of the increased pollution of existing streams through industrial and municipal wastes, and partly because of the poor natural resources management, so that silt levels have increased and stream flows have reduced.

The groundwater underlies the area in eight distinct aquifers.

- Bangkok aquifer, the uppermost, can be tapped at 15 to 30m from the ground surface. It has high salt levels and is not much used.
- Phra Pradeng aquifer, at a depth of 60-80m, is heavily used.
- Nakhon Luang aquifer, at a depth of 100-140m, is probably the most heavily exploited for water supply in Bangkok.
- Nonthaburi aquifer is very extensive and lies at a depth of 170-200m. It has been used by large consumers since the higher aquifers became polluted.
- There are some wells about 250m deep in the Sam Khoh aquifer in the north of Nonthaburi and Pathum Thani.

UNICEF/Bernard Wolff

Rapid industrial development and high population growth around the cities results in conditions like this in Klong Toey, the largest slum in Bangkok.

Water stress in selected countries and regions

East and North Africa — Ten countries are likely to experience severe water stress by the year 2000; in several countries the only feasible way of meeting year 2000 municipal demand will be by the diversion of irrigation water.

China — Fifty cities face acute shortages; water tables beneath Beijing are dropping 1-2 metres per year; farmers in Beijing region could lose 30 to 40 per cent of their supplies to domestic and industrial uses.

India and Pakistan — Tens of thousands of villages now face shortages; many cities and most townships have water only a few hours a day.

Mexico — Groundwater pumping in parts of the valley containing Mexico City exceed recharge by 40 per cent, causing land to subside; the option to import more fresh water is extremely expensive.

Global Consultation on Safe Water and Sanitation for the 1990s — Background Paper

- Deeper aquifers have not been widely used. They are the Phya Thai aquifer (350m deep zone), the Thon Buri aquifer (450m zone) and the Pak Nam aquifer (500m zone).

The recharge of these aquifers by percolation is hindered by an impervious clay layer underlying the area. Therefore most recharge is essentially by lateral groundwater flow from the periphery of the Lower Central Plains. Local groundwater recharge has been reduced by an increase in the paved surface area, and now only amounts to about three per cent of the mean annual rainfall of 1191mm. There have been no efforts at large-scale artificial recharge of the aquifers. Abstraction has therefore quickly led to overdraft.

An inventory of the wells in each district in the metropolis and the adjoining provinces was made ten years ago. The output of most of the wells surveyed could not be assessed as the owners had kept no record of rates and quantity of pumping. The control of drilling and the monitoring of usage has not been a priority. The Groundwater Act of 1987, however, requires all well-owners to register with the Groundwater Division of the Department of Mineral Resources.

The total abstraction, including abstraction by the Metropolitan Water Works Authority (MWWA), is now estimated to be over 1.5 million cubic metres per day, although MWWA has considerably reduced its abstraction. In 1987 it drew about 200 000 cubic metres per day (seven per cent of its total needs) from 50 deep wells, and planned to stop abstraction by 1990. It also planned to extend its water supply (obtained from surface sources) to the industrial districts of Paknam and Prapradaeng, where groundwater depletion was a serious problem.

The critical areas of groundwater exploitation include the administrative districts of Bangkapi, Phra Kanong and parts of Phra Pradaeng and Samut Prakarn. These areas use about half of all the groundwater consumed. The central parts of Bangkok, with the highest population, uses only a quarter of the abstracted groundwater because, unlike the critical areas, it is fully covered by public piped water-supply.

Environmental effects

The depletion and the pollution of the groundwater have had serious environmental effects. Subsidence has occurred on a large scale, spreading from Bangkok to the new industrial zones in Samut Sakhon, Ayutthaya and Chonburi. The maximum rate of subsidence was 1.14 metres between 1940 and 1980.

Subsidence has created serious problems in the design, construction and maintenance of buildings, roads and bridges, drainage and sewerage structures, water distribution systems, canals, conduits, pipelines and dock facilities. The cost in damage to buildings, roads, and drainage systems is considerable.

The threat of flooding increases every year as large sections of the city sink and the existing stormwater drains are unable to function, especially when the level in the Chao Phya river is high. The ground surface elevation in the central part of Bangkok is about 1.0-1.5 metres above mean sea level (MSL) and is only 0.4-1.0 metres above MSL in the critical areas. The result was severe flooding for two months in 1980 and floods of varying intensities every year. This creates a serious health threat as the drains overflow into low lying areas.

Subsidence has also caused damage to the well casings and water transmission pipes that are connected to the pumping wells. Consequently, pollution has infiltrated the lower aquifers, adding to the problems of controlling water-quality deterioration.

Groundwater pollution

Groundwater pollution has four main origins: industrial, domestic, agricultural, and seawater intrusion.

Seawater intrusion is the most serious threat to groundwater resources. Since the late 1960s many wells have been abandoned by the MWWA and private well-users because of their increased salinity. In fifteen years the chlorine content of water from MWWA wells has increased fivefold, with water from some wells now having a chloride concentration of several thousand mg/litre. Intrusion has been at a rate of 500m per year in areas of heavy abstraction. Many industries have been forced to dig deep wells to tap lower aquifers, replacing the wells whose water has shown an increase of chlorides and other salts. There are also numerous cases of vertical leakages of salt water from upper to lower aquifers because of the poor quality and poor maintenance of well casings.

Industries are reluctant to switch to the MWWA supply where it has become available because of the cost difference. The cost of water from the MWWA was reported to be eight times as much per cubic metre as groundwater.

The corrosion of well casings and imperfectly sealed wells has also caused considerable pollution of groundwater from industrial and domestic wastewater. This risk is especially high during periods of flooding.

Proposed control measures

Inadequate legislation and tariffs have certainly been stumbling blocks in efforts to curb over-abstraction. Although laws prevent the drilling of wells in certain areas when old wells are abandoned, enforcing this has been difficult. A


UNICEF/Bernard Wolff

As sections of the city subside, the threat of flooding increases — and canals like this will swamp these houses.

campaign is needed to make the general public and the industrial management aware of the water demand legislation. This should ideally go hand in hand with an integral set of laws, incentives, fiscal and other penalties (or tax reliefs), and standards.

A tariff system for the consumption of water, charged according to the amount of water withdrawn, the purpose for which it is used, and the degree of contamination it causes, should be considered. If a progressive pricing system is introduced, one that is socially and politically acceptable, it can be enforced among the water consuming industries. It can then become a major instrument of water conservation, reuse, and treatment.

The impact of the social, economic and environmental aspects of water resource misuse must be weighed. Overall institutional arrangements should serve to permit the implementation of economically efficient water quality management in the metropolitan area. Changes called for include public education and a pricing policy which seeks to change people's consumption habits.

Industrial users

The lack of water reuse and conservation strategies in the industrial sector is a serious factor. Industrial wastewater reuse and water conservation should be used as tools for pollution control and abatement. This type of conservation means that there will be less wastewater to be treated and a reduction in overall consumption, a dual strategy of water conservation and water resource recovery.

Many of the industrial users of groundwater have very poor housekeeping practices because of the traditional belief that the water is free. Very often the first line of defence against waste, the metering of all water use, is not used. In view of the current and prospective environmental standards, each industrial plant should ask itself which is the best way to comply with regulatory demands. In considering the alternatives, there are really only two: no discharge, or discharge complying with the current and future requirements of the regulatory agency. Where conditions dictate treatment for discharges, the resulting effluent might be suitable for reuse within an industrial plant, for example as cooling water.

Rational water management in the metropolis needs a co-operative, multidisciplinary effort. Engineers, hydrologists, agronomists, ecologists, economists and sociologists have to act in conjunction with civil servants and corporate executives and politicians. Their objective must be to increase efficiency by reuse, recycling and conservation.

Chandran Nair is a consultant at Siamtec Int Ltd, 87 Nai Lert Building, Sukhumrit Road, Soi 5, Prakanong, Bangkok 10110, Thailand.