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Water Supply for Tehran
Dr M Borghei

Tehran, the capital city of Iran is facing problems to supply potable water and suitable sanitation for its increasing population. Due to immigration from villages and other cities to the greater Tehran area, nobody knows exactly how many people live there but estimates range from 6 to 9 million. Taking the more reliable statistics released by the government in 1982, Tehran's population has expanded to 7 million which shows a 40 percent rise in less than five years. This unexpected growth has created headaches for TRWB- Tehran Regional Water Board- The body responsible for water supply and sewerage. In summer 1983 many areas within the city experienced water cuts and it will be no surprise to see water rationing coming into force during the peak demand periods of the present and future years, unless some action is taken today. Under a scheme, called the "Lar project", TRWB will be able to meet part of the crisis in a few years time, however in the mean time as well as several years to come, the shortages are inevitable and thus a reasonable solution must be found for this complex situation. The present research study has been taken up to assist TRWB in utilizing the scarce water resources in the area to the best advantage. Having drawn water as much as possible from the nearby rivers, extra water must be found from underground. Surface waters within the city area could contribute to this balance, although they only exist in part of the year and in the form of flood waters. There has been signs of increasing pollution in underground supplies recently, and thus plans to increase the utilization of this important source for treated water supplies has been slowed down. Further more the quantity of water which could be available from underground and from rivers is under question. To meet the increasing demand for treated water supplies for domestic use, industrial consumption and agricultural purposes, an overall program which should include utilization of resources and re-allocation of fresh waters for uses other than domestic must be pushed forward.

Tehran's Water Resources

Like most cities in Iran, Tehran was entirely

dependent upon groundwater until 1933 that water was brought into the city from river Karaj some 40 km. to the west of the city. Now Karaj source, through Karaj dam, is a major supplier for TRWB. The dam's reservoir provides some 210 mcm. (million cubic meters) of live storage and regulates the river flow which at the dam site amounts to 465 mcm. per annum. The operation of this reservoir has been based on 184 mcm./a for Tehran area and 160 mcm./a for irrigation of south Tehran plain. However in recent years up to 280 mcm. per annum has been taken up by TRWB in the expense of irrigation and forestry.

Latian dam on Jaje-rud river, east of Tehran provides a further 95 mcm. storage, while the average flow of the river is 310 mcm./a. At the present, over 130 mcm./a of this water is pumped to treatment works while the rest is passed downstream for industrial raw water and for irrigation. This reservoir too was designed to supply only 80 mcm./a for treatment works, but is currently over drawn by more than 50 percent.

Lar dam, constructed on river Lar, 50 km. north west of Tehran, was designed to storage 860 mcm., which is about twice the average annual flow of the river. It was expected that the reservoir would provide over one year's storage capacity, in 1976, when TRWB had estimated Tehran's water demand at 500-600 mcm./a. Unfortunately this reservoir which was planned to come into operation in 1983, has been the centre of much controversy as it is loosing water through a ground leakage and is unable to hold any appreciable amount of water. Tracer studies has detected the leak and work is going on to repair the reservoir, although it is not hoped to be completed before mid 1985. Once brought into operation, Lar dam, will provide a further 180 mcm/a for TRWB.

Groundwater has been used in Tehran from the beginning and abstraction has been on the increase ever since, particularly since the development of the modern drilled pumped well. But TRWB developed its first groundwater source in 1963. They now operate several groups of wells situated in the south of the city, abstracting about 50 mcm./a, which is chlorinated and distributed directly.

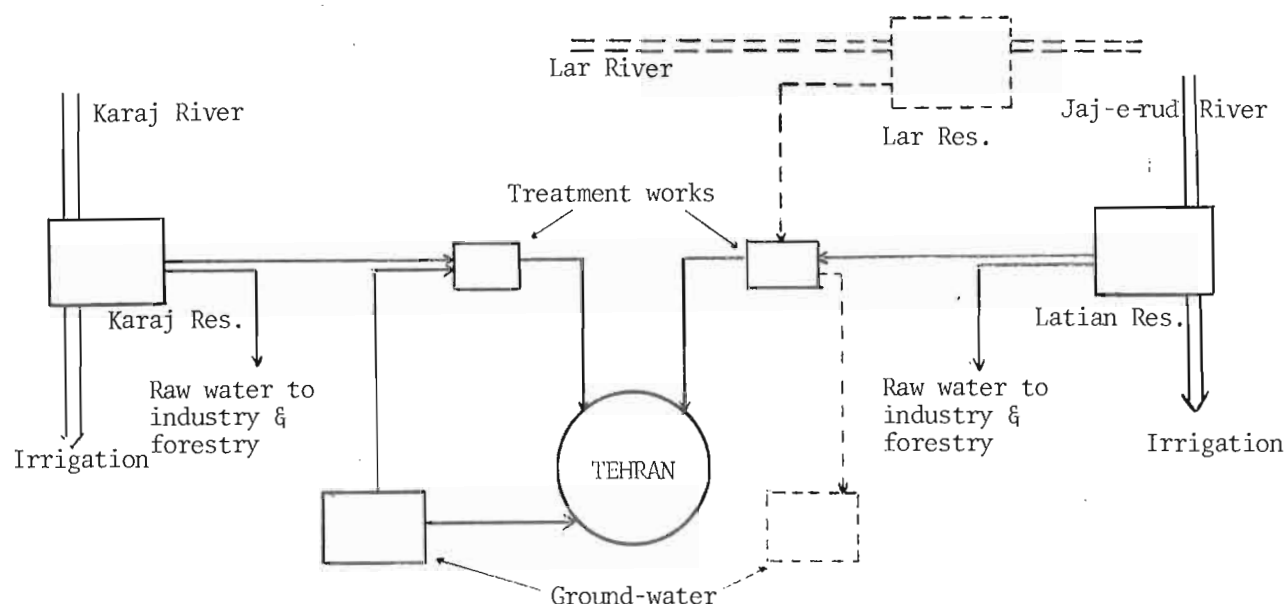


Figure 1: Layout of Tehran's water resources.

Figure 1 shows the bulk water supply system for Tehran. It must be added that many industries within or around the city area are using groundwaters independently and this source (through boreholes or qanats) is also used to irrigate well over 50'000 hectares of agricultural land.

Demand Projection

Table 1, shows an overall picture of TRWB's activities in the past 20 years. The supply of treated water and the number of connections has been increasing to meet the demand. As this trend shows, industry has been forced to look for other resources, rather than depending on TRWB's supplies. It is estimated

that only less than 2 percent of total water used by the local industry is provided by TRWB. The amount of groundwater developed show a decrease in the second half of 1970's and an increase in recent years, due to the necessities. It must be mentioned that abstraction of groundwater has been carried out by private sector (industry, farms, private dwellings) of which an exact account is not known. The demand for treated water is not shown in this profile, but it is understood

that the TRWB has great difficulties in supplying more treated water to meet the demand. Looking at the number of connections and taking an average of 8 persons per connection shows that nearly 5 million people are using the privilege of tapped, treated water and yet it leaves more than 2 million without.

Table 1, TRWB's treated water and consumption profile.

| Year | TRWB treated water supply | | Raw water (TRWB) | | Connections |
|------|---------------------------|-------------|------------------|----------|-------------|
| | Rivers | Groundwater | Industry | Forestry | |
| 1963 | 49.3 | 3.04 | 0.36 | -- | 172000 |
| 1967 | 106.2 | 6.51 | 0.72 | 5.62 | 384500 |
| 1971 | 214.3 | 55.6 | 1.52 | 15.7 | 429300 |
| 1975 | 317.4 | 34.6 | 3.90 | 13.3 | 500312 |
| 1977 | 327.9 | 31.2 | 4.20 | 11.1 | 527023 |
| 1978 | 360.3 | 22.7 | 4.45 | 12.7 | 532041 |
| 1979 | 393.2 | 32.3 | 4.20 | 10.2 | 549161 |
| 1980 | 397.1 | 37.0 | 4.30 | 9.1 | 565614 |
| 1981 | 401.5 | 41.8 | 3.95 | 15.9 | 579717 |
| 1982 | 417.2 | 53.0 | 2.40 | 17.0 | 596656 |

All figures except the number of connections are in million cubic meters per annum.

The rate of increase of treated water has slowed down during the past five years, due to diminishing of new resources. Rivers have surpassed their capacity and it is impossible to transfer more water from them under the present situation without seriously damaging the cultivation of farm lands.

FUTURE DEVELOPMENT

To meet the growing demand, new resources must be looked upon. Although once brought into operation, Lar dam will contribute fairly to the present supplies, diversion of more water from reservoirs is not possible unless water is made available for irrigation from other sources. In the longer term water will have to be transferred from some 150 km north from Alborz mountains, with great expense. In the medium terms, other supplies notably surface waters and groundwater within the greater Tehran area must be fully utilized.

Surface Waters

Notable surface waters within Tehran area are divided into three different categories which are listed below:

- 1 -Inflow from Alborz mountains
- 2 -Flow within the city area
- 3 -Outflow towards the south

Inflow is in the form of small rivers primarily as a result of floods and snow melt during the spring months. Total annual inflow has been varied between 200-280 mcm/a, depending on the precipitation.

Flow within the city area occur as a direct result of precipitation, and flows through open canals. As the average rainfall within Tehran area is about 225 millimeter per year this flow is not appreciable.

Outflow from this area are the canals which divert the floods and surface runoffs, including some industrial effluents. Due to the addition of untreated or primarily treated only, domestic and industrial effluents to the open canals, flow within or outgoing the city is heavily polluted and not suitable

for treatment and distribution into the network. So far it is used for irrigation only. The inflow into the city from the mountains happens during the winter and early spring months and is not significant in other seasons of the year. In the present time this water is only helping to recharge the aquifer otherwise it is almost wasted. It is notable that the flow exists in the time of year when it is least required for irrigation.

The pollution of the inflow at the upstream is mostly physical pollution, i.e. turbidity and suspended solids, therefore it can be treated in conventional treatment works which already exists. But once this water is in the city area it becomes heavily polluted and is not safe anymore.

On the whole it seems to be feasible to construct reservoirs at the upper end of inflow streams to control and collect the floods. It is estimated that in this way some 80-100 mcm/a of fresh water could be added to existing supplies.

Groundwater Supplies

Groundwater was first looked upon as an aid to reservoirs during the dry seasons. But as the demand exceeded forecasts, this source became an important part of the supplies for Tehran's suburb's and the local industry. It has been estimated that 500 mcm/a is currently abstracted through boreholes, but TRWB's share has not exceeded 53 mcm/a so far. To rely further on this source a very clear picture of the quantity and quality of this water must be available. To estimate the quantity, modelling techniques which would take into account all the components of water balance, could give valuable information on aquifer characteristics, such as storage capacity and abstraction limits under varying hydrological conditions.

Water Balance of the aquifer includes such terms as recharge due to precipitation and surface waters, recharge through sewage wells

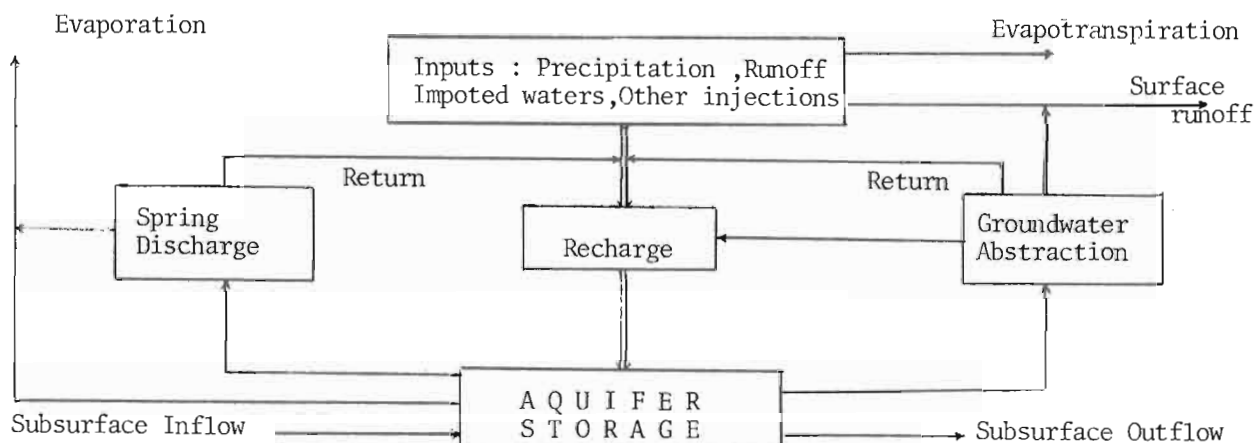


Figure 2 : Water balance of the aquifer

Table 2 : The quality of ground water (new TRWB wells)

| Sample | EC 10 ⁶ | Na ⁺ | Cl ⁻ | NH ₃ | Detergent (ABS) | Oil & Grease |
|--------|--------------------|-----------------|-----------------|-----------------|-----------------|--------------|
| 1 | 693 | 60 | 40 | 0.36 | 0.21 | 80.0 |
| 2 | 927 | 44 | 71 | 3.6 | 0.43 | 110.0 |
| 3 | 600 | 90 | 72 | 0.15 | 0.70 | 45.0 |
| 4 | 912 | 81 | 165 | 0.12 | 0.00 | 20.0 |
| 5 | 1020 | 108 | 184 | 0.26 | 0.37 | 45.0 |
| 6 | 510 | 20 | 78 | 0.14 | 0.18 | 40.0 |
| 7 | 500 | 19 | 75 | 0.16 | 0.08 | 20.0 |
| 8 | 330 | 18 | 35 | 0.08 | 0.12 | 40.0 |
| 9 | 550 | 35 | 45 | 0.28 | 0.13 | 60.0 |
| 10 | 480 | 51 | 70 | 0.11 | 0.16 | 20.0 |

All figures except electro conductivity are in mg/l. EC figures are in mohs.

under flows, qanat transfers, qanat-borehole abstractions and evaporations. It is important to note that the large and increasing quantities of surface waters imported to the area and such features as qanats, natural springs and sewage wells make this an exceptionally complex hydrological situation. A simplified diagram of the main components of the water balance and the relationship between the individual terms is given in Figure 2. It has been estimated that on average 70-80 percent of water used in Tehran is joined the aquifer through sewage wells.

The Model of an aquifer system is a representation in mathematical form of the flow through an aquifer together with the known or estimated recharges and abstractions. The parameters of the model describe the resistance of the aquifer to store water. This hydrological system is extremely complex as accurate estimates of recharge, evapotranspiration, runoffs and subsurface movements are not at hand. But, if provided with accurate hydrological records on one side and the aquifer water level fluctuations (well water level) on the other side over a period of several years, then this model will be able to forecast abstraction limits under all given conditions such as wet or dry seasons or even under drought conditions.

A mathematical model such as described above has estimated that TRWB could abstract on average, 120 mcm/a safely which could increase to 180 mcm/a on very wet years. But so far the expansion has not been possible due to pollution. The groundwater pollution is as a result of the method of sewage disposal normally practiced, that is to say by means of sewage wells (Tehran is not served by a sewage systems). Despite this long term practice the quality of groundwater has been remarkably good until recently. Table 2, shows the result of chemical analysis of ten samples of waters from new wells which were expected to be used by TRWB. These wells are over 170 m deep and are situated in the south of the city. It was plan-

ned to use this groundwater to supplement supplies in the pre Lar period. However the presence of the exotic chemicals, notably detergent, indicated that the contamination of the aquifer is taking place as a result of sewage wells. This uncertain quality, has discouraged its direct distribution into the network. On the other hand treatment costs are very high as new treatment works, being capable of treating this water, must be designed and constructed. Even so, unless the whole area is served by a sewage system, the risk of groundwater pollution will continue to grow.

CONCLUSIONS & RECOMMENDATIONS

Water is scarce in the Tehran area and can be a limiting factor in the expansion of the city. To avoid shortages in the near future the following points must be considered in planning.

- 1-Water resources development, planning, and management should be consistent with ecology health and economy. More water from the existing resources could create more arid land, or lower food production.
- 2-Reservoirs could be constructed to collect the flood waters and thus provide 80-100 mcm/a of fresh water.
- 3-Modelling the aquifer for quantity and quality would provide useful information on the extent of utilization of this resource. Groundwater of low or acceptable levels of pollution can be distributed for domestic use while more polluted waters should replace fresh river waters for irrigation. Therefore more water from the rivers will be released for use in the city.
- 4-Industrial and domestic effluents must not be discharged untreated into the sewage wells.
- 5-Conservation could represent the most economical source of new water supply. This could be pursued in a variety of ways, planning management, technology and education.
