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WATER PROBLEMS IN THE MIDDLE EAST

By COLONEL K. W. MERRYLEES, O.B.E.

Report of a lecture delivered to the Royal Central Asian Society on Wednesday, October 8, 1958, Sir Hugh Dow in the chair.

The CHAIRMAN said: This afternoon I have to introduce to you Colonel Merrylees, who is going to talk to us about Water Problems in the Middle East. Colonel Merrylees is a retired officer of the Royal Engineers; but, like many of us, he is still working and finding that one has to work a good deal harder after retirement than one had to work before. He has spent many years in India, but I understand that he is not going to talk about India in particular and instead will talk about many parts of the Middle East.

I RECENTLY opened a copy of the Journal and saw inside the cover the map covering part of the area which this Society now is interested in, and I thought I could not do better than take this area for my talk today. It is, of course, a vast area, so I shall start with Pakistan, and work as far towards the West as I can in the time. Not only is the area large, but in it are some of the biggest low-rainfall areas in the world, which consequently, are the most difficult from the point of view of water development and supply.

No country is free from water shortages, even the British Isles, but there are deserts in Iran and Saudi Arabia on which the rainfall is less than on the driest countries elsewhere. I shall not talk about storage schemes, which nearly always involve the construction of dams, as these are straightforward engineering projects, and do not have the same problems and difficulties as schemes for the development of underground sources, with which I am chiefly concerned. I believe that in every country in this area there are underground reserves of water, safe from evaporation losses, which have so far never been tapped, and it is to indicate some of these sources and the problems of their useful development that I will now start a tour from the most eastern country, Pakistan.

You will doubtless have read of the great storage schemes, in being or proposed, but the main difficulty is rather political than engineering since the boundary with India has been placed between the headworks of the main Punjab canal system, on the Sutlej and Beas rivers, and the distribution system. Unless boundaries are placed on watersheds this problem is almost certain to arise, and I shall show further examples later. Should the supply from the headworks be reduced or even cut off the only possible alternative would be further storage on the rivers wholly in Pakistan, supplemented by the extraction from subsoil water moving in old stream beds buried in the alluvium which makes up most of these plains. This considerable amount of water is lost into the sea bed eventually, as in many places throughout the world, and the only problem really is in the correct siting of wells to obtain the maximum quantities and stop part of these losses. In the hilly western part, where the rainfall is small, there is, in almost every valley, alluvial deposit in which some water flows and which could be recovered for the use of the inhabitants of the valleys and the plains below, before it is, eventually, lost in the sea.

Afghanistan has few water problems. In the north there is a fair rainfall, and the terraced strips are watered from the surface streams and from the flows in the alluvial fill in the valley bottoms. The Helmand river, which flows across the southern plain, has recently been dammed by an American Company to feed this plain, and consequently there is now no surface flow across the frontier into Iran, as there used to be, and agricultural land has become a desert, and will remain so until the subsoil flows near the old river bed are found and developed.

This brings us to the two countries with the most difficult water development problems—Iran and Saudi Arabia. Iran is, for the most part, a salt desert surrounded by mountain ranges, and, unfortunately, most of the rainfall is on the outer side of the mountains, and so only a very small part of the country benefits directly from this, though snow on the higher ranges does provide some water on the central plain. Any of this water not extracted in or near the foothills passes into the salt desert and evaporates from there. Part of this water is extracted by a system of tunnels called "Qanats," some of which are believed to have been built hundreds of years ago, and of which there are said to be some three million miles altogether in the country. These same tunnels are found in both Baluchistan and the Trucial Coast and were probably constructed in all these places by Persians. A large proportion of these qanats have already gone out of action, and the remainder are no longer economical because it is a most expensive process to clean out and repair underground tunnels in modern times. A qanat is constructed as follows: At the point where a valley emerges from the hills and becomes part of an open plain, a well, called the "mother" well, is dug until the water table is met. If this place is then judged to be satisfactory, the well is continued into the aquifer as far as possible. A second well is then dug about fifty yards downhill from the first, and a tunnel made between them. This tunnel has a gradient less than the surface slope, but enough for water from the first well to flow down it, since this tunnel is started a foot or two below the water table. This process is then repeated, the wells or shafts decreasing in depth until the tunnel emerges at the surface of the ground. Only land below this tunnel exit can be irrigated, and, because the mother well can only take a part of the subsoil flow, the whole scheme is both wasteful and expensive. Something must clearly be done to improve the recovery from the subsoil flow because the sizes of the villages and cultivated fields are limited only by the amount of water which can be made available. Some of the tunnels are of very great length, like the one at Yezd, which is said to be fifty-seven miles long, or deep like the qanat feeding the British Embassy garden in Tehran, which has a mother well four hundred feet deep, and under three feet in diameter, up and down which men go using hand and foot holes in the well wall.

The depth of water in the mother well must depend on the amount of seasonal rain- or snow-fall, though the variation is less than the surface run-off in good or bad years, but even with correct siting of the mother well, only a small percentage of the full flow can with certainty be recovered. One way of improving on this antiquated qanat system is to put in a blind dam where each valley emerges from the hills. Since this type of dam is supported on both faces by the valley fill, it can be a thin waterproof wall of interlocking concrete piles, and the impounded water taken off through a sluice in the top of the dam into an open channel. At this point the channel will " command " a much larger area of cultivable land than any qanat can, and these fields will be further away from the salt land which usually is found close below the present fields. The maintenance on such a dam is very small indeed and compares most favourably with the other modern method, the pumping out of the subsoil water by diesel- or electric-motor driven pumps in open wells or boreholes.

The qanat system is costly, uneconomical and expensive in manual effort to maintain, but, worst of all, it wastes so much valuable water in areas where water is of primary importance.

The Zagros Mountains lie between the salt desert of central Iran and the Persian Gulf, and, since the core of this range was forced up through deep limestone beds, many of the valleys run parallel to the axis of the range. Shiraz lies in one of these upper valleys which has a width of about two miles and is over deep alluvial fill, and previously had gone to waste in a salt lake, without an outfall, below Shiraz. Sufficient wells have now been sunk above the town to give Shiraz the first adequate piped supply of any town in Iran. Further north a tunnel has been driven from a similar valley, in which the Karun River flows, so that a large and permanent supply can be passed to the Isfahan district. The large and important new water supply for the city of Tehran is obtained from a valley about twelve miles away, and will eventually be secured by the construction of a dam in the same valley.

The surface flows in the valleys of the Tigris and Euphrates rivers only requires the age-old canal systems to bring them into use, but hundreds of wells have been sunk away from the rivers, and the problem here has been to site such wells on buried watercourses so that the maximum quantities can be obtained and stationary saline water avoided.

Across the Gulf and Saudi Arabian peninsular is almost entirely desert, with a rainfall seldom exceeding three inches anywhere. The eastern, or rather north-eastern, half of Saudi Arabia is on limestone, which, near to and under the Gulf, is thousands of feet deep, and in which there are fissure flows of good water. I have never accepted the usual explanation that this water comes from the meagre rainfall on the deserts in the interior, and the large quantities which are recovered in the Hofuf Oasis and in the Island of Bahrain seem to bear out my theory. I think it much more probable that this water is from rainfall on the slopes of the Zagros range, and that it passes under the Gulf, some eventually flowing from the Saudi coast under Bahrain. The quality is not very good, but there is plenty of it, and in Bahrain the wells are only about 300 ft. deep. Much further development could be done near the coast of the Gulf north of

Bahrain, but further south, on the Trucial coast, the subsoil is full of brine and it is very difficult to separate the comparatively fresh water in such a loose shell and coral formation.

Further down the Gulf, in Muscat, there is quite a good seasonal rainfall on the hills and on the Jebel Akhdar, but a surface flow only after heavy storms. Along the Batinah coast there are many shallow wells, sited by the local cultivators from observations on the trickles of fresh water which appear on the sandy beach as the tide goes out, wells being sunk inland of the better flows. At Sur, on the extreme east point of Arabia, the beach flows have not been located, and all water has to be carried nearly five miles from wells in a wadi bed inland from the town. The same subsoil flow could, in fact, be developed from a shallow well in the main square of the town. The town of Muscat is sited in a vast volcanic mass of hills, and lives chiefly on roof catchments and unreliable shallow wells. About nine miles inland are hot springs, evidently water which has fallen on the limestone of the Jebel Akhdar and has been heated below ground on the volcanic rocks. The water has to be cooled before it can be used on the gardens, but is free from sulphur and of good quality. (The great difference which the water of these hot springs has made to the cultivation on these slopes was illustrated in some of the slides which were shown later.) Muscat Town could be supplied from the same fissures, quite close to the town.

The western side of Arabia is both under-populated and under-developed, but, as there is a fair rainfall on the coastal hills, there seems no reason why a useful amount of water should not be made available from correctly sited wells near the coast.

Across the Red Sea, North Africa has very similar problems. Except for the Nile Valley and the Oases there are desert conditions almost everywhere, and, except politically, there is no problem close to the Nile. The oases, such as Siwa and Kufra, give an indication of how water problems in certain desert areas might be tackled. Trial walls through the sand to the Nubian Sandstone have shown that this stratum carries water in places far from any rainfall, and, in fact, this water can only go underground from the upper reaches of the Nile, and probably by far the greater part enters the subsoil in the Sudd swamps. This would explain, very reasonably, the tremendous losses in this area which are usually ascribed to transpiration and evaporation.

This vast subsoil movement passes north in a belt several hundred miles wide, and eventually most of it is lost in the bed of the Mediterranean Sea. That the water is of good quality all the way I do know because, in the early part of the last war I had to send a small party of Sappers with the Wadi Halfa-Kufra convoy to a point about half-way between the two places, to renew the wooden steining of one of the wells, so that the convoy could use the water on each journey. Further proof is that the Nile at one point in a limestone gorge in Egypt gets an accretion of several millions of gallons a day from its bed. If ever the Sudd is by-passed by a canal, as has been proposed, the water-table over a very large area of northern Sudan would be very adversely affected.

Further west, along the Mediterranean coast, there are certainly many subsoil flows which can only have started very long distances to the south, apart from those deriving from the rainfall in Cyrenaica, but the wells often have to be deep, too deep in fact to be sunk during the war, but in them the water would always stand a little above the sea level of the Mediterranean.

I would now like to illustrate some of the points I have made and show slides of some of the areas. (Slides of the Trucial coast, Buraimi Oasis, Muscat and the Libyan coast.)

I have only touched on some of the major problems, as I have seen them, but to take each town or district which is short of water and examine it would take a very long time.

DISCUSSION

The CHAIRMAN: Colonel Merrylees is prepared to try to answer any questions there may be, and there are one or two which I should like to ask. I have had a good deal to do with water problems in the Middle East, particularly in West Pakistan. One thing I should like to know is how the underground water supplies can be located, otherwise than by trial and error, if at all. When these streams have been located, how wide are they or do they vary tremendously in width? I am thinking particularly of experience of Karachi, where I spent many years of my life. When I went there in 1910 it had a population of about 130,000, and it got its water supply by wells and by percolation. Karachi, instead of having a population of 13,000, now has about 1,300,000. Even before I left it was obviously outgrowing its supply, because we found that as we dug a well it simply lessened the supply from another well. We finally had to deal with the situation by bringing water from the Indus. It seems that most of this underground water supply can be tapped only in small quantities at a time. I should like to hear more about it.

Colonel MERRYLEES: There are various methods to be employed, but it rather depends on the country one is in. A riverbed may be as wide as the original watercourse, but usually it is shaped as I have shown. (A roughly triangular section was shown in a diagram, the apex below, and in the original eroded valley bottom, before this was filled with detritus from the weathering of the higher hills.) The main flow may not be near the centre. To get the maximum amount of water out of any underground flow one has to go into it very nearly at the centre. There are many underground flows where very big quantities of water are carried. I know of three big springs. One in Kashmir, one near Kermanshah, which is used for agriculture, and a bigger one at the top of the railway tunnels in the Taurus mountains. There is no certainty that smaller flows do not exist in other places, untapped, which simply disappear out to sea or into the salt beds.

A MEMBER: I should like to ask whether something can be done concerning the planting of trees on a large scale. The French are having considerable success in the Sahara with tree planting.

Colonel MERRYLEES: Tree planting, once it is established, can do with very little water because trees themselves hold a good deal of water, but it is the starting that is the difficulty. There have to be quite considerable quantities of water for the seedlings and for the first few years of growth. It is no use tree planting in an area where there is not sufficient water of the right quality. In some areas there is water which is sufficiently good for goats, sheep and humans, but not good enough for trees. The Sahara should be capable of development in certain areas because there is a considerable movement of water under it. I believe I am right in quoting the French geologists who say that Lake Chad, being fresh, must have an outlet. It cannot be to the south because of the geological conditions, and therefore it must flow to the north. The only place one can link with it where water of a suitable quality appears in sufficient quantity is Benghazi. It sounds a long trek, but it is not an impossible one. There seems to be nowhere else where that kind of water could go.

Colonel ROUTH: Are there any overall plans to develop this water supply and to make the land usable?

Colonel MERRYLEES: The Persians, under their second seven-year plan, have started quite a lot of development; it is expensive, however, and except for sunken dams there is a need to drill wells and put in pumps. There is a definite limit to the price of water that can be used for agriculture, particularly in poor places. Iran is like so many Middle East countries, having a few very rich people and a great many poor ones. It is a question of the capital cost of the original scheme followed by the cost of pumping water.

Dr. ROLAND BROMLEY: Do eucalyptus trees attract water? When I was in the Middle East recently I saw many of them.

Colonel MERRYLEES: The eucalyptus tree requires less water to grow well than does any other tree. I believe that is the difference. It is not a question of attraction. If water is not there, I do not think any tree can attract it. What trees do to a large catchment area is to hold water about them and prevent it being evaporated by a hot sun, until it is soaked into the ground and can be picked up by underground movement.

General WATERHOUSE: Colonel Merrylees referred to sunken dams. There seems to be a possible snag, and I wonder whether it is met in practice. It involves raising the level of the water-table locally. If the valley is in limestone or something of that sort, it seems that when a sunken dam is put in the water will get round the ends of it.

Colonel MERRYLEES: It depends upon what the dam is fixed to, and limestone is very susceptible to fissures in odd places and losses in that way. Major Jarvis, in one of his books on Sinai, describes how he put a dam across a limestone valley and waited for the rains. When they came there was a lovely reservoir, but the next morning there was no water. Where there is water which can be picked up by a mother well, it is obvious there is a fairly impervious bottom to that particular part of the valley, and therefore if you fix your dam into the rock of the valley it will hold most of the water. The valley may be 200 yards wide and the bottom of the water-table may be only 20 feet down, and so if you drive the piles in and make the dam, the increase in pressure would be very small.

General WATERHOUSE: Provided you are dealing with a local water-table?

Colonel MERRYLEES: Yes. The qanats are usually placed where the valley comes out below the foothills, and this forms a local water-table on the aquifer.

A MEMBER: What is the explanation of hot water at the junction of volcanic rock and limestone?

Colonel MERRYLEES: The rainfall on the 9,000 ft. Jebel sinks through the foothills with enough pressure for it to be forced down into fissures near the volcanic block, which is still quite warm 300 or 400 ft. down, and that water, after passing through the fissures and coming up under pressure, will be hot. It is not steaming; it is about 110°F.

The CHAIRMAN: It only remains for me to thank Colonel Merrylees, on your behalf, for his lecture, which I have certainly found entrancingly interesting, and I hope that that has been the experience of all of you.

The vote of thanks was carried by acclamation.

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