THE WATER SUPPLY OF THE EGYPTIAN EXPEDITIONARY FORCE, WITH SPECIAL REFERENCE TO THE EFFICIENCY OF MECHANICAL RAPID FILTRATION WITH CHLORINATION.

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The provision of an epidemiologically safe water supply to the Egyptian Expeditionary Force, as it fought its way across the Sinai Desert to deliver Palestine from the hand of the Turk, will long be remembered as one of the most remarkable achievements of the war.

The route was already historic, as along it the ancient kings of Egypt and Assyria had led their hosts against each other. Napoleon followed the same route in 1798, and Sir William Willcocks is of opinion that the Israelites also used it. The 17th chapter of Exodus gives us an insight into their difficulties regarding water supply.

For a modern army, however, the problem was more difficult, for even the army of Napoleon was in numbers less than one-tenth that of the Egyptian Expeditionary Force. Along the first part of the route is a chain of wells capable of supplying small numbers of troops, and this sufficed for the needs of the Australian and New Zealand cavalry which formed the advance guard, but it was quite inadequate for the main army. The eastern part of the Sinai Desert is practically waterless, and it was on the other side of this waterless area between Gaza and Beersheba that the Turks had entrenched themselves and actually managed to hold up our advance for over a year. It was therefore necessary to provide the army with water from a source outside Sinai, and the only one was the Fresh Water Canal which takes the water of the Nile to Port Said and the other stations on the Suez Canal.

When it is considered that this canal leaves the Nile near Cairo and flows through some 70 miles of the Delta, where it is exposed to every conceivable pollution, and that in addition to being a veritable cesspool it is also bilharzia-infected, it will be seen that the problem of purifying the water for consumption by troops was no easy one.

The primary question to be solved was whether the slow sand filter or the mechanical rapid filter should be used.

It is interesting to note that at home the Metropolitan Water Board, forced by the exigencies of war which demanded economy of coal and labour, had set

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themselves a similar problem. In the thirteenth Research Report, Sir Alexander Houston sums up the question at issue thus:

"Is it permissible to filter stored water so rapidly as to create a material economic gain in the saving of filtration area, yet by the aid of anti-filtration or post-filtration sterilisation processes to produce a water which is epidemiologically safe, innocuous, tasteless and reasonably satisfactory from a physical and sentimental standpoint?"

Rapid filters have been extensively adopted in America. On the other hand British opinion, influenced by the possibly not altogether disinterested advice of engineers and supported by the results of certain chemical analyses, largely adheres to the slow filtration method which "has stood on the whole favourably the test of time."

In Egypt, however, there was no doubt as to the gross contamination of the supply, and it was realised that it was of negligible importance what the results were as regards albuminoid nitrogen, ammonia or oxygen absorbed, so long as a water could be provided which was *bacteriologically safe*. Moreover at Kantara, which was the base of the advancing force, space had to be economised, as had money and labour, while the occurrence of sand-storms might, it was thought, seriously interfere with the working of slow sand filters. It was therefore decided to adopt the method of sedimentation, rapid filtration and chlorination.

Six similar plants were installed at different military posts of the Suez Canal Defence, and it is interesting to note that when the Turk was driven from the immediate vicinity of the Suez Canal, one of these plants was transferred from a smaller post to Kantara where it was subsequently connected with the historic pipe-line across the Desert. Such an economy would not have been possible had the slow filtration process been adopted.

The type of plant used was a modified "Jewel." In the first instance, the water passed through a strainer of brass wire gauze with a mesh of a sixteenth of an inch to exclude the snails which are the intermediate hosts of worms causing bilharziasis. Thence it was led to a settling tank on the maze principle, on entering which a solution of aluminoferric was added. The water took some ten hours to flow through the tank, and by this treatment alone the transparency was increased four or five times and 40 per cent. to 60 per cent. of the organisms removed. It then passed to the filters.

Each filter consisted of an inner steel cylinder, containing 40 inches of *coarse* sand supported on gravel, and an outer cylinder which was three feet higher. The water rose between the cylinders at a speed which allowed of a maintenance of a head of $2\frac{1}{2}$ feet above the sand level and after passing through the filter-bed of the internal cylinder, reached the exit pipe through perpendicular strainers of perforated brass. The filters were periodically cleaned by reversing the direction of the flow and raking the surface of the sand. After washing, it was necessary to run to waste for twenty minutes to allow the sand surface to settle. The running to waste occurred automatically, indeed all the valves were so arranged that the process was quite fool-proof. On leaving the filters, the water was quite clear, and 95 per cent. of the total organisms found to have been removed.

The water was then conducted to storage tanks, at the entrance to which it was chlorinated to the extent of usually 0·75 to 1 part chlorine per million of water. The actual method of chlorination differed at some of the tanks, but, so long as efficient mixing was accomplished, it did not appear to matter which was used. The amount of bleaching powder to be added was gauged by a modified form of the ordinary Horrocks test, a modification of which was also used for the testing of the bleaching powder itself.

From the bacteriological point of view, the process since its installation has given the utmost satisfaction. Samples have been taken weekly and an average series of results is given below.

Summary table of bacteriological results based on 3½ years' experience and the examination of multiple samples.

Source of sample	Colony count per c.c.	Glucose fermentation	Lactose fermentation	"Flaginae" *B. coli*
Fresh Water Canal	1200	in 0·05 c.c.	in 0·05 c.c.	in 0·1 c.c. often in 0·05 c.c.
After sedimentation	800	not in 0·05 c.c.	not in 0·05 c.c.	not in 0·05 c.c.
After filtration	50	not in 0·5 c.c.	not in 0·5 c.c.	not in 1 c.c. often not in 5 c.c.
After chlorination	20 – 30°*	not in 10 c.c.	not in 10 c.c.	not in 10 c.c.

* Developed chiefly, if not entirely, from non-pathogenic spores unaffected by the chlorination.

The freedom from bilharzial infection was presumed, as all water was stored snail free in the plant, reservoirs and pipes 36–48 hours before actual consumption.

It was originally laid down that no water which contained *B. coli* in 1 c.c. should be consumed by troops in the E.E.F. As, however, the examination took several days to carry out, for practical purposes a test with quantities varying from 0·5 c.c. to 10 c.c. of water for the presence or absence of acid and gas after 48 hours incubation in lactose McConkey broth was relied upon. It was of course only necessary to test the water as a routine after filtration and after chlorination. The efficiency of the preliminary sedimentation was estimated by a transparency test in which a piece of bright metal was observed through columns of water of different depths. It will be noted that the bacteriological standard is below the usual civil one, but the freedom of the troops from water-borne disease will be accepted even by slow sand filtration enthusiasts as a most convincing proof of the safety of rapid filtration and chlorination methods of treatment. It should also be remembered that the comparative immunity from disease occurred in a sub-tropical climate amidst conditions—concentration of troops on dust swept areas and initially most impure water—most favourable to heavy incidence of water-borne diseases.

It is not the writer's intention to discuss the advantages and disadvantages of the method from the financial point of view. These are fully set out in the reports of the Metropolitan Water Board and elsewhere. He wishes, however, to place on record the efficiency of a method over which there is much important controversy, and it has been tested, not by laboratory experience, but on such a vital matter as the water supply of an advancing army.

The supply from the filters at Kantara was originally intended to supply 500,000 gallons a day for a small force of three divisions detailed to recapture the Egyptian frontier towns of El Arish and Rafa, to which the water was pumped in stages through a twelve-inch main laid upon the desert sand. It proved so successful, however, that when the conquest of Palestine was contemplated, the pipe-line continued to follow the advancing troops and was subsequently laid on to the Gaza-Beersheba line, *a distance of* 147 *miles from the filter-plant* and 220 from the Nile.

The ancient prophecy, that when the waters of Egypt should flow into Palestine that country should be delivered, thus came to be fulfilled as a result of a world-wide war. At the same time, there was carried out physiological experiment on a vast scale which proved that rapid filtration and chlorination methods of treatment can render an initially highly polluted and dangerous water *safe* for human consumption, and which has substantiated one of the most modern contentions as to the purification of water supplies.

In conclusion, I have to thank Sir Alexander Houston for the interest he has shown in my work, and for the furnishing of the reports of the Metropolitan Water Board and other references. My thanks are also due to the several bacteriologists of the Kantara Military Laboratory who, during the three-and-a-half years under review, were always willing to render assistance in the examination of special samples; and to my friend, Captain Rupert Briercliffe, O.B.E., R.A.M.C., who was associated with me in the work, for placing at my disposal many records to supplement my own.