A HISTORY OF WATER PURIFICATION IN THE BRITISH ARMY
WITH SPECIAL REFERENCE TO SMALL UNITS ON ACTIVE SERVICE

Major W. R. O. EGGINGTON,

Introduction

The difficulties involved in supplying a potable water to the men under their command has been a problem to generals through the ages, and has become more acute in the last three hundred years. Prior to this time, armies were relatively small in number, and fighting generally limited to one set battle. In those circumstances, the troops were able to obtain sufficient water from wells and rivers, and to move on before contamination of the water produced any severe outbreak of disease. Furthermore, the armies generally disbanded for the winter months, so reducing still further the chances of disease from polluted water spreading through their ranks. For these reasons, and the fact that the aetiology of disease was not understood, history has given us very few facts regarding possible water-borne disease in the British Army prior to the 18th Century. For example, it is known that the English Army under King Henry V, in their march from Calais to Agincourt, suffered so severely from diarrhoea that, despite Shakespeare's account, the King attempted unsuccessfully to come to terms with the French, and in fact during the battle his archers fought without trousers. It is unfortunately impossible to say whether the disease was water borne or not, but as camp sanitation was non-existent, the disease was most probably spread by flies.

However, as war became more complicated, and larger numbers of men became involved, destruction of the land through which the armies passed destroyed wells and polluted rivers and streams. Diseases such as dysentery, typhoid and cholera ravaged armies and often accounted for more casualties than the actual battles. It was to stop this useless wastage of fighting manpower that armies throughout the world attempted to devise methods of producing drinking water for the troops. The problem soon divided itself into two parts; the supply of water to large static garrisons, and its supply to units in the field.

So far as large garrisons were concerned, the apparatus used for the cleansing and storage of water were very similar to their civilian counterparts for towns, and the military problems were intrinsically the same as the civilian. The second part of the problem of supplying the troops in the field, who, in the British Army were based on the regiment consisting of between five hundred and eight hundred men, was more difficult. The problem here was unique to the army, and little help could be expected from civilian experience. For any apparatus to be successful, it had to satisfy five important criteria.
1. It must be able to produce a water free of impurities which the troops would drink, from a variety of sources in any part of the world. In other words, water containing an unpleasant albeit harmless taste was unacceptable, as the troops would rather drink polluted but palatable water. The water source with which the equipment would have to deal might contain suspended inorganic solid matter, pathogenic bacteria, or even animals such as cercariae.

2. The apparatus had to withstand the trauma of transportation over poor roads, tracks or rough ground without damage.

3. If the apparatus broke down, it must be capable of repair within the force, not necessarily in the actual unit, but certainly not solely at the manufacturers.

4. The equipment would have to be relatively easy to operate, so that the average soldier detailed to work it could quickly cope with its technicalities. It was not essential that the soldier knew how it worked, although this was advisable, but books of instructions would obviously be out of place in an advance or retreat.

5. The apparatus would have to be relatively inexpensive. No army in Britain's history has had a surplus of money allotted to it, and priority would obviously be given to armaments.

In this dissertation, it is hoped to demonstrate how the British Army attempted, with greater or lesser success, to find a solution to this problem, and examples have been taken from the various campaigns where troops and their equipment were sent from Britain to fight in Europe and Africa.

CHAPTER I
EIGHTEENTH CENTURY

James Lind (1736–1812) was known as the father of naval hygiene, and amongst his many contributions to the health of that service was a method of distilling small quantities of pure water from sea water. Although this method was not followed up in the Army, another of his suggestions for improving the quality of water was used, and continued to be mentioned for nearly a century. This method was the exposure of water to air in divided currents. The water was simply poured through a sieve or plate pierced with holes, and allowed to fall at least one foot into a receptacle. Numerous refinements to the apparatus were added later, but the principle remained the same. This method was said to remove hydrosulphuric acid, offensive organic vapours and, very optimistically, some degree of dissolved organic matter. The fact that this method was thought worthy of inclusion for so long a period gives some idea of the line of thought current at that time. Not having any knowledge of bacteriology, all efforts were directed towards producing a water that looked clean, and if Lind's method helped produce a clear water, then the method remained worthy of acceptance.

Some idea of the ignorance of medical knowledge on the aetiology of disease can be gained from a report written in 1765 on the diseases encountered by the British Army in the Low Countries in the campaign of 1742–49. The author, Dr. John Pringle,
Physician-in-Ordinary to Her Majesty, went into great detail into the suggested aetiologies of the various diseases contracted (dysentery, malaria, typhoid and cholera). He decided that the conditions were caused by the “moist and putrid air of the marshes in which the troops were stationed”.

In view of this lack of knowledge, one has a certain amount of sympathy for a Dr. Hamilton, who in 1787, wrote a small book on the duties of a regimental surgeon. In this book, he advised regimental surgeons to contact local civilian doctors in areas in which their troops were quartered, and, if the drinking water in the region was known to be contaminated, then advises “small beer” to be drunk instead.

CHAPTER II
EARLY NINETEENTH CENTURY

Out of the confusion and mistaken ideas surrounding the subject of drinking water, an important step forward was taken by Dr. J. Millingen, Surgeon to His Majesty’s Forces. In his book, The Army Medical Officers’ Manual, published in 1819, he emphasised the proper selection and protection of water sources. He advised that the banks of a river flowing near a camp should be divided into three parts; that part furthest up the river to be used for drinking and cooking, the next section for watering cattle and horses, and the lowest section for washing. Sentries should be placed at these points to ensure that pollution of the river did not occur. He also suggested that, if the river became muddy from heavy rains, the medical officer should examine it. If the water was considered to be unfit to drink, then shallow wells should be dug, and more sentries placed to ensure that the water was only used for cooking and drinking. Further on in his book, Millingen advised the digging of a trench near the bank of a river, and allowing water to percolate through it, the earth acting as a coarse rapid filter.

Although to the present-day student, Millingen’s advice seems commonsense, in a way he was ahead of his time. The importance of camp layout was not realised, and either the medical officers did not pay any attention to his suggestions or, as is more likely, they were unable to convince their respective Commanding Officers of its importance.

To give some idea of how quickly these ideas were forgotten, one has only to read a book written by Robert Jackson in 1824 on the “Formation, Discipline and Economy of Armies”. The author discusses in great detail selection of recruits, illnesses in the different parts of the Army, camp layout, and instructions for troops on the march. However, he makes no mention of regulations with regard to drinking water, and in fact his only reference to water is one sentence concerning its beneficial use for washing. Whilst this book may be taken as an extreme case, it is certainly clear that, if the British Army went to war with this gap in their knowledge of sanitation, then very high sickness rates would result. Unfortunately this was to occur, for thirty years later, with no further advances in this field, the Crimean War broke out.
CHAPTER III
THE CRIMEAN WAR

A relatively healthy army sailed from Britain to land in the Crimea in April, 1854. Sickness started to occur in large quantities in July and by January, 1855, it reached catastrophic proportions. Figures published soon afterwards revealed that zymotic diseases (Cholera, dysentery, and diarrhoeas from other causes), which in part were caused by polluted water, were ninety-three times as prevalent as amongst the troops in Britain, and nearly two hundred times as prevalent as amongst the civilian population in Britain.

Among the numerous reports still available on the conditions of the soldiers and military hospitals during the Crimean War, very little has been written on the arrangements for the supply of a safe drinking water. Florence Nightingale, although interesting herself in very nearly every aspect of the medical services in the Crimea, dismisses the subject by saying that the water carts were dirty. The Sanitary Commissioners sent from England to advise the medical services on all sanitary matters, devoted most of their time to the state and siting of hospitals. What recommendations they did make regarding drinking water were later hotly disputed by the Army medical authorities as either having already been implemented or being impracticable.

We are therefore left with two sources of information:
(a) The official records of the Medical Board of Health to Lord Raglan.
(b) Diaries of Regimental Medical Officers.

Both sources are unfortunately sketchy, and deal only with small areas of the overall picture. For example, the Medical Board of Health reported that the division in front of Sebastopol were adequately supplied from springs which were well protected, and the water led by iron piping to tanks and reservoirs which were all clean and in a good state of efficiency. This optimistic picture does not, however, state how the water was carried from the tanks and reservoirs to the frontline troops, nor indeed whether the front line troops even used this water, or found other sources nearer to the units.

A grim picture is painted in the unpublished diaries of a Dr. William Cattell, who was the regimental surgeon to the 5th Dragoon Guards. He stated with regard to one camp site that, although fresh spring water was available on arrival, the troops polluted it by allowing it to be used by horses. Later, in a river which was also being used for drinking water, the men washed themselves and their clothes, and the unit butcher used it as a convenient place to dump his offal. Although warnings were later given to the men not to use the river water, in the absence of any alternative supply the warnings were ignored. Cattell reports yet another instance when the unit arrived at a camp site to find the wells filthy. As they were the only source of water in the area they had to be used, and inside three days cholera occurred in the unit.

From the examples given certain facts emerge. Some efforts were obviously being made to provide an adequate water supply for large bodies of men. With regard to
individual units, the situation was chaotic. Millingen’s suggestions on protection of water sources and elementary principles of camp layout were either being ignored by the unit doctors, or, in the case of Cattell, his advice was being overruled by the unit. Finally, in the absence of their being mentioned, it must be assumed that no small filtration apparatus yet existed for relatively small bodies of men.

The Royal Commission appointed in 1857 to enquire into the sanitary conditions of the army were responsible, amongst other things, for the publication, in 1859, of a new addition of the Queen’s Hospital Regulations. These new regulations entirely altered the position of the unit Medical Officer. Previously, he had been entrusted officially merely with the treatment of the sick and injured. Now, the new regulations ordered him to advise the commanding officer of his unit on all matters pertaining to the health of the troops. These new regulations gave the unit medical officer the authority he needed to advise on matters of hygiene, and although it was still up to the Commanding Officer of the unit whether the advice was taken or not, extra weight would be given to the Medical Officer's recommendations by the simple virtue of the official recognition of this increase in his work.

The Royal Commission also recommended that an Army Medical school should be set up, in which the specialities of military medicine, surgery and hygiene should be taught to young medical officers. As a result of this, a Professorship of Military Hygiene was established, and its first occupant, Dr. E. A. Parkes, M.D., F.R.S., published a Manual of Practical Hygiene in 1864, to act as a reference book for medical officers. In this manual, the medical officer was informed once more of the importance of efficient camp layout, to prevent contamination of water by either animal or human waste. Details were also given on the selection of water sources—in fact a resurrection of Millingen's work of fifty years previously.

Parkes also mentions apparatus for the filtration of water for the individual soldier. This was a small flannel bag through which the water was strained before passing into the water bottle. Charcoal could be sewn into the bag to make the strainer more effective, but this was optional, not a general issue, and most probably the soldier would have to pay for it.

For large quantities of water, a simple small-sized filter was at last described. This consisted of two barrels placed one inside the other, the space between being filled with sand, gravel or charcoal, through which water slowly passed (Fig. 1). The whole apparatus would act as a coarse sand filter, and was cumbersome and slow in action. Despite their obvious disadvantages and allowing for the fact that it was probably a most inefficient piece of apparatus, its use marked a great step forward in water purification in that filter apparatus for small groups of men was now recognised as essential. At the end of his account of water purification, Parkes admitted that the organisation for the supply of water should be better than it was at the time. He pointed out that water carts were so cumbersome that they could not be brought up to the front line in time of actual fighting, and he suggested that water bags, carried by horses or mules, should be used, and the water issued at the same time as the ammunition.
CHAPTER IV
LATE NINETEENTH CENTURY

In the Zulu Campaign of 1879, sand and charcoal filters were still being used by the troops, the most common one being Crease’s filter. The disadvantages of such apparatus were similar to the earlier models, and the Surgeon-General in charge of the medical side of the expedition stated in a report that, although the filters were acceptable in large field hospitals, they were still unsuitable for field service, as they were too cumbersome, and would not stand any rough handling.

The picture improved somewhat over the next six years, and by the time of the Egyptian Sudan campaign of 1885, the force in Africa was equipped with Maignen’s “Filter Rapide” (Fig. 2). This apparatus was capable of clarifying 1,000 gallons of water an hour. Hoses sucked water by means of hand-operated pumps into tinned copper tanks. The tanks measured approximately 5 ft. x 3 ft. x 4 ft., and the filtering surface consisted of asbestos cloth, charcoal and chalk.

Although Parkes, in his manual written in 1887, mentions the apparatus with only guarded enthusiasm, the troops using it were lyrical in its praise. This shows a marked contrast to previous pieces of equipment of which criticisms usually emanated from those unfortunate enough to have to use them on active service. Certainly the expedition had a very low sickness rate, and for this the Filter Rapide was given all the credit. It is much more likely that the expeditionary force being relatively small in number, and with the lessons of the Crimea learned by bitter experience, camp layout was much more efficient, and pollution of the water sources more easily controlled.

Various testimonials were given to the efficiency of the Filter Rapide, including one by the Commanding Officer of the expedition, General Viscount Wolseley. In
these testimonials one fact emerges, and that was that the apparatus was so strongly constructed that it maintained its working efficiency throughout the campaign. Whatever may be the true value of Maignen's Filter, it is only at this time that the British Army had a portable apparatus capable of supplying frontline troops with water.

If the trend towards better water clarification had continued on the then known knowledge, it is probable that future British Forces would have used modifications of Maignen's filter for some considerable time. However, a radical change in the water purification knowledge occurred in 1887, when the army realised that water could contain pathogenic bacteria. Prior to this, as we have seen, all efforts had been directed towards producing a clear and pleasant tasting water. Now it became necessary to provide a purification process which not only clarified, but also sterilised the water.

![Figure 2. Maignen's Patent 'Tank' "Filtre Rapide."](image)

There have been three lines of development in attempts to tackle this problem:

(a) **Filtration** — employed for both clarification and sterilisation.

(b) **Heat** — as a method of sterilisation.

(c) **Chemicals** — as a method of sterilisation of water previously clarified by filtration.

In such a new departure, it was obvious that the first attempts to sterilise water would most probably prove unsatisfactory. After all, the army had only just begun to prepare a satisfactory filtration apparatus after a hundred years of experimenting,
and the answer to the problem of sterilisation was just as complicated as that for filtration.

The first reference made to field sterilisation apparatus was in the Second Sudan War of 1898, when bromine gas was used. Bromine was first suggested by a Staff Surgeon Schumburg in the German Army. Experiments performed by the British Army Medical School at Netley had shown that 0.06 gms. of bromine, if added to a litre of water and allowed to stand for five minutes, rendered most surface water safe for drinking purposes. It was also found that the colour and taste of the bromine could then be removed by a mixture of sodium hyposulphite and anhydrous sodium carbonate, leaving only a slightly stale taste. Whether at this point in their experiments the army chemists were ordered to supply sterilising outfits to troops embarking for the Sudan Campaign at very short notice, or whether they had no field experience, the fact remains that the troops were issued with glass ampoules of 2cc. volume containing 0.06 gms. of Bromine gas. As was to be expected, the fragile glass capsules did not stand up to the rough handling of service conditions. The ampoules that were used produced a water taste that was unpopular with the troops, and following the Sudan Campaign they were not used again.

CHAPTER V
THE BOER WAR

Two distinct methods of obtaining pure water were in use by the British Army during this period, these being:
(a) Filtration.
(b) Heat exchange.

In theory, both methods were relatively satisfactory, but for reasons which will be shown neither apparatus worked efficiently, and this, to some extent, contributed to the high sickness rates of the troops.

Filtration

The apparatus available consisted of two sets of filters, the first containing sponges, and the second Chamberland porcelain filters which sterilised the water. As has been said above, this method had much to recommend it. The sponges had a considerable effect in mechanically arresting suspended particles and, if cleaned regularly, could be efficiently maintained. The Chamberland filter merely consisted of a cylinder of unglazed porcelain made from a well-baked kaolin of a certain degree of hardness (Fig. 3). The cylinder was enclosed in a metal jacket, and water was passed into the outer cylinder where it then passed through the porcelain. It was estimated that, using water at a pressure between 1½–2½ atmospheres, one cylinder would filter 3 quarts of water an hour. Tests showed that \textit{S.typhi} and \textit{V.cholera} were stopped by the filter. The cylinder needed to be cleaned quite often, but this was a readily easy operation.

Notter and Firth in their book \textit{The Theory and Practice of Hygiene}, published in 1900, appear very pleased with this apparatus, although they did suggest that asbestos should replace the sponge filters. As an apparatus in use in a laboratory it might well
have appeared satisfactory, but issued to units in the field on a scale of 1 per 200 men, serious deficiencies came to light. The apparatus, even in good working condition, was incapable of supplying sufficient water for the men. Furthermore, the porcelain filters, carried as they were in carts which were pulled by horses, often over rough ground, tended to crack. This meant they either refused to work at all or, even worse, they allowed polluted water to pass through. Another fault was that some of the filters supplied had flaws in them, through which inadequately filtered water would pass, unknown to the operator.

Heat Exchange

Heat exchange was the other method of water purification available to the troops in the field. The various apparatus in service all depended on the fact that, with a sufficient area of metallic surface of good conducting capacity and with sufficient time, a given quantity of liquid would yield nearly all its heat to an equal volume of the same type of liquid. The incoming cold water was made to receive heat from the outgoing hot water. This had two advantages; the amount of fuel necessary to raise the water to the required temperature was greatly lessened, and the water issuing from the apparatus was about as cold as when it was originally supplied.

As has been said above, many varieties of this type of apparatus were available. One model made by Desmaroux was quite efficient, but was completely impracticable, for if it broke only its inventor could repair it. It was finally decided to use the Waterhouse Forbes model (Fig. 4). The water in the exchange heater was boiled by gas or kerosene, and the temperature of the water finally delivered was only 4°–8°F above that of the water intake. As the water was only boiled for a few seconds, it was claimed that the dissolved gases were not driven off. In actual practice, tests...
showed that three-quarters of the oxygen had been driven off, but even so the water tasted quite palatable. Somewhat surprisingly, the apparatus was said to be efficient enough to destroy *S. typhi*, *V. Cholera* and *E. coli*. The Waterhouse Forbes model had only a short service life, although it was quite portable, weighing only 130 lbs, as its output of 25 gallons an hour was inadequate. Its heating mechanism was most unreliable and could not be used at night as it gave away troop positions. Before the end of the war, the apparatus was withdrawn from service.

Although the failure of the army purification apparatus was responsible for some of the high sickness rates, other factors were equally as important. The Royal Commission, set up by Parliament in 1902 to investigate defects in the medical arrangements during the Boer War, found that although Chamberland filter equipment was issued at a scale of one per company (about 200 men) at the beginning of

![Figure 4. Waterhouse-Forbes Model.](http://militaryhealth.bmj.com/)

the war, the supply was insufficient, and later units had no equipment at all. In the army at that time there was no method of bacteriological and chemical testing of water, no regular disinfection of water-carrying carts, labelling of impure water sources, and no hygiene information amongst the troops. During the big typhoid outbreak at Bloemfontein, sewage was disposed of in pits quite close to shallow wells where drinking water was obtained. As the water table in this area was high, it does not in retrospect need much scientific knowledge to imagine the ease that pollution could occur, especially in times of heavy rain. By the end of the war, the army had suffered seventy-thousand cases of typhoid and dysentery as against twenty-thousand battle casualties.

Despite the collapse of the supply system, it was obvious that the British Army still had a great deal to learn on sanitation, both in fundamental camp layout and water apparatus.
CHAPTER VI
EARLY TWENTIETH CENTURY

Following the experiences of the South African War, considerable attention was paid to the subject of providing pure water for the troops. Extensive work was performed at Aldershot and at the Royal Army Medical College. Exponents of different methods burst into print, proclaiming the advantages of their favourite methods, and the overall picture became somewhat confused. Some idea of the different methods tried can be seen from a report on a demonstration held in Millbank Barracks in 1905. At this demonstration chemical methods of water purification included Bromine (Schumburg's Process), Iodine, Chlorine, Sodium Bisulphite, Potassium Permanganate, Copper Sulphate and Alum. As well as these chemical methods, filtration apparatus using various patterns of Field Service Filters and four varieties of heat exchange apparatus were also shown. Of the water sterilisers tried out at this time, the most efficient was the Griffiths apparatus, again using heat exchange. This apparatus yielded 60 gallons of water an hour with the water inside attaining a temperature of 180°F. and the outgoing water 12°F. hotter than the ingoing. Unfortunately, the apparatus still had the disadvantage of being heavy—it weighed 196 lbs. without carriage, so restricting it to fixed points. It also needed a good motor pump and a plentiful supply of fuel. Finally, some form of filter was also needed to remove particulate matter.

No-one could accuse the authorities of not paying attention to suggestions for improving the methods of water purification. It was realised by everyone that the methods then in use were unsatisfactory, and every suggestion was laboriously tested. Berg, at the International Congress of Hygiene and Dermography in Paris in the year 1900, advocated the use of peroxide of chlorine generated by sulphuric acid on potassium chlorate. The disadvantages of issuing crude sulphuric acid to troops in the field were obvious, and the method was rightly deemed impracticable.

Nessfield in 1903 proposed the use of chlorine gas liquified under pressure in lead-lined iron cylinders. He suggested that 7.5 ccs. should be slowly discharged into 18 gallons of water to be purified, and subsequently dechlorinated by sodium sulphite. His methods were duly tested by the Army, who found that even after thirty minutes contact time the water was not sterilised. In any case, there were severe practical difficulties in supplying compressed chlorine to troops in an army which had not yet come face to face with gas warfare.

Rideal and Parkes in 1901 suggested the use of sodium bisulphite in a strength of 15 gms. to a pint of water. This method was tried out in the South African War, but with no great success. A more accurate trial attempted later gave hope that this might be a satisfactory method if 2 gram tablets were used for a water bottle.

Another suggested method depended upon the liberation of iodine by a weak acid acting on a mixture of iodide and iodate. Although this method appeared promising, it involved the use of three different tablets and was reluctantly dropped, as trials showed it to be too complicated to be fully understood by the average soldier.
In this time of frustration, two important steps forward were at last made. It was recognised that there must be an organised body of men trained in the use and care of the different filtrating and sterilising apparatus. Previously, relatively technical equipment was handed over to men who were untrained and often unsympathetic as to its management. Numbers of medical personnel were trained to form water squads, supervising the supply of water to the troops. At the same time, instruction was given to all ranks on the object and aims of water purification. The lessons of the Crimean and Boer Wars with regard to water discipline and camp layout had at last been learned.

(To be concluded with references)

---

**Caravans for Hire in the Pyrenees**

Two caravans to let on private property in beautiful country. Fully equipped, gas cookers, electricity. Tent-awnings, to both caravans, double the living-space. Separate W.C. tents. £10 per week, except August £12 10s. 0d. Owner will tow to seaside or mountain sites within a reasonable distance, if required. Shopping centre, PAU, 5 miles. Please apply early to avoid disappointment over car-ferry bookings, to:—

Mrs. D. Forbes, Clos Camardon, Jurancon, B. Pyr., France.

'Phone (59) 27.80.26.