THE WATER SUPPLY AND SANITATION OF CAMPS IN INDIA.

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The following remarks are the outcome of some experience in the East and refer to certain sanitary measures, the necessity for the observance of which is too often more or less under valued by military officers, both during peace manoeuvres and on field service.

WATER SUPPLY.

The first and most important measure to be carried out by the medical officer when troops occupy an encampment is to select the source for the drinking water supply and take steps to have it kept free from any pollution. When a river or stream provides the supply, precautions should be taken to see that the water is procured from a point above the camp, and the places marked out for bathing and for watering animals. In standing camps the approach to the intake from the river or stream should be roughly paved, the surface in its vicinity cleared of rank vegetation, the stream slightly deepened at the intake if necessary, and all vegetable débris removed. Washing of clothes and bathing should be strictly forbidden near or above the intake; all animals must be kept away from its vicinity, and if required, a light dam might be thrown across the stream just below the intake. When drinking water has to be procured from a river with high banks, it should preferably be drawn by means of a light pump with a strainer attached to the end of its suction pipe. When it has to be taken from a channel in a broad, dry river-bed, sump wells or small galleries should be dug a few feet from the edge of the stream, out of which, after filtering through the intervening layer of sand and gravel, the water can be taken by a pump or clean zinc bucket. When a spring forms the source of supply it should be cleaned of all leaves and débris, its head dug out, and a cask or box sunk in it, to lessen the chance of pollution of the water when it is being drawn. A clear area with a radius of at least twenty yards should be rigidly preserved round the spring, on which no bivouacs, cooking places, or animals must be allowed. No crowding of people should be allowed round about nor should animals be permitted to approach the vicinity of a drinking water spring: the water should be drawn in clean metal vessels. In
standing camps the spring should be surrounded by a clear protecting zone with a radius of 100 yards, which must be kept unoccupied. The surface drainage from the ground above must be prevented from entering the spring by an intercepting drain, cut so as to conduct the surface water to a point below the spring-head. The surface of the ground should be sloped away from the spring and shallow drains dug to carry away all spill-water. When the drinking water has to be procured from wells, preference should be given, the quality of the water being equal, to one which is clean, in a good state of repair, not too close to a village, nor in the centre of recently manured fields. A clear zone with a radius of twenty yards ought to encircle each drinking water well, no crowding should be allowed around the well-mouth, animals must not be near it, and the water should be drawn up by a light pump or clean zinc buckets. In standing camps wells should be cleaned out before being taken into use, if it is necessary and practicable, surrounded by a protecting zone with a radius of 100 yards, provided with a low stone coping, and if possible a cover, while spill-water drains should be cut outwards from the vicinity of the mouth. The water should always be drawn by means of a light pump with a strainer attached to its suction pipe. When water has to be procured from a tank or pond, the supply for drinking should be obtained at a site as remote as possible from the places where the animals are watered or washing is done. In standing camps all animals should be watered from troughs placed at a little distance from the tank, in which bathing and washing of clothes should be strictly prohibited. When it is necessary to search for water, the borings should be made at the bottom of a hollow in a plain or where vegetation is luxuriant, at the lowest point near the foot of hills, at the junction of the watercourses from two valleys, or under the highest side of a valley. Water from marshes should not be used if any better is obtainable.

On active service troops often suffer severely from water-borne diseases, and various plans have been suggested by which it was hoped to provide them with a pure drinking water. It is generally necessary to clarify the water before making an attempt to purify it, and this can easily be done by sedimenting with alum or straining it through a cloth or Maignen's filter. In order to render water innocuous it has been proposed to sterilise it by means of chemicals, the principal agents recommended being potassium permanganate, bromine and sodium bisulphate, but the results obtained under the conditions of active service have so far not been satisfactory, and the
methods have been reported as unreliable and cumbrous. Lately, Vaillard has sterilised water in ten minutes by means of tabloids containing (a) potassium iodide and sodium iodate; (b) tartaric acid, and (c) sodium hyposulphite.

The Pasteur-Chamberland, Mallie, and Berkefeld filters can efficiently sterilise water, but they have not proved satisfactory when tried with moving bodies of troops, as portions of them are easily broken, leakage often occurs, allowing the sterile and raw water to become mixed, and the filtering medium requires to be frequently cleaned and sterilised, both of which operations are liable to cause minute lesions of the surface of the bougies, with consequent impairment of the germ-stopping power of the filter. The most suitable filter for use on field service is the Berkefeld, which, though not so efficient and durable as the other two patterns, has the advantage of being more rapid in action. Lengthened trials in India and Netherlands—India, with installations of these filters containing multiple bougies—have shown them to be very unreliable and troublesome when employed on tropical service. Leakage and breakages constantly occur, repairs are frequently required, and no reliance can be placed on the efficiency of their sterilising powers unless frequent bacteriological examinations of the filtrate can be made.

Only by boiling can water be rendered absolutely safe, and unfortunately the process is often difficult to carry out on active service. Two forms of field sterilisers are at present highly recommended. One, the Forbes-Waterhouse water steriliser, is the pattern used by the American Army. This apparatus weighs 90 lbs. when packed, and can deliver hourly 25 gallons of sterile water, having a temperature 15° to 20° F. higher than that of the raw water, with the consumption of only 8 ozs. of kerosine oil. The apparatus should be worked under shelter, as wind easily disturbs and extinguishes the flame of the lamp. The second pattern of steriliser is Dr. Leigh Canney’s, which consists of a copper cylinder, the bottom of which is involuted into eighteen pockets, so as to increase the area of its heating surface. The whole apparatus weighs 60 lbs. and can sterilise 6½ gallons of water in from nine to thirteen minutes, according to the temperature of the water, with the consumption of about 8 ozs. of petroleum. Dr. Canney states the water can be cooled in six minutes to a point at which it may be easily drunk by simply covering the mug containing it with a wet cloth. I find in India that by this method the water can only be cooled to 160° F. in six minutes, and twenty-five minutes have
to elapse before it can be swallowed with comfort. The advantages of the Forbes-Waterhouse are: (a) Continuity of action, as the reservoir holds enough oil (5 quarts) to allow of it being worked for twenty-four hours, the raw water can be continuously supplied to the apparatus from a barrel, and the sterile water is delivered unintermittingly; (b) conservation of heat by the heat exchanges, with consequent economy of fuel, only 8 ozs. of oil being required for the sterilisation of 25 gallons of water; (c) comparative coolness of the sterile water, which on delivery is not more than 20° F. above the temperature of the raw water. The disadvantages are: (a) Cost; (b) weight. The advantages of the Leigh Canney steriliser are: (a) Cheapness; (b) lightness; (c) simple to work; (d) easy to repair; (e) can also be used to boil soup or tea. The disadvantages are: (a) The large consumption of fuel, 1½ pints of oil being required to sterilise 25 gallons of water; (b) continuity of action cannot be maintained, as time is lost during the emptying and refilling of the boiler; (c) the sterile water takes twenty-five minutes after delivery to cool down to 130° F. The greater weight of the Forbes-Waterhouse steriliser is not much of a drawback to the apparatus, as it is almost counterbalanced by the extra fuel required to be carried for the Leigh Canney steriliser. Both the sterilisers are strongly constructed and should be able to withstand a fair amount of rough usage when on field service. The output from each apparatus is about 25 gallons per hour, as the Leigh Canney pattern must lose in delivery if worked for an hour or more, owing to its want of continuity of action.

It is necessary (except when the drinking water is procured from a deep well or main spring, every precaution being taken to prevent pollution of the supply during collection, distribution and storage) that all standing camps should be provided with approved water which has been sterilised by means of either of the above apparatus. Troops on manoeuvres and on the march should also be supplied with sterile water. As carts can be used on such occasions, the necessary apparatus for a regiment—four sterilisers and two 200-gallon storage tanks—may easily be sent on ahead of the troops, and sufficient water sterilised in four hours to satisfy the wants of the men when they arrive in camp and to replenish the water-bottles and water-carts, or pukhals, for the following day. It is a far more difficult matter to provide moving bodies of troops on active service with sterilised water; for it is not always practicable to carry the water boilers and necessary fuel with a rapidly moving, lightly equipped punitive force, and almost impossible in the case of
mounted troops employed on a reconnaissance lasting several days. A scheme such as Leigh Canney's, if attempted to be carried out with a force of 10,000 men, would require at least 140 mules for the transport of apparatus and the fuel necessary for fourteen days, and the sterilisers would probably not be available at the end of a long day's field operations, when the water-bottles and carts are empty and the men ready to quench their thirst at the first ditch. With the best endeavours, water-carts and pukhal-mules often cannot keep in constant touch with their units, and I do not anticipate that the mules with the sterilisers would do better. There is no doubt that troops should be supplied with some portable and rapid means for sterilising water on the field, and I think the only method will be to provide each man with sterilising tabloids and instruct him to invariably use them with any water of doubtful character. In addition, every 200 men should be provided with one steriliser, in the charge of specially trained men, which could supply them in four hours, while encamped, with sufficient approved water for their water-bottles and carts, or pukhals; though in the case of troops marching all day, camping late, and starting early next morning, the boiling of a sufficient quantity of water to meet requirements will often be found a very difficult matter.

The Forbes-Waterhouse steriliser is, I think, the best pattern for use in the field, as it has several advantages over Leigh Canney's, the lightness of which is nearly counterbalanced by the weight of the fuel required to be carried for its operation. Besides, the only type of steriliser which will be of practical use on the field is one that can supply the thirsty soldier with cool sterile water in the shortest possible time, and the Forbes-Waterhouse apparatus meets this requirement better than any other that I am acquainted with. In the case of mounted brigades on a rapid reconnaissance, companies detached to proceed on picquet almost as soon as the force has encamped, and scouts, the safety of the water supply will have to be assured, after all the approved water they may have taken with them on leaving camp has been expended, by sterilising tabloids and conversion of the water rations into tea. To obviate as much as possible the drinking of unsafe water by the men, the company officers should satisfy themselves that all water-bottles and carts, or pukhals, are filled with boiled water whenever it can be provided before the men leave their bivouac, and at the same time they should impress on them the necessity for, and safety resulting from, moderation in drinking while in the field and on the march, so that they should not be without some good water at the end of the day's operations.
Notwithstanding the very best efforts on the part of officers, it will often be difficult to persuade the men of the advisability of husbanding their good water, and next to impossible to prevent them drinking from the first available source when they are hot, tired and thirsty, and no sterile water is at once procurable. Drinking water should always be carried and stored in camp and in the field in covered metal vessels, which must be provided with taps and frequently cleaned. Leather pukhals and mussacks must never be employed for these purposes, as they are generally dirty and impossible to clean with any degree of certainty.

The minimum amount of water required per head per diem on field service is three gallons in hot weather and two gallons in cold, half being used for drinking and cooking purposes and the rest for the maintenance of cleanliness. This amount may have to be reduced on occasions to one gallon per head, cleanliness being then disregarded. In standing camps the daily allowance of water should be about five gallons per head, and never more than ten gallons; since there is difficulty in disposing of much surplus water when there are no drains. In connection with the incidence of the water-borne diseases—enteric, cholera and dysentery—among troops in camps and on field service, it should always be kept in mind that the men will be less susceptible to them if the camp area is carefully sanitized, all refuse removed and burned, excreta buried deeply and covered several times a day, trenches frequently disinfected, all cases immediately isolated, and their clothing, bedding, feeding utensils and tents disinfected. These sanitary precautions will also assist in preventing the spread of disease.

**Camp Sanitation.**

*Cooking Places.*—These should be placed on the flank of the camp which is opposite to the side nearest the trenches, just inside the perimeter when required for night work, but outside it when intended for use during the day, and at least 100 yards from the nearest latrine or urinal. The surface around kitchens should be cleared for a radius of at least ten yards and kept scrupulously clean. Kitchen refuse must always be kept separate from ordinary dry rubbish, and neither it nor the sullage water should ever be thrown on the ground. In temporary camps occupied for only one or two days, cook-house garbage and slops may be cast into separate small pits about two feet deep, which are to be dug outside the perimeter. The earth at the bottom of the pit for slops should be well loosened for a depth of a couple of inches and a little loose
earth should be thrown over the slops and dry refuse several times a day. All kitchen refuse pits should invariably be completely filled in before the troops march out of camp. In standing camps all cook-house garbage and slops should be deposited in separate covered zinc or tin receptacles, which are to be emptied at least once a day and disinfected by chlorinated lime or by burning some dry litter in them. The ground on which the receptacles are placed should be well beaten down and kept clean, the sites being frequently disinfected and moved from time to time.

Disposal of Refuse.—Refuse in any form should never be permitted to lie about a camp area. In temporary camps all rubbish should be swept into heaps and burned as soon as the camp has been struck. In stationary camps the tent floors, spaces between tents, and the camp streets should be swept daily. All light rubbish, paper, fragments of food, &c., should be collected in gunny bags to prevent any of it being blown about, removed, and burned on a selected site well away from the camp. A considerable amount of dry rubbish and litter can be usefully disposed of by burning it in the latrine and urine trenches and over soiled areas of ground, and so utilising it as a disinfectant. Though litter and dry rubbish may be safely disposed of by burial in deep pits, the method is not to be recommended for refuse in general, which should always be burned. A convenient and effective method for disposing of refuse in standing camps is to throw up a small bank two feet high round a horseshoe-shaped piece of ground, on which the litter is first allowed to partially dry and then thrown evenly along the outside of the bank and ignited. The fire burns almost continuously and no nuisance is caused. On no account should litter or refuse ever be spread out on the ground to desiccate under the influence of sun and air, as a nuisance will certainly be caused, flies will be attracted, and there is a great risk of food and water becoming contaminated. All garbage and offal should be removed daily from kitchens and slaughtering places and burned at some distance from the camp. The environs of the encampment for a radius of 100 yards should be kept free from all avoidable surface pollution. Slaughtering places and other soiled areas of ground should be daily disinfected by burning litter over them. In stationary camps, Horsfall's movable destructors might be employed for the destruction of refuse—when fuel is easily obtainable.

Latrines and Urinals.—Immediately on the occupation of a camping ground, places well outside its perimeter and to leeward should be marked off by flags for the use of the men till the trenches
have been dug, so as to prevent as much as possible the indiscrimi­nate surface pollution of the camp environs. These sites should be closed and cleaned as soon as the latrines are ready, and afterwards disinfected by burning dry litter on them, the excreta being deeply buried. Latrine trenches should in all cases be dug to leeward, in echelon on the outward flank of the camp, on a site not likely to be flooded by storm-water from higher ground, well away from the water supply, and, when the ground allows of it, at least 100 yards from the nearest tent, cooking-place, or slaughtery. It is always better to dig a few long trenches than a number of small ones, as they can be more easily supervised, and soil pollution is more limited. Accommodation should be provided for at least 10 per cent. of the strength of the force. In camps to be occupied for a single night the trenches need not be more than 2 feet deep, and no trench should be more than 2 feet wide at the top and slightly less at the bottom, the soil of which should be well loosened for a depth of several inches. A trench 20 feet long is sufficient for 100 men, and three, each 50 feet in length, will meet the requirements of a regiment. Shallow urine trenches, the bottom earth of which has been well loosened, should also be dug. When a camp is to be occupied for two or three days the trenches must be dug at least 3 feet deep, and for an occupation lasting a week or ten days the depth must not be less than 4 or 5 feet, since the use of shallow trenches will only result in a larger extent of soil pollution. All deep trenches must be filled in when the contents are about 2 feet from the top, and the earth should be well banked up over them so as to clearly mark their sites. To ensure the trenches being kept in a sanitary condition, the men should be particularly instructed to throw some earth over their dejecta before leaving the latrine, for which purpose a few scoops might be provided. The sweepers should be made to cover all exposed excreta by throwing a little loose earth into the trench three times a day; they should allow no soiled paper to blow about, and the pioneer on duty should make several daily visits to the latrines to see that these instructions are complied with. In camps occupied for more than a single night a shallow drain should be dug on the higher side of the latrine to prevent surface water entering the trench, which, if possible, should be sheltered with a light thatch roof. All latrine and urine trenches should be daily disinfected by burning in them a layer of dry litter three or four inches thick. The greatest care should be taken that all trenches have been properly filled in and banked over before the troops vacate the camping ground. To prevent unnecessary surface
pollution of the camp area, night latrines and urinals should be provided in all camps. They should be placed in the space between the perimeter and the outer line of tents on the side opposite to the cooking places, their position being denoted by a lamp or white post. In standing camps they ought to be worked on the removal system, the receptacles (empty kerosene tins) being taken into use at night-fall and removed at reveille, when the sites on which they were placed should be cleaned and disinfected with burning litter or chlorinated lime solution (1.5 per cent.). In camps occupied for only a night or two, or when receptacles are not available, a few broad, shallow trenches should be dug, filled with 3 or 4 inches of dry litter or, still better, wood ashes, and used as night latrines, their contents being removed and buried at daybreak, and the trenches disinfected; but only necessity can countenance this method. As soon as possible after the occupation of a standing camp by troops, steps should be taken to deal with all excreta on the removal system. The latrines ought to be roofed over to exclude rain, and protected by a shallow surface drain to prevent the ingress of surface water. Empty tins can be utilised as buckets. They should fit close under the seats, be completely boxed in, and if possible provided with a lid to exclude flies. A box for dry earth, with some scoops, should be provided for each latrine. The receptacles into which the buckets are emptied should always have close-fitting covers. Urinals can easily be extemporised from empty tins. A method that works very well, when attended to, is to bore some holes in the bottom of a tin and then almost fill it with bhoosa or sawdust, if it is procurable. The absorbent should be thoroughly stirred up every day, and will require to be replaced by fresh material once a week. The drainage from this urinal gives little trouble and is not offensive. It is very advisable to maintain a double set of buckets and receptacles for each latrine, as this will allow of their being disinfected every day, a process which can easily be effected by burning in them some dry litter or manure, over which a little kerosene has been poured. It is very necessary that some chemical disinfectant should be available for use in the latrines and urinals of standing camps. An acidified solution of chlorinated lime (1.5 per cent.) would be the best, since its cheapness, portability and recognised powers as a deodoriser and disinfectant more than counterbalance the drawback arising from its disagreeable odour. A very little of this solution placed in the latrine and urine pans would prove a great deterrent to flies. Day latrines and urinals should be located at least 100 yards from the
nearest tent or cooking place, and the ground about them must be kept in a clean and sanitary condition. The urine and excreta should be removed for burial in deep (at least 6 feet) trenches on some site well away from the camp. The daily increment of excreta must be covered with a layer of earth, the trenches disinfected by having a layer of dry litter, 3 or 4 inches deep, burned in them every day, and carefully filled in when the contents are within two feet of the surface. This system of removal works very well if carefully supervised, but is far inferior to the American Army trough method, in which milk of lime is utilised as a disinfectant, a plan which might with advantage be introduced into the larger standing camps.

When field operations have to be carried out in a country with an Arctic winter, all excreta and garbage from a standing camp should be disposed of by cremation. Otherwise, when a thaw sets in the nuisance caused by the exposed filth, which the frozen state of the ground prevented being covered at the beginning, would be appalling, as was demonstrated in Northern China.

Infectious Diseases.—The most important infectious diseases which occur in connection with British troops on field service in India are enteric fever, dysentery and cholera. The first is the scourge of modern armies, especially when troops are in standing camps. If a case occurs, the patient should be at once isolated and his feeding utensils, clothing and bedding carefully disinfected. The infected tent should also be disinfected, struck, removed, exposed for some days in an open place to the influence of the sun and wind, and its site left unoccupied. The feeding utensils, clothing and bedding of the other occupants of the tent should be cleaned, aired and disinfected, if necessary, and the men themselves should be kept under observation for a fortnight. Careful attention must be paid to the cleanliness of the camp area, latrines, urinals and trenches. If another case occurs, any overcrowding in the tents should be corrected, unnecessary fatigue and exposure prohibited, and strict attention paid to the proper protection of food and water supplies. When cholera occurs in camp, the patient should be isolated, the contacts segregated at a little distance from the troops, the infected tent, clothing, &c., dealt with as in enteric, and the neighbouring tents struck and pitched on a fresh site. If the contacts furnish a second case they must be again moved to a new site. All contacts must be quarantined for ten days. If the disease displays the least tendency to increase, all cases of diarrhoea and all men who are seen to frequently visit the latrine should be sent to
hospital for observation and treatment. Strict attention should be paid to the protection from pollution of food and water supplies, and to the general sanitation of the encampment. A case of dysentery is to be dealt with in a similar manner—as regards isolation and disinfection—to one of enteric. Contacts need not be quarantined, but if more than one case occurs in a tent it should be vacated, disinfected, struck, and removed to a fresh site, the original site being left unoccupied. When a tent has become infected by any contagious disease it should be evacuated, all clothing and bedding removed for disinfection, the poles scrubbed with a 5 per cent. solution of carbolic acid, and while still pitched, both the inside and outside of the tent should be thoroughly drenched with the same solution. The tent should then be struck, removed, and exposed to the sun and wind for ten days on some open site. The polluted tent area and its immediate surroundings should be well saturated with a 10 per cent. solution of chlorinated lime and, if possible, should not again be encamped on. Tents used for the treatment of any infectious diseases should be similarly dealt with. Every large standing camp should be provided with a Thresh's portable emergency steam disinfector, or an Arnold's steam steriliser, for the disinfection of clothing belonging to cases of contagious diseases.