ENTERIC FEVER AND SEWAGE DISPOSAL IN TROPICAL COUNTRIES.

(One Map.)

By MAJOR A. R. ALDRIDGE, R.A.M.C.,

Naini Tal, N.W.P., India.

That many epidemics of enteric fever have been caused by contamination of central water-supplies is beyond dispute, but evidence is accumulating that makes it difficult to attribute its widespread prevalence in endemic form in India and elsewhere to this cause. It is necessary, however, to guard against assuming that therefore the disease is not water-borne. There are in India innumerable chances of water, when stored for domestic use, being contaminated, besides the same possibility in the case of food, feeding utensils, and cloths used for cleaning them. And when it is claimed that dust or flies play an important *rôle* in its dissemination, it is not necessary to assume that the bacillus is taken into the mouth or respiratory passages directly, but rather that it is conveyed to water, &c., by means of dust or flies.

There seems, indeed, a danger of constructing two apparently opposed theories, where in fact the one is actually the complement of the other.

In Indian cantonments sudden, severe epidemics, such as are to be expected as the result of contaminated central water-supplies, account for but a small proportion of the cases of enteric fever: and pipe water-supplies have not produced the improvement that was expected, although in many cases their construction is such as to make it difficult to conceive the possibility of repeated pollution. Nor has the boiling of drinking water, which has been carried out for several years in many stations, apparently produced any reduction. It is noticeable, however, that in almost all cases the boiled water has been stored in detail in barracks, this being necessary so as to allow it to cool.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

The following table shows the prevalence of enteric fever among British troops in all stations in India with an average strength of over 1,000.

Average annual admission rate per 1,000. 1889–98[1].

Agra	48·6	Rawl Pindi	28·6
Bareilly	40·6	Secunderabad	25·2
Lucknow	40·2	Bangalore	20·3
Chakrata	36·8	Poona	18·1
Ranikhet	36·5	Kamptee	12·2
Meerut	35·6	Rangoon	9·6
Mhow	35·1	Wellington	8·8
Allahabad	34·5	Mandalay	6·1
Sialkote	33·0	Calcutta	5·4
Umballa	31·1	Aden	4·9
Quetta	30·7	Bombay (Colaba)	4·2
Peshawar	30·1	Belgaum	2·9

Of these 24 stations the 13 having the highest admission rates are geographically very distinctly separated from those having low rates; all being situated in, or closely bordering on the dry, dusty, alluvial plain of Upper India. The climate of this tract is for a great part of the year excessively dry and dusty. On the other hand, of the 11 stations having a relatively low rate four are situated on or near the coast, with a damp climate throughout the year; while the remainder are situated on rocky soils of volcanic origin and are relatively free from dust.

Further, in the first group the season of greatest prevalence is during April and May, the driest and dustiest months of the year.

The following table shows the total number of cases in these 13 stations during the period 1891–1900.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
421	193	439	884	843	598	583	640	620	467	538	599

In the other group there is an exacerbation during the rainy season, in August, which in some cases is greater than that in the spring, as the following table shows:

Total admissions in group II., 1891–1900.

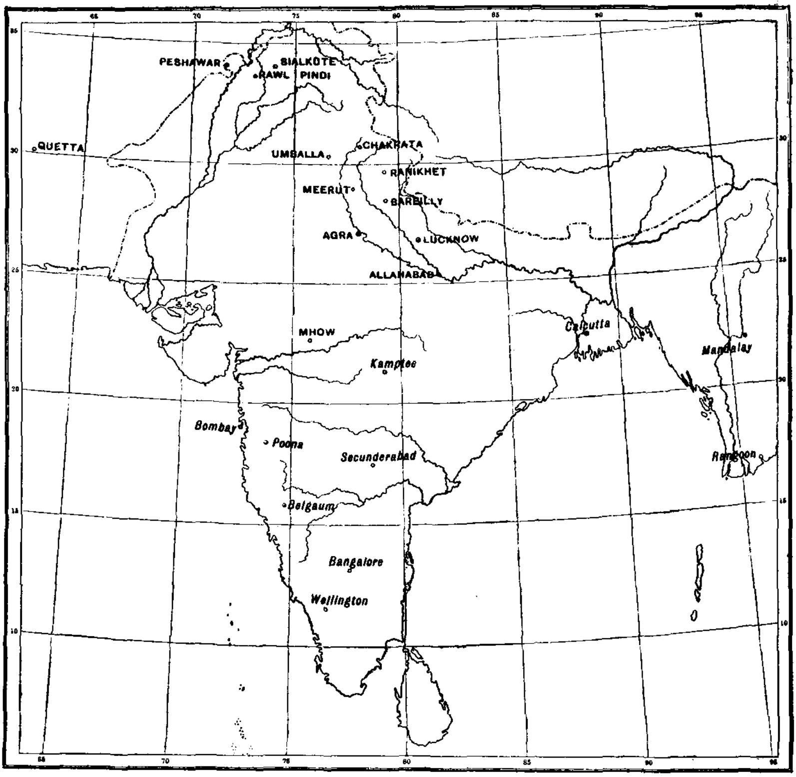
Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
93	124	148	128	112	114	219	296	229	144	118	84

No peculiarity of water-supplies will account for these differences, for well and pipe supplies are to be found in both groups. As regards sewage disposal, the dry earth system of latrines is in force in all; and

[1] Annual Report of the Sanitary Commissioner with the Government of India, 1899, p. 51.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

with only one or two exceptions a trench system (either shallow or deep) of disposal.



All places in capitals have an admission rate over 28 per 1000.
All places in italics have an admission rate under 26 per 1000.

The latrines and urinals are not provided with impervious floors, and all spillage, which,—from their construction—in the case of urinals is frequent, soaks into what is in most stations a dry, powdery earth.

It is a matter of common observation that water stored in such dry, dusty places will in a very short time be covered with a scum of dust, even though the receptacle be covered.

The same must happen with food and utensils: while the habit of Indian cooks of "cleaning" metal vessels,—in spite of all protests—with earth, may also be a means of this dust reaching water and food. That some of this dust comes from the floors of the latrines and urinals, scattered as they are all over barracks, often at no great distance from cook-houses and stored water, can hardly be doubted.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

Similarly in many stations the trenching grounds are sufficiently close to barracks for the sandy soil of which they are composed to be easily carried by the wind, and particularly by dust-storms, which are of frequent occurrence in many of these stations during the dry season.

Recent researches tend to show that the vitality of *B. typhosus* in water and soil is not great; in fact, as Horton-Smith[1] has pointed out there is so far no proof that the bacillus can multiply outside the human body. Such an assumption is, however, not necessary to account for its frequent presence in polluted soils, for it has been fully established that persons recovered from an attack of the disease may for months and years continue to disseminate the bacillus in the faeces, and more particularly the urine.

These researches seem to indicate that when enteric fever is almost continuously present there must be repeated infections from fresh evacuations, which can be explained in the way suggested; but such can hardly be conceived in the case of well-protected pipe supplies. Numerous instances could be cited in support of this view.

Two epidemics in Cherat[2], one of which was investigated by the writer, showed a marked tendency for the cases to occur in groups, with an interval closely corresponding to the incubation period of the disease, suggesting that each group was infected from the former. Thus, one barrack furnished its first case on 27th May, the second 14 days later, a third 15 days later, and after another interval of 10 days six cases between 5th and 20th July. Another barrack had its first case on 19th June, two following on 25th and 28th; after an interval of 16 days five cases between 14th and 23rd July, and one more case after another interval of 11 days. A third barrack, commencing on 7th July, had five cases in five days, and 14 days later two more. Both epidemics attacked chiefly (one almost exclusively) the occupants of barracks at one end of the station, close to the incinerator, where faecal matter was continually standing in heaps, mixed with dry refuse to partially dry before it could be put into the incinerator. The water was derived from protected springs, four miles distant from the station. The springs were well away from any apparent source of contamination. The water was however stored in barracks in loosely covered vessels, and dust-storms were of frequent occurrence. May not each of these groups of cases

[1] Goulstonian Lectures for 1900, *Lancet*, Vol. I. p. 826.

[2] Annual Report of the Sanitary Commissioner with the Government of India, 1899; and Report by Major A. M. Davies, R.A.M.C., "On Sanitary Investigations and Bacteriological examinations at Cherat," June, 1898.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

have been infected by this means from the evacuations of the former cases, passed during the early stages of the disease, before admission to hospital?

Recently enteric fever was very prevalent in a station with a pipe water-supply derived from protected wells, and in which no possible source of contamination could be found. I failed to find in the water either *B. typhosus* or any organism indicating sewage contamination. Nor could any connection be traced between the cases and any particular supply of food, dairy produce, or mineral water, nor with any particular place of residence or resort. It was found that the clothes, including kitchen cloths, were being washed at a place very close to the filth trenches, so that dust from the trenches was being blown in clouds over them. I exposed a sterilised cloth to this dust, and from "washings" from this isolated *B. coli*[1] and a bacillus giving the typical reaction in milk of the *B. enteritidis sporogenes*.

The following experiments were undertaken with a view of testing how far the bacterial contamination of water by means of dust could be traced.

In order first to ascertain the bacterial constituents of soils which might be expected to be polluted, 1 c.c. of soil was mixed with 100 c.c. of sterile water and this water examined.

Streptococci were searched for on surface agar plates, and suspected colonies sub-cultured in broth.

For the colon group, the water was added to ·05 % carbolic broth, incubated for 24 hours at 37° C. and then plated on glucose-litmus agar and carbolic agar.

B. enteritidis sporogenes was searched for by the usual reaction in milk.

Water No. 3 was from a filtered pipe-supply, frequently examined bacteriologically and containing about 30 colonies per c.c., none resembling *B. coli*.

The tank No. 4 was filled by a pump and pipe from a covered well. The water of this well, examined at the same time, contained 185 colonies per c.c. and did not show the presence of *B. enteritidis sporogenes*.

Cladothrix and *B. mycoides* are not commonly found in good waters[2],

[1] This bacillus was typical as regards colonies and microscopical appearances. Gas was produced in glucose-agar in 24 hrs. Indol in 4 days. Milk not coagulated in 3 days.

[2] Houston, "Report on the Chemical and Bacteriological Examinations of Soil Washings." 28th Annual Report of the Medical Officer to the Local Government Board, pp. 453 and 455.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

	Number of colonies per c.c.	Streptococci	*B. Coli*	*B. enteritidis sporogenes*
1. Soil from floor of latrine	26400 *B. mycoides* very numerous; *Cladothrix*	·01 c.c. Present Broth turbid, stringy deposit, pellicle On agar colonies granular, no chains at edges Cocci in short chains or some groups	1. c.c. Considerable number of coliform colonies Milk coagulated in 48 hrs. Gas in 24 hrs. Indol in 4 days	1. c.c. Not present
2. Soil close to a latrine	18500 *B. mycoides*; *Cladothrix*	·01 c.c. None	2. c.c. Coliform Colonies not numerous Milk coagulated in 4 days No gas Indol in 6 days Neutral red decolorised	1. c.c. Present Reaction in 24 hrs.
3. Water stored in an uncovered 'chattie' in a barrack-room	283		1. c.c. Considerable number of coliform colonies Milk coagulated in 4 days Indol in 5 days No gas	
4. Water from iron tank, with loosely fitting cover; 40 yds. from a latrine	620	·5 c.c. None	5. c.c. None	1. c.c. Present Reaction in 24 hrs.
5. Sterile water exposed in bottle 10 yds. from a latrine for 1 hr. on windy day	1290 *Cladothrix* (50 per c.c.) *B. mycoides* very numerous	·1 c.c. None	5. c.c. None	1. c.c. None

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

though I have occasionally found them in small numbers in water from uncovered wells, in which cases also they may have been derived from dust.

These observations indicate that water may be contaminated by various bacteria carried by dust. Since *B. typhosus* has on several occasions been isolated from the soil, and it having been proved that it can withstand a considerable amount of drying[1], it can hardly be doubted that the bacillus may be conveyed by dust.

In accounting for the almost universal prevalence of *B. typhosus* in Indian cantonments the probability of infection from native sources must not be overlooked. There can be little doubt that the disease is much more common among natives than has hitherto been supposed. Thus, Captain G. Lamb, I.M.S., has recently published[2] a series of 11 cases, the diagnosis having been confirmed in 9 by the sedimentation test, in 2 by post-mortem appearances. Other observers[3] have also recorded considerable numbers of cases, in many of which the diagnosis has been similarly confirmed.

The histories of modern campaigns still further confirm these views. All recent British campaigns, with the exception of Ashanti, in which enteric fever was absent, have been in dusty climates, and in all enteric fever has been very prevalent. The conditions of active service add to the facilities for the dispersal by dust and flies of excremental matter, dry methods of disposal being always used. At the Modder River, S. Africa, the soil was "trampled and pulverized by thousands of feet to an impalpable powder. This mixed with excreta was wafted in dense clouds." The men "urinated and defaecated in the neighbourhood of the tents[4]." No doubt in some cases central water-supplies have been infected, but apparently not in all. In the Spanish-American war at Jacksonville, Lexington, and Knoxville the troops used water from the same source as did the civil population, yet while the troops suffered severely the civil population practically remained exempt[5]. In Egypt, in 1885, certain of the troops supplied with distilled drinking-water suffered severely[6].

[1] Macé, *Traité de Bactériologie*, p. 710.

[2] Lamb, G., from Plague Research Laboratory, Bombay. "Typhoid fever in natives of India, its diagnosis by means of the serum sedimentation reaction."

[3] Buchanan, A., *Indian Med. Gazette*, 1899, pp. 336, 403, 446; 1900, pp. 53, 174. Rogers, L. *Ibid.* 1902.

[4] Ryerson, G. S. (Lieut-Col., Canadian Army Medical Staff). Address to Toronto Clinical Society, Oct. 1900.

[5] Munson, *Military Hygiene*, p. 681.

[6] Army Med. Department Report, 1885.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

In European towns, too, the decline in enteric fever has been noticed to follow more closely on the substitution of sewers for various dry methods of removal than upon the improvement of water-supplies.

Death-rate per 1000 *from Enteric Fever*[1].

	Before sewering	After sewering
Frankfurt	·87	·24
Dantzig	·90	·18
Munich	2·42	·17

In the Leicester epidemic of 1894 one street showed five times as many infected houses among those using the tub-system as among those having water-closets and sewers. At Newcastle cases were twice as numerous in houses with the dry-earth system as in those with water-closets: and in Birmingham the incidence was one and a half times greater with pails than with water-closets[2].

I have attempted to show that in combating enteric fever in tropical places it is not sufficient to obtain a water pure at its source, nor even to purify a doubtful water; but that the chances of its contamination later are as great,—in many cases greater—than at its source. I believe that these possibilities have not received the attention they deserve. What means, then, should be adopted to meet this contingency?

(1) Avoidance as far as possible of all storage of water near habitations where, from the proximity of dry-earth latrines and filth trenches, it may be polluted.

Boiling, except as a temporary measure, where there is definite reason to suspect contamination of the supply is likely to add to rather than lessen the risk, on account of the storage necessary for cooling. Boiling and cooling can only safely be carried out in a special apparatus, such for instance as the Waterhouse-Forbes, which seems to have proved a success in America.

(2) Latrines and urinals should be situated as far as practicable from kitchens and from stored water. At present it is only too common to see them within 30 or 40 yards of uncovered wells, water tanks and kitchens. They should have impervious floors, from which spillage can be removed by washing, so that it may not contaminate the dust.

(3) All food, feeding utensils and everything used in their preparation (including the washing of cloths, &c.,) should be protected from dust and flies.

(4) It can hardly be expected, however, that these means alone

[1] Oldright, quoted by Munson, *loc. cit.* p. 541.

[2] Moore, quoted by Munson, *loc. cit.* p. 538.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press

will be enough, and a thorough trial, at some place where enteric fever has for many years been excessive, of water-carriage of sewage, combined with a method of disposal that will avoid dust dissemination seems more than justified. For the carriage of sewage, water-closets and sewers would be the most satisfactory method: though trough closets and removal by pumping into iron tanks on wheels might, for economic reasons, have to be substituted in some cases, it can only be considered as distinctly inferior.

(5) For sewage disposal, one of the bacterial methods, with application of the effluent to land, seems particularly applicable.

Experiments in India have already shown that even with a dilution as low as 3 gallons per head a satisfactory amount of purification can be obtained[1]; the effluent being non-offensive and non-putrescible. While in England the criterion of the results of these methods is that the effluent shall be sufficiently pure, as measured by chemical standards, to allow it to be discharged into rivers, in India this will seldom be necessary. Irrigation is necessary during a considerable part of the year in almost all parts: this in fact is one of the chief obstacles to the profitable application of crude night-soil to the land. The same degree of purification need not, therefore, be insisted on. A non-putrescible effluent, in which the organic matter has been reduced to constituents which can be readily assimilated by growing plants is all that is required; and such an effluent has been shown to have considerably greater manurial value than crude sewage. In fact the water of the sewage, which is an obstacle to its disposal in England, would be an advantage in India.

To determine which of the various methods available is best suited to the requirements of Indian cantonments will require careful experiments. A closed septic tank, followed by continuous filtration, in connection with which I had the opportunity of making some experiments, gave good results, both as regards the condition of the effluent and the amount of labour required; and there are many points in favour of this method.

In combating the disease in armies in the field the principles remain the same, though the means that can be adopted must vary somewhat.

[1] James, C. C., "Notes on sewage disposal," 1901. *Ibid.* "Further notes on sewage disposal," 1901. Silk, A.E., "A sewage disposal experiment in Calcutta," 1900. Roberts, E., "On some practical methods of sanitation in India," 1901. By Director-General of Agriculture, Bombay, "Report on the cropping experiments at Manjri," 1901.

https://doi.org/10.1017/S0022172400001790 Published online by Cambridge University Press