THE SUPPLY OF DRINKING WATER IN INDIA AND ITS CONNECTION WITH THE SUBSOIL WATER.

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This paper is written with the object of giving a possible explanation of the outbreaks of diseases, such as enteric, cholera, &c., which sometimes occur when all recognised precautions have been taken. In India most of the water used for drinking and domestic purposes is obtained from wells, therefore a knowledge of the construction of the same, and their sources of supply, is of great importance.

Wells may be divided into two classes: (a) shallow, (b) deep. A shallow well draws its water supply from the subsoil, while in a deep or artesian well the water is obtained from below some impervious stratum which separates it from the subsoil above. By far the larger number of wells met with belong to the first class. The remainder are deep or artesian wells and should always yield good water, but often, on account of faulty construction, communication with the subsoil water and consequent contamination occurs. Sometimes the spring (artesian) water may ascend to a higher level than the subsoil water. If this be the case, water will flow from the artesian well into the subsoil, and the well water will probably remain pure; but, on the other hand, if the subsoil water level is higher (temporary or otherwise) the reverse is often the case, and if the subsoil water is impure it may pollute that in the well. Pipes used for pumping purposes are also a source of danger (vide Dr. G. Turner's report on the water supply to the Suffolk County Lunatic Asylum, in which two outbreaks of dysentery occurred, due to leakage in the pipes), and considerable difficulties are met with in preventing pipe leakage, and the results are always uncertain. It is therefore evident that no well water can be relied upon unless the purity of the subsoil water is above suspicion.

The direction of the subsoil water flow is usually towards some river, proceeding more or less in channels. The deepest parts form streams, which are fed by smaller tributaries, so that, generally speaking, certain areas of ground are drained by certain underground streams, much in the same way as the surface of the earth is drained. The rate of the movement of the subsoil water is slow, depending upon the nature of the subsoil, but in the so-called...
streams it may travel very rapidly. Not every one appreciates the importance of, say, when troops are encamped on the banks of a river, arranging to draw the drinking water from up stream, and only allowing animals to be watered, &c., down stream, and I think it is scarcely less important to make corresponding arrangements in regard to the subsoil water supply. Thresh takes a square mile occupied by 1,400 people, and finds the water obtained from three sides constant and free from organic impurities, but the water from the fourth side (the direction of the subsoil water flow) varied, and was often impure and unfit for domestic purposes. As most stations in India are occupied by more than 1,400 people to the square mile, wells on side of subsoil water flow are likely to be even more polluted.

During a small outbreak of enteric in a station where I was posted the Senior Medical Officer himself analysed the water in every well. While I, unknown to him, by means of a contour map of the subsoil water of the station (fig. 2) classified all the wells as...
bad, good, &c.; and his classification of the wells from the chemical examination and mine corresponded throughout. My classification was made by condemning wells receiving their supply from an impure source and vice versa, and I feel certain that if contour maps were made of all thickly populated areas, many wells would be put out of action with advantage to public health.

This examination of the source of water supply to a well appears to me to be of greater advantage than examining a well chemically, because the well water may sometimes be pure and at other times polluted and unfit for drinking purposes. The same applies to the before-mentioned deep or artesian wells, and it is quite possible that this temporary infection of wells is a cause of occasional outbreaks of diarrhoea, dysentery, &c.; the well water being unquestioned, because from constant use and may be occasional analysis it is thought to be pure. An instance of this is shown in well (E) fig. 1, which is a case that has come under my notice.

The well (A) receives its water supply from subsoil stream (C), the subsoil water supply of which is contaminated by a large bazaar.

The well (B) receiving its water from stream (D) is pure, and the source of supply beyond contamination, as it is protected by a large parade ground, and the country beyond is not thickly populated.

The well (E) is usually good, but may be temporarily contaminated, due to heavy rainfall; when the stream (C) swells to level (F) the water in well (E) becomes polluted.

If the ground in the neighbourhood of stream (D) was in any way fouled, it might, after a heavy rainfall, become contaminated; as a matter of fact it is not, and (B) is a constant and pure supply. Well (A) has been closed, and water from well (E) only used after being boiled.

Arrangements are being made to close (E) and convey water from (B) by means of pipes. It would therefore appear that much might be done to further improve the health of Indian stations by paying more attention to the geological formation of the ground in the vicinity of the station, and especially to the origin, course and protection of the subsoil water, and for this purpose I think that a contour map of the subsoil water, made by an engineer, and giving the rise and fall of subsoil water and other necessary geological data, should be made of every station, thus forming a basis upon which to work. A map of this kind seems to me to be as important to those responsible for the hygiene of Indian stations as a detailed map of the country is to the strategist.
Some place great faith in the purifying property of the earth, and hold that after the rain has passed through a sufficient thickness of this natural filter, micro-organisms are not found, and that the water is free from organic matter. Koch is a great adherent to this, but other authorities are equally against it in practice. The town of Frankfort derives a good water supply from the subsoil water of an extensive wood, but this wood is carefully kept free from habitation and other sources of contamination. No authority would, however, infer that you can with impunity dispose of refuse, or have bazaars, grave-yards, &c., over your origin of subsoil water; certain conditions are absolutely necessary before the subsoil water can be in any way trusted, namely (a) the locality must not be thickly populated; (b) any refuse to be disposed of must be spread over large areas and on no account put in pits; (c) there must be a living surface, and on no account must this be removed; (d) the porous filtering subsoil must be of a sufficient thickness; if too thin, then its purifying power by oxidation and filtration is limited, and the rise of the subsoil water must, on this account, be known. Here also it is important to know the character of the filtering media. If of a sandy nature, purification can take place by virtue of oxidisation assisted by periodic flushing; on the other hand, if the subsoil contains much clay, especially black clay in which there is a large percentage of organic matter, such a process of purification is impossible, and we have, in fact, a culture medium. Now, we cannot know that these necessary conditions exist unless a thorough examination of the ground has been made, and therefore the importance of a thoroughly reliable map. Caution must be exercised when reliance is placed upon the purifying property of the soil, especially if the characteristics be unknown, for the soil is, after all, a filter, and all filters, whether artificial or natural, are treacherous, and are a source of danger if not constantly attended to by some competent person. One must also be always on the look-out for the formation of fissures, which may occur at any time, and at once destroy one's filter, especially in view of the fact that impurities may travel long distances in fissures without undergoing oxidation or change. For example, the cause of the epidemic of enteric at New Herrington was traceable to a drain three-quarters of a mile away, and due to a fissure in the subsoil stratum. The above applies to subsoil water, but it is also important to know all about your collecting surface of the supply to deep or artesian wells; if far away the water will probably be pure, but if within a few miles the collecting
surface ought to be protected. Especially is this the case if the soil is very porous or fissured. Another source of pollution to be carefully guarded against is the presence of disused wells, which are often used by natives for insanitary purposes. Should these wells be situated on the up-stream side of the station, they obviously are a source of great danger, and clearly shew the necessity of keeping all the wells over the source of the water supply under rigid supervision. That subsoil water ought to be protected can be seen from the following list of waters, arranged according to purity:

(1) Deep spring water; (2) deep well water; (3) upland surface water; (4) moorland water; (5) subsoil water (distant from aggregation of houses); (6) land springs; (7) river water; (8) subsoil water (under villages and towns).

In conclusion, I would quote the following from Thresh, which I think applies even more forcibly to India: "Notwithstanding the immense progress which has been made in this country in recent years in practical sanitation and sanitary administration, outbreaks of preventable diseases, due to pollution of water supplies, have been all too frequent. Common-sense suggests that if it is desired to obtain a pure supply of water a source should be selected removed as far as possible from any contaminating agencies, and every reasonable precaution which science or experience can suggest should be taken to prevent either wilful or accidental pollution."

I certainly think that much might be done in India to further the progress made in recent years by studying more minutely the geological formation of our stations, and by paying special attention to the direction of flow, &c., of the subsoil water. Maps should be made by engineers, supplying all necessary information, and be issued to standing barrack committees and district municipal boards, &c.; and when land is selected by them for building or entrenching purposes, &c., due consideration should be given to the direction of the flow of the subsoil water, and entrenching grounds should always be put on the down-stream side of the subsoil water supply to a station. If the nature of the ground or the want of space prevents this being carried out, then those wells receiving their water supply from areas liable to pollution should be closed, and the water supply drawn only from wells which are not open to any possible source of contamination.