An Enquiry
into the Water Supply
of a Rural District
and
its probable bearing
on the health
of the Population.

W. Thomas Crawford M.A.
The most careless and unscientific amongst us will readily acknowledge our almost absolute dependence on that precious and happily generally own present element water, and this being so, such questions as to the salinity of its source and the efficacy of the means employed in bringing it into our houses are of supreme importance, both to the individual and the community at large.

From 442 B.C. when the first Roman aqueduct was constructed by the Roman Emperor Claudius (whose name is bore) to the present day, the question of water supply has occupied the attention of civilized nations. The Greeks are commonly credited with the knowledge and use of aqueducts but unfortunately there exist no remains of such constructions. Solomon constructed an aqueduct to convey water from Bethlehem to Jerusalem. The Egyptians collected water from the tops of mountains, conveyed it through earthenware pipes
and regulated its fall by breaks into casks according to the strength of the pipes. (vide Sir E. Chadwick. General History of the Principles of Sanitation. 1889, p. 62.)

While the lines of grand fragments which stretch in various directions across the Roman Campagna still testify to the care and labour which that famous nation expended on their water supply. I would like to call attention in present to the interesting fact that the Romans never brought the water to the light till it has to be used, and it must therefore have escaped many sources of contamination. An Aqueduct near Sora which is in use up to the present day, is a testimony to the excellency of their work.

The discovery of death dealing germs in the precious element has been left for later times, and we are now aware of constant menace to life and health in a simple cup of cold water, while if Jaeger (Die pathologie des infektionen fieberhaften Intemin. Zeitschrift fur Hygiene. Vol XX. 1892. p. 526)
be right in attributing an outbreak of jaundice fever in a military station on the Blu (a tributary of the Danube) to the fact of the men bathing in the stream which was infected with the Proteus fluorescens bacillus, our very ablutions are sometimes a source of danger.

With the object of enquiring into the water supply of the district with which I am more immediately connected, I have during the last few months analysed the drinking water used by the inhabitants of the town of Worksop in the county of Nottinghamshire and some of the surrounding villages, and having also examined the vital statistics of the district for the last ten years, I think it will be interesting to inquire what relation, if any, can be traced between the two. In doing this I propose to consider:

I. The general configuration and geological formation of the country.

II. The various sources of water supply.
The analysis chemical and bacteriological of the water.

The vital statistics of the district and lastly the bearing of the water supply upon those statistics.

A workhop with a population of 120 may be considered a typical rural town and it lies in the midst of one of the most picturesque counties of the Midlands of England, in what at one time was the old Sherwood Forest.

The country is in strong contrast to the steep escarpments of the mountainous stone districts of Derbyshire and the high peaks of the millstone grit of Norfolk. It is undulating and the average height of the land above the sea level is 100 feet. The greater part of the land is under cultivation but it is also extensively wooded. Three miles from the town are two collieries which give employment.
to a large number of the inhabitants.

The district is rich in mineral resources. We have the vast mineral wealth of the Coal Measures covered by higher formations, some of which are inferior to those in agricultural value and which contain in regular sequence fine sand, lime stone (said by Sir Gilbert Scott to be one of the best building stones in the kingdom) numerous beds of brick earth, a band of iron stone of unusual richness, and below all several seams of workable coal.

The physical features of the district are dependent on geological causes. They consist of two lines of hills running nearly north and south with steep escarpments towards the west. These ridges are broken by small streams, the Nethan, the Poltair, and the Strichen which flow from west to east.

The soil also varies with the stratification, being in parts a clay clay
but more generally very clay and sandy. Taking the beds in their order of superposition we have:—

**Secondary**
- *Permian*
  - Upper Magnesian Limestone
  - Marl and Sandstone
  - Lower Magnesian Limestone

**Primary**
- *Coal Measures*
- Upper Coal Measures
- Lower Coal Measures

The *Keuper* occupies but a very small portion of the district. It consists of marls and sandstones. The former are used in one or two parts for brick making.

The *Bunter* consisting of Conglomerate and pebble beds covers the largest area. It probably has no great thickness, but as it dips gently towards the east and the surface has nearly the same inclination
it covers a large extent of country. Its striking feature is the quartz pebbles, the debris of older rocks which sometimes form a hard conglomerate, but generally lie loosely in the sand.

The Upper Triasian limestone forms a thin layer and in it many fossils are found.

The Permian marl and sandstone consist of alternate beds of red marl (or strong clay) and sandstone.

The lower Triasian limestone is of great importance and covers thethal district. In one part it attains a thickness of 120 feet. It is a calcareous sandstone containing a large admixture of silica.

The coal measures are formed of an upper layer of brown stone and red grit rock. The latter which is of great thickness and of very open character contains large springs of water which when tapped by bore holes form artesian
II. In investigating the question of
point II, I find that Lorkesp
used to be supplied with water
from numerous wells, but as these
being found in most cases to yield
and impure water, a bill was passed
in 1875 authorising the town to be
served from an artesian well which
was sunk through the sandstone
to a depth of 160 feet. The water
is stored in a large central reservoir
and there is a daily supply of
20 gallons per head of the popula-
tion.
To the north and west of Lorkesp
and included in this district in
which, as Medical Officer, I am
particularly interested are the villages of Barton with a population of 639, Oldcroft with a population 491, and Hodersick boasting 125 inhabitants. To the east lie the colliery villages of Shireoaks and Stetley and to the south Hardwick. It is with the water supply of these villages that I propose to deal and this is in each case derived from numerous wells which are chiefly shallow. I have taken the samples analysed from these wells which are in most general use.

With regard to the drainage, in 1859-60 carried out a thorough system of sewerage and drainage at a cost of £6000, the system being devised by Mr. Robert Rawlinson. The sewage is utilised in a well managed sewage farm built on ground sloping away from the artesian well from which it is a mile distant.
In the villages the drainage is chiefly on the privy system. Below the lime stone there is a large and good supply of water which breaks out in the form of springs all over the district. The wells are almost entirely surface wells, are in close proximity to the houses and have no special means of protection from contamination. The obvious want seems to be deep wells sunk at a distance from all possible source of pollution and from which the water could be conducted by means of pipes to the houses. Only in the village of Aldwaters is there such a well the people being allowed to make use of it on a small yearly payment.

With regard to the analysis of the water I have taken samples from the various pumps and have conducted the analysis on the same day. In addition to the chemical
I have paid great attention to the bacteriological examination of the water, looking upon this as of equal, if not of greater, importance than the chemical examination as showing its possible bearing on the occurrence of enteric fever and diarrhoea.

In conducting the bacteriological examination I have used gelatin peptone as the culture media, and a gelatin of the same degree of alkalinity in each experiment. This is a very important point as has been shown by Reinsch ("Die bakteriologische Untersuchung des Trinkwassers," Centralbl. f"ur Bakteriologie, 1891. Vol. X p. 413) by means of some interesting experiments on the addition of different quantities of a concentrated solution of sodium carbonate to the gelatin peptone, and the effect produced thereby on the development of water microbes. He found
that the introduction of 0.01 gram Sodium Carbonate caused the number of colonies found to be six times as great as that revealed by using the ordinary gelatine.

Dahmer, more recently in experiments on the development of bacteria present in water derived from the Rhine has found that the addition of 0.15 per cent Sodium Carbonate induced the development of the largest numbers of water microbes.

Another point of importance is that the gelatine must always be melted at the same temperature, in order that no microbes should be destroyed by being exposed to excessive heat.

The gelatine then was made alkaline by the addition of 0.15 per cent Sodium Carbonate, and was always melted at a temperature of 25°C. So the gelatine contained in a sterilised test tube I then added by means of a sterilised pipette half a cubic
centimetre of the water to be examined, mixed it well, and poured the contents into a sterilised Petri dish and allowed the minuses to develop for two days at a temperature of 16° C. I then counted all that were visible by means of a hand lens of 3/4 inch focal distance.

In obtaining the water for examination in every case I pumped continuously for 15 minutes before abstracting the sample. This of course is not a fair test of the bacterial condition of the water gaining access to the bell, as the sides of the latter are covered by a slimy deposit, and if the water has remained stationary for any length of time ample opportunity is afforded for the extensive multiplication of microorganisms on such surfaces. On pumping being resumed these surfaces will be washed down and consequently...
in the first pumping the water will receive a great influx of microorganisms. Herceus examined a well water which had been very little used during the previous thirty six hours and found 5,000 organisms per cc. But after the well was emptied by continuous pumping a second sample was collected after an interval of half an hour, and only 35 in the cc were present.

Maschek has shown the effect of pumping on the microbical contents of well water thus:—

After continuous pumping for 15 min. 439 per cc.
After pumping for many hours —— 463 per cc.
Later —— 68 per cc.


But admitting these facts no one thinks of pumping a well dry before drawing the drinking water, and I think such observations would be valuable for elucidating
reliable information as to the condition of the water drunk, and
as following this idea I acted as indicated.
I began my analysis by examining the water as supplied to the
town by the Horrocks Water Company, and this may be taken as a guide
to what the purity of the water in this district should be. The result
was as follows:
Physical characters. Is sediment colour taste or smell well aerated.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
<th>Parts per</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>4</td>
<td>100,000,000</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>8</td>
<td>100,000</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanganate</td>
<td>120.3</td>
<td>Parts per</td>
</tr>
<tr>
<td>Total solid matter</td>
<td>6.5</td>
<td>100,000</td>
</tr>
<tr>
<td>Total hardness</td>
<td>255.3</td>
<td>100,000</td>
</tr>
<tr>
<td>Chlorine</td>
<td>3-4</td>
<td>100,000</td>
</tr>
<tr>
<td>Nitrogen as Nitrate &amp; Nitrites</td>
<td>0.66</td>
<td>680 per cc.</td>
</tr>
<tr>
<td>Bacteria</td>
<td></td>
<td>680 per cc.</td>
</tr>
</tbody>
</table>

Carlton 9s.1 Pump.
This water was taken from a pump.
On the Village Green. It is on the highest ground in the village and is used by a large number of people living round about. The ammonia, nitrogen, and chlorine are well below the average of a good drinking water, but the alkalimide Ammonia is slightly in excess and is probably derived from vegetable contamination.

Physical characteristics: No color, slight taste or sediment.

Reaction: Alkaline

Saline ammonia: 0.1 parts per 100,000,000

Organic ammonia: 16 parts per 100,000,000

Nitrogen absorbed from Permanganate: 40 parts per 100,000,000

Total solid matter: 85 parts per 100,000,000

Total hardness: 23.5 parts per 100,000,000

Chlorine: 5.4 parts per 100,000

Nitrogen as nitrate nitrites: 7 parts per 100,000

Victoria: 800 parts per

Carlton No. 2 Pump.

This water was taken from a well in a farm yard and is used by the farm people and the inhabitants of a row of ten houses close...
at hand. The Ammonia and Albuminoid Ammonia are high, this is probably due to vegetable contamination.
The water shows a high degree of hardness.

Physical Characters: No colour, taste, smell or sediment.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>16 parts per 100,000,000</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>14 parts per 100,000,000</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanocarate</td>
<td>7.0</td>
</tr>
<tr>
<td>Total Salt Matter</td>
<td>77.2 parts per 100,000</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>81.4 parts per 100,000</td>
</tr>
<tr>
<td>Chlorine</td>
<td>4.0</td>
</tr>
<tr>
<td>Nitrogen as Nitric Ammonia</td>
<td>0.01</td>
</tr>
<tr>
<td>Bacteria</td>
<td>980 per cc</td>
</tr>
</tbody>
</table>

Wrotton No. 3 Pump.

This well is immediately outside a row of Collier's houses and is used by eight families. The pump being against one of the cottages, and the gutter into which much filth is thrown, runs immediately along side. I was surprised to find the water yielding this comparatively satisfactory result of analysis.
Physical Character: Slightly yellow colour, no taste, smell or sediment.

<table>
<thead>
<tr>
<th>Component</th>
<th>Parts per</th>
<th>Parts per</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline</td>
<td></td>
<td>6.0</td>
</tr>
<tr>
<td>Saline Ammonia</td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td></td>
<td>140.0</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanganate</td>
<td></td>
<td>6.0</td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td></td>
<td>24.2</td>
</tr>
<tr>
<td>Total hardness</td>
<td></td>
<td>7.2</td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Nitrogen as Nitrate Nitrites</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Bacteria</td>
<td></td>
<td>1360 per cc</td>
</tr>
</tbody>
</table>

Carlton No. 4 Pump
This well is close to a group of houses, but there is no apparent cause of contamination near it. The Ammonia + Chlorine are rather high.

Physical character: No colour, taste, smell or sediment.

<table>
<thead>
<tr>
<th>Component</th>
<th>Parts per</th>
<th>Parts per</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline</td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Saline Ammonia</td>
<td></td>
<td>10.0</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanganate</td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td></td>
<td>22.7</td>
</tr>
<tr>
<td>Total hardness</td>
<td></td>
<td>7.4</td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>Nitrogen as Nitrate Nitrites</td>
<td></td>
<td>1664 per cc</td>
</tr>
</tbody>
</table>
Bartlet No. 5 Pump.
This well stands upon high ground quite away from sources of contamination. It is the source of supply for a row of 3 houses. The ammonia and chlorine are both low.

Physical character. No colour that smells a sediment.

Reaction
Saline Ammonia
Organic Ammonia
Oxygen absorbed from Permanganate
Total Solid Matter
Total hardness
Chlorine
Nitrogen as Nitrate & Nitrites
Bacteria

2 parts per 6,000,000.

Bartlet No. 6 Pump.
This water was taken from a well in the garden of one of a row of houses in the lower part of the village, and not far from a large pond. The ammoniacoid ammonia is high, but the chlorine is below the average of a good drinking water.
Physical Character. In colour, taste, smell or sediment.

Reaction: Alkaline.

Saline Ammonia: 3.4 parts per 100,000,000.

Organic Ammonia: 15 parts per 100,000,000.

Oxygen absorbed from Permanganate: 9.0.

Total solid matter: 60 parts per 100,000.

Total hardness: 34.3 parts per 100,000.

Chlorine: 5 parts per 100,000.

Nitrogen as Nitrate: 0.9 parts per 100,000.

Bacteria: 1220 per cc.

Carletto No. 4 Pump.

This is from a well in a crowded & low-lying part of the village. There are several wells near to it, but this is the only one used for drinking purposes. All the water in the others is obviously very bad. Physical character: Slight yellow color; no taste, smell or sediment. Reaction: Alkaline.

Saline Ammonia: 6 parts per 100,000,000.

Organic Ammonia: 14 parts per 100,000,000.

Oxygen absorbed from Permanganate: 13.0.

Total solid matter: 56 parts per 100,000.

Total hardness: 28 parts per 100,000.

Chlorine: 6.3 parts per 100,000.

Nitrogen as Nitrate: 0.12 parts per 100,000.

Bacteria: 1160 per cc.
Aldecoates.
This water was taken from the public well in the village of Aldecoates which is used by the large majority of the inhabitants on a small yearly payment. It is carefully looked after. Its ammonia and chlorine are low and the water is one of the best in the district.

**Physical Character:** No colour, taste, smell or sediment.

**Reaction:** Alkaline.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Parts per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>3</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>5</td>
</tr>
<tr>
<td>Oxygen derived from Permanganate</td>
<td>5.6</td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td>8.0</td>
</tr>
<tr>
<td>Total hardness</td>
<td>14.2</td>
</tr>
<tr>
<td>Chlorine</td>
<td>3.7</td>
</tr>
<tr>
<td>Nitrogen as Nitrites Nitrites</td>
<td>0.06</td>
</tr>
<tr>
<td>Bacteria</td>
<td>680 per 1 cc</td>
</tr>
</tbody>
</table>

Hodenceh Chief Pump.
This well was sunk in a ploughed field in the supply for the hamlet. It showed no signs of pollution from the manure which was spread on the ground.
Shirocako Chief Pump.
The well from which this sample was taken supplied a row of colonial houses 9 is not far from a lime quarry. The Ammonia x Chlorine are low in amount, the water being good.
Physical Charaters. No colour, taste, smell or sediment.
Reaction: Alkaline.
Saline Ammonia: 2
Organic Ammonia: 10 [Parts per 10,000,000]
Oxygen absorbed from Permanganate: 120 [in groups of 30%]
Total Solid Matter: 80
Total hardness: 40 [Parts per 100,000]
Chlorine: 3.7 [100,000]
Nitrogen as Nitrites x Nitrites: 0.06
Bacteria: 680 parts cc.
Steeley water.
This water comes from a spring passing from the limestone, and is used by the inhabitants of a row of eighteen houses. It is a fairly fresh water the ammonia & chloride being low, but the water is hard.

Physical character. Color, taste, smell or sediment.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>3 Parts per 100,000,000</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>68</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanganate</td>
<td>63</td>
</tr>
<tr>
<td>Total solid matter</td>
<td>42.1</td>
</tr>
<tr>
<td>Total hardness</td>
<td>2.4</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.2</td>
</tr>
<tr>
<td>Nitrogen as Nitrate &amp; Nitrite</td>
<td>640 per c.c.</td>
</tr>
<tr>
<td>Bacteria</td>
<td></td>
</tr>
</tbody>
</table>

Hardwick Pump.
The well had to sink to a depth of 200 feet. It supplies the hamlet (which consists of about thirty houses) and yields a good and pure water. It is quite removed from any possible source of contamination.
Physical Character. In colour, faint, small or sediment.
Reaction ........................................  Alkaline.
Sulphate Ammonia ................................ 2 \{ Parts per
Organic Ammonia ................................ 9 \{ 100,000,000.
Oxides of ferrous from Permanganate ..... 130.
Total Solids Matter ............................... 50 \{ Parts per
Total hardness ...................................... 12.8 \{ 100,000.
Chlorine ............................................. 7.2 \{ 100,000.
Nitrogen as Nitrate, Nitrites ................. 0.16.
Bacteria ............................................. 1200 per cc.

Well supplying a row of houses near country.
Since making these analyses the
water from this pump and that of
the three following has been con-
demned as being contaminated
with sewage. The experiment of
deepening the wells was tried with
out improving the water, and it
was then found that some sheep
were chockin and had polluted the
water. The inhabitants of the houses
were much adverse to giving up the
water which they had used for some
years without any apparent bad effects.
### Physical Characteristics
- Slightly brown colour
- Small taste or sediment

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>6 parts per 100,000,000</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>16 parts per 100,000,000</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanganate</td>
<td>160</td>
</tr>
<tr>
<td>Time 2 hours at 80° C</td>
<td></td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td>26 parts per</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>24 parts per</td>
</tr>
<tr>
<td>Chlorine</td>
<td>7.3 parts per 100,000</td>
</tr>
<tr>
<td>Nitrogen as Nitrate Nitrite</td>
<td>0.32</td>
</tr>
<tr>
<td>Bacteria</td>
<td>1.4 parts per cc</td>
</tr>
</tbody>
</table>

Well supplying a row of houses near London.

### Physical Characteristics
- Slightly brown colour
- Small taste or sediment

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>6 parts per 100,000,000</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>15 parts per 100,000,000</td>
</tr>
<tr>
<td>Oxygen absorbed from Permanganate</td>
<td>140</td>
</tr>
<tr>
<td>Time 2 hours at 80° C</td>
<td></td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td>30 parts per</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>45 parts per</td>
</tr>
<tr>
<td>Chlorine</td>
<td>8.5 parts per 100,000</td>
</tr>
<tr>
<td>Nitrogen as Nitrate Nitrite</td>
<td>0.29</td>
</tr>
<tr>
<td>Bacteria</td>
<td>1.84 parts per cc</td>
</tr>
</tbody>
</table>
well supplying a row of houses near borkhey.
Physical Character. Slight brown colour. No small taste or sediment.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>9</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>14</td>
</tr>
<tr>
<td>Oxygen absorbed 1 proportional to 180</td>
<td></td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td>90</td>
</tr>
<tr>
<td>Total hardness</td>
<td>30</td>
</tr>
<tr>
<td>Chlorine</td>
<td>2</td>
</tr>
<tr>
<td>Nitrogen as Nitrate-Nitrite</td>
<td>8.32</td>
</tr>
<tr>
<td>Bacteria</td>
<td>1366 per cc</td>
</tr>
</tbody>
</table>

well supplying a row of houses near borkhey.
Physical Character. Slight brown colour. No small taste or sediment.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline Ammonia</td>
<td>7</td>
</tr>
<tr>
<td>Organic Ammonia</td>
<td>16</td>
</tr>
<tr>
<td>Oxygen absorbed 1 proportional to 180</td>
<td></td>
</tr>
<tr>
<td>Total Solid Matter</td>
<td>90</td>
</tr>
<tr>
<td>Total hardness</td>
<td>36</td>
</tr>
<tr>
<td>Chlorine</td>
<td>8.5</td>
</tr>
<tr>
<td>Nitrogen as Nitrate-Nitrite</td>
<td>8.30</td>
</tr>
<tr>
<td>Bacteria</td>
<td>1260 per cc</td>
</tr>
</tbody>
</table>
From the above analyses one is naturally brought to the conclusion that the water supply of the district leaves much to be desired in the way of purity, as though the supply to the town of Workop is good, that of the country districts is only possible. The chlorine is always present in a higher degree than is desirable, while the amount of organic matter often raises upon the suspicions. The supply in the village of Buxton is very defective the water from which it is derived being mostly small and the soil through which the water must percolate into the wells is foul. But if new wells were sunk in the limestone the cost would be probably greater than a really safe supply from outside, and they would not afford a pure and safe water.

The vital statistics of the district and the bearing of the water supply upon
those Statistics.
I have based my remarks upon the reports of the Medical Office of Health for the last 10 years. I find that in the two districts the death rate has been as follows:
In 1885. it was 10. per 1000.
In 1886. it was 10.5 per 1000.
In 1887. it was 11. per 1000.
In 1888. it was 11.4 per 1000.
In 1889. it was 14. per 1000.
In 1890. it was 17. per 1000.
In 1891 it was 18. per 1000.
In 1892 it was 19.3 per 1000.
In 1893 it was 19.5 per 1000.
In 1894 it was 20. per 1000.

In examining this table one is struck by the very marked rise in the mortality. On inquiring into what I find that during the first four years there was very little illness in the district and the death rate was consequently below the average. In 1890 there were a large number of deaths of persons over 60 years of age. In the three following years
Influenza was very prevalent, and there is a rise in the number of deaths from that affection. I find that the neighbourhood has been most remarkably free from cases of Typhoid Fever, only one death from this cause having been reported in these ten years. The question of the relation of this disease to bad water though of great interest is one of no little difficulty. In this district very few of the waters can be classified as organically pure, and many of these are very far from being so. In the earlier days of water analysis the mere fact of some neighbouring well containing an excess of oxidizable matter or of chlorine was considered sufficient to explain an outbreak of Typhoid Fever. But subsequently to Laënnec's discovery of the Typhoid Bacillus this loses much of its importance. If the bacillus be really the cause of the fever, as there seems reasonable probability is the case,
then no matter how bad the water may be, it cannot possibly directly lead to typhoid unless the bacillus is actually present in the water. This is most difficult to determine and the isolated cases in which the discovery has been claimed must be received with caution. But as Hein (Lehrbuch der bakteriologischen Untersuchung und Diagnostik) justly remarks, when large quantities of bacteria are present the chances always are that the more dangerous kinds of bacteria are among them. In some cases the habitual use of an impure water seems to convey an immunity to typhoid, so when a person has come from a district in which there is no typhoid, to another equally free and has shortly after been attacked with the fever, may there not be an indirect action of impure water? May not the bacilli, coli communis or some other organism have the same relation to typhoid as the
diplococci found in the mouths of healthy persons close to the diplococcus pneumoniae? And is nature in the case of people of sound and robust constitution is able to do so much in the way of destroying them, while it is only in the case of those who are debilitated or have an inherent weakness that they are able to develop pneumonia? May it not also follow that in some cases where circumstances are favorable and the resisting forces weak, that these organisms may be able to cause an attack of typhoid? Though this would seem a capable explanation of some cases still the probabilities are rather against it. It would be asking too much of nature whose powers are great, but hardly great enough to overcome what should then be a constant strife. Did the bacillus of typhoid bear the same relation to typhoid as the diplococcus already spoken of to that of pneumonia, we would
expect typhoid to be more widespread than it is. Moreover the rapid spread of an epidemic when it does attack communities such as those with which we are dealing, is very strongly in favour of the theory that the disease arises from a distinct pathogenic germ and one which-sided arising de novo but can always be traced to a preceding case, and not from one which during many generations leads a perfectly harmless existence. This being so we are perhaps too much inclined to look upon a water which on chemical examination has been found to contain an excess of ammonia or of chlorine as a certain cause of disease. A water contaminated with sewage is not necessarily injurious. Wine has been drunk by diabetic patients without any ill effects, and in this respect I may mention a case in point which has been brought under my
Notice. At Croes in the Isle of Wight, there is a gentlemen house situated on high ground which slopes towards the sea. The drainage from this house is removed by a sewer pipe which has an outlet just above high water mark. It was discovered one day that the fishermen came to this pipe to fill the water casks which they took to sea with them, as they considered it to be the best water in the district? They had been drinking this sewage water for years without at all suffering in health.

No case of typhoid had ever occurred in the hotel, as had it done so the disease would undoubtedly have spread to those using the water from the sewer. This proves that sewer contaminated water, so long as it does not contain any pathogenic germ, may be drunk with impunity.

With regard to diphtheria I find that during the ten years specified
there have been fifteen cases. An outbreak of this terrible malady took place at Aldershot in November 1893, and its origin was traced to a child who lived in a cottage near the outfall of a small sewer. At the time an analysis was made of the water in the various wells of the district and as only one was found to be suspicious, we can fairly ascribe the epidemic to sanitary defects.

I find that diarrhoea is very prevalent and during last summer many cases of this were continually occurring, and I attribute this to the large number of bacteria present in the water. Owing to the large amount of alkaline salt which it contains the water neutralizes the acidity of the gastric juice and so the bacteria escape destruction. Large numbers are constantly taken into the stomach, and the organisms so admitted will I think set in three ways. Some will no doubt prove
Directly irritating to the mucous membrane; others during the process of growth will set up fermentation and give rise perhaps to irritation and spasm; while thirdly the phenomena arising from their multiplication may cause local inflammation. In all cases diarrhoea will be the result. Again it seems highly probable considering the epidemic form which these vibrios do so often assume, that there is a diarrhoea bacillus so distinct as that of typhoid or cholera, and its discovery waits to reward one of the many hard working and painstaking scientists either at home or abroad. Meanwhile the simplest precaution of boiling the water before use for five minutes is fairly effective as a preventive. A case is on record where a man had for some months drunk only water which had been boiled, he then began to drink unboiled water and at once began to suffer from profuse intestinal
irritation and this was ascribed to the number of bacteria contained in the unboiled water.

But the question arises, are we to condemn a water which it contains a large number of bacteria and what is to be the maximum limit? It is impossible to set a boundary line of general utility. If 500 germs in 1 cc of water is taken as the highest maximum permissible (as has been suggested) one would have to condemn the water supply of many towns as well as which had been constructed at great expense and perhaps have been used for years with contentment. Hein asks (Kurzbuch der bakteriologien in der internen heilkunde und diagnose) "what harm can an extra two hundred or so of harmless water bacteria do to man who introduce into their digestive canals a much larger number of living germs with certain kinds of food and drink?" But a certain amount of suspicion must
always be attached to a water which contains a large number of bacteria for they show that it arises from some inferior source and the possibility exists that some infectious agents may accompany them. Every means should therefore be taken to remove them from the water, and in this connection we may note that even the best filters with which they seek to purify the surface waters in many towns and which certainly free it from many germs yet allow bacteria of all kinds to escape. There can be no doubt that sand filtration is generally unsatisfactory, and on this point such authorities as Hein and Frankland, Pieske and Frankel are agreed. A series of interesting experiments on the subject conducted by the two latter scientists is recorded in Frankland's valuable book "Micro-organisms in water" p. 154 D Seg.

It is instructive also to note the re-

:ult of Burrier's researches into the
effect produced upon the organisms by boiling the water in which they are contained. He found that a temperature of 180°F. maintained for 10 minutes destroyed the spores of tubercle Bacillus, while 5 minutes sufficed for the death of those of anthrax. The pathogenic micrococci, the bacillus of typhoid and diphtheria and the microbes of malaria can be destroyed by simply boiling the water and then allowing it to cool. He found also that a momentary exposure to a temperature of 70°F. was fatal to the comma Bacillus. Currier computes that water is completely sterilized by a temperature of 100°F. for 15 minutes, except in the case of the most determinedly resistant microbes. (See Currier “Sterilisation of water.” New York Medical Record 10:23, 1890 p. 630.)

Before quitting this branch of my subject, let me add a word as to the manner in which the bacteria gain
access to the water. We have already seen (see ante p. 14) that the number of bacteria constantly decreases the more fresh ground water is drawn into the well by continuous pumping. Hence we must conclude that the bacteria reach the drinking and household water chiefly by currents from the surface and also by cracks and passages which run through the soil from the cesspools towards the walls of the well. In this manner pathogenic bacteria can also reach wells and as Flügge points out in his work on micro organisms (page 714 of Itatun Schuppi's translation) "we have the best opportunity for the infection of drinking water when an imperfectly covered well stands in the middle of the ordinary dirty court, as a rule all objects and waste water are poured out on the soil of these courts, and further, the arrangements are frequently such that the superfluous water employed for washing clothes flows back again into the well." This is
the condition of affairs in many instances at Milton.

There is a marked tendency to the occurrence of dyspepsia, and strangers coming to reside in the district are soon affected with this troublesome complaint. This I attribute to the hardness of the water. I have also been struck with the number of cases of cancer I have seen during the last 18 months, especially cancer of the stomach, of which there have been five instances in my own practice and I have seen two others. These cases had all a history of having suffered from dyspepsia for many years, and that again the hardness of the water seems to suggest itself as a possible, if not as a probable cause.

The high death rate of the district is thought about chiefly by a high infant mortality, and also by the great number of deaths from that disease to which the soldiers are
peculiarly liable. This I attribute to their working in a semi-rude condition in galleries along which there is a strong and unavoidable draught. The mines themselves are dry and well ventilated and cases of anthracosis are not very common. The climate of the district added by the porous nature of the soil seems favourable to those suffering from a tendency to phthisis, and only eight cases of this have come under my notice.

To sum up then during the last ten years the district has been wonderfully free from symptomatic disease. But the analysis of the various samples discloses a most unsatisfactory condition of the water supply, and should typhoid once break out there is every reason to fear a rapid spread of the disease. It is reassuring to know that the consideration of the present state
Dear Sir,

In submitting the accompanying thesis for the Degree of Doctor of Medicine, I beg to certify that it is composed by myself.

Yours faithfully,

W. Crawford
Of affairs is being urged on the attention of the authorities, and strong representations have been made as to the necessity for a new water supply. The question of expense is naturally a deterrent in the way of energetic action, but it is to be hoped that the newly elected urban councillors will mark their accession to office by an honest endeavour to right matters. There is an old saying to the effect that the pitcher which goes often to the well is sure to be cracked at last, and the principle holds equally good in the subject we have had under consideration. The immunity so enjoyed so far is no guarantee of future security, and there exists in the midst of our district a conjunction of circumstances which only waits—the same brands—"for a spark—for our kindling gear to deal death around."
It is difficult to convince the slow moving and conservative rustic mind of the danger which lies at its very door, but we must hope for more enlightened views with succeeding generations, and in the meantime put an end to the present insanitary conditions which are far in arrear of the wants of progress of this up-to-date nineteenth century.

William Thomas Crawford.