On manure poisoning, with suggestions for the prevention of the pollution of wells in agricultural districts / by Eben. Duncan.

On Manure Poisoning, with suggestions for the Prevention of the Pollution of Wells in Agricultural Districts.

By Eben. Duncan, M.D., F.F.P.S.G., &c.

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For an opportunity of investigating the occurrences on which this paper is founded I am indebted to Dr. Milroy of Kilwinning. A letter was written by him to the *Glasgow Herald* in September last, calling attention to the poisoning of a well at the village of Benslee by Glasgow manure, and to an outbreak of typhoid fever which had resulted in consequence among the persons who drank the water of that well.

I visited the village of Benslee a few weeks ago, and, with the assistance of Dr. Milroy, I made a careful enquiry into the facts bearing upon the origin of that outbreak. My attention was also directed to another case of well-poisoning by manure in the neighbourhood of Kilwinning by which a whole family had suffered. The proof of the connection between the alleged cause and the effect in these cases seemed to me to be very complete. Although the traffic in town manure, which so frequently contains the poisonous excrements of diseased human beings, is carried on in all parts of the country, sufficient attention has not hitherto been directed to its evil results. I therefore think that a complete record of these occurrences is of considerable importance.

The first case which I shall narrate is the poisoning of the well at Whithurst Farm, Kilwinning. I give you the facts as related to me by the farmer, and corroborated by Dr. Milroy. In the end of December, 1881, the farmer-tenant of this farm bought a quantity of manure from the Glasgow Corporation. This manure he spread over a grass field adjoining the farm steading. In the centre of this field was situated a spring-well from which he drew his domestic water-

supply. The water from this spring was conducted by an open stone drain a distance of 150 yards through the field to a pump-well at the farm-buildings. As a large part of the field so manured sloped downwards in the direction of this open drain, every shower of rain washed the manure into the drain, and through it into the farmer's well. When the manure was spread over the field the water in the well became discoloured and somewhat offensive. About a fortnight thereafter, one of his children took ill, and in about three weeks from the day on which the water was polluted with the Glasgow manure, the farmer's wife and his seven children were stricken with typhoid fever. The farmer also suffered from a feverish attack, which, however, did not assume the specific characters of typhoid.

The following table, showing the manner in which this field has been cultivated during the past ten years, is important:—

ROTATION OF CROPS ON WHITHURST FARM.

1874—1st year.	Corn.	Farmyard manure—*No Fever.*
1875—2nd ,,	,,	No manure.
1876—3rd ,,	Hay.	,,
1877—4th ,,	Pasture.	,,
1878—5th ,,	,,	,,
1879—6th ,,	,,	,,
1880—7th ,,	,,	,,
1881—8th ,,	—	Glasgow manure—*Fever.*
1882—9th ,,	Corn.	No manure.
1883—10th ,,	,,	,,
1884—11th ,,	Hay.	,,
1885—12th ,,	Pasture.	,,

Owing to the method of cultivation it is manured only once in eight years. The manure is spread over the field at the end of the pasture period, and ploughed into the soil to prepare it for growing corn. It is interesting to observe that eight years before the occurrences which I have narrated, when this field was manured with ordinary farm-yard manure, the family experienced no evil results from drinking the water. The Glasgow manure used by this farmer is a mixture containing a large proportion of human excrement. The excreta are collected on the pail and tub system in the poorer parts of the city, where there are no water-closets. In these places typhoid fever is rarely, if ever, absent. No precaution is taken to disinfect such manures as are known to contain typhoidal discharges. The specific poison of typhoid fever having

been added to the farmer's water-supply by the manure, the whole family showed the ordinary symptoms of typhoid fever, after the usual period of incubation. In corroboration of the connection between the manure pollution and this outbreak, it may be remarked that no other cases of typhoid fever existed in the vicinity at this time.

In the end of 1883, the farmer of North Millburn, near Kilwinning, bought a quantity of manure from the Glasgow Corporation, and carted it to a large grass field near the mining village of Benslee. The spring-well which supplied this village was situated in the centre of this field. The water from this spring was conveyed by an iron pipe to a small reservoir sunk in the ground near the edge of the field; the sides of this reservoir were built of brick, and the top of it was covered with loose flags of stone. The farmer emptied the manure beside the reservoir, and afterwards spread it over the field.

The following extract from a letter written by Dr. Milroy, and published in the *Glasgow Herald*, September 20th, tells what followed. He says:—"A farmer, about the end of year 1883 or the beginning of 1884, emptied a large quantity of Glasgow manure within a few yards of the pump-well of Benslee. This manure was also scattered over the field which supplies the well with water. At that time the worthy housewives of Benslee rose almost *en masse*, declaring that their water-supply was ruined. That Glasgow manure must have been charged with the specific germ of enteric fever, which the rains washed into the well, for now smart attacks of fever began to show themselves, and since that time fever has destroyed the health of many, it has lowered the *physique* of the whole community, and taken away six lives."

In the first part of his letter Dr. Milroy tells us that during the two years previous to this occurrence there had been no case of typhoid fever in Benslee. I made careful enquiries into these occurrences, and found that they happened as Dr. Milroy had stated. The farmer informed me that the manure was carted to this field in the end of December, 1883. I ascertained that the person first affected with typhoid fever in this outbreak was a girl who sickened on the 15th of January, 1884. The parents of that girl informed me that they noticed that at that time the water of the well tasted badly, and that the manure-heap spoken of by Dr. Milroy was still lying at the side of the well when their daughter

took ill. The population of the village was estimated at 300, and of these 50 were subsequently affected with well-marked symptoms of typhoid fever, and many other persons suffered from febrile attacks and diarrhœa.

The sanitary arrangements of the village are sketched on the diagram, and are very well calculated to afford every facility for the propagation of this disease. The excreta are emptied into gutters which run along the front of the rows, and the sewage from these gutters is carried away by a drain which runs a distance of 50 yards to the Benslee Burn. In its course it passes quite near the brick well, and there is a great probability of further contamination of the water from this source. Some of the excreta are thrown out with the ashes on the ash-heaps behind the rows, and in this way an opportunity was also afforded of ærial dissemination of particles of the poisonous matter.

TABLE OF ROTATION OF CROPS ON FIELD IN WHICH BENSLEE WELL IS SITUATED.

1878, 1880—Corn.	No manure.
1881—Hay.	,,
1882—Grass.	,,
1883—Corn.	Glasgow manure.
1884—Corn.	No manure.
1885—Corn.	,,

Four months after the first appearance of fever in Benslee, and while it was still running its course there, typhoid broke out in the neighbouring village of Fergushill. I enquired whether there was any evidence of the people of Benslee having conveyed the fever to this village. I had the following reply from Dr. Milroy:—"The children of Benslee and of Fergushill attend the same school and play about the Fergushill Rows. I have often seen human excreta on the step of the dip well at Fergushill. Germs could readily be carried in this way from Benslee to Fergushill. Again, the villages are only a few hundred yards distant the one from the other, and the people are mixing daily. The well at Fergushill being badly polluted with sewage, if the typhoid fever poison did get in it would certainly propagate in the water." As there was no other ascertainable cause for the occurrence of this outbreak at Fergushill, we may safely conclude that the infection came as stated by Dr. Milroy. The wonder is that, under the circumstances, it did not occur sooner.

This was not the end of the mischief. The outbreak of fever ran its course through the summer. It was constantly renewed, as in Benslee, by the bad sanitary conditions of the village. From first to last between 50 and 60 persons were stricken. Then from this source a new series of poisonings took place.

The Fergushill Burn, into which the sewage from the fever-stricken row is drained, ran past the farm of Mr. John Kirkhope of South Fergushill. Mr. Kirkhope's dairymaid became affected with the fever in September. She was either infected by this water or by visiting her father, who lay ill of the fever in Fergushill.

At the same time, an outbreak of typhoid fever occurred in the Glasgow Infirmaries. In the Royal Infirmary, in the Western Infirmary, and in Belvidere Fever Hospital 104 persons were stricken as if by poisoning. Nurses and patients, surgical and medical, were alike stricken. In his report to the Town Council on this epidemic, Dr. Russell, Medical Officer of Health to the City of Glasgow, remarks:—"It will never be accurately known how much mischief this outbreak has worked. A constant stream of patients was passing into and out of these institutions, while infection was being distributed with them. Several discharged patients have already been discovered ill. In such subjects, weakened by previous disease, the results must be severe. The majority of the cases are of a bad type."

It is only necessary to say further that this outbreak in the Infirmaries, leading to such lamentable results, was traced by Dr. Russell to infection of the milk sent to these institutions from Mr. Kirkhope's farm at South Fergushill. The details of this investigation may be found in Dr. Russell's report to the Town Council of Glasgow dated 18th September, 1884. The water of the farmer's well was, in his opinion, contaminated by some overflow of the Fergushill water-course, which contained the sewage from the fever-stricken village. The circle of poisonings is now complete. We have first the fever-contaminated manure sent out without the slightest precaution to the unsuspecting farmer by the Glasgow authorities. We have followed the development of it in Benslee. We have traced it from Benslee to Fergushill; from Fergushill we have followed it to Mr. Kirkhope's farm, and we have been informed by Dr. Russell that it was thence conveyed back to Glasgow, and delivered with the milk at the doors of the Glasgow Infirmaries. We are further informed that from the

Infirmaries it has been disseminated into surrounding districts by Infirmary patients.

This one exportation of Glasgow manure has been the starting point of a series of poisonings from which we know that 200 human beings have already suffered and numbers have died. But what is true of Glasgow manure is also true of the manure transported to the fields from every community in which such diseases as typhoid fever prevail. Four years ago I related to this Society a series of similar outbreaks which occurred from the poisoning of wells in the village of Millport by privy manure containing typhoid excreta collected in Millport itself.* I pointed out in that paper that the history of such epidemics gives us a clue to the origin of contagious maladies in remote pastoral districts, which have hitherto been cited as instances of the spontaneous generation of these diseases. I do not believe in the doctrine of spontaneous generation in common filth. In these cases it is not the filth itself which does the mischief but the germs of disease from the excrements of diseased human beings which are associated with the filth and which propagate themselves in it.

There is a remarkable statement in the 6th report of the Rivers Pollution Commissioners, published in 1874, which puts clearly and tersely what I believe to be the true theory of the propagation of typhoid fever. They say:—"The one essential condition for the propagation of such diseases as typhoid fever and cholera is the conveyance of infected matter from the stomach or bowels of the patient to the mouths of other persons."

This statement, with which I fully agree, points to a variety of media through which the infected matter may be carried to the mouths of others:—(1) dust particles of the dried excreta carried by the air may be breathed and swallowed; (2) the water-supply may be directly polluted with them; (3) the polluted water may carry the disease germs into milk, or the milk may be directly contaminated by dust particles of the excreta; (4) other articles of food may be similarly contaminated.

With regard to the contamination of drinking water, with which we have specially to do in this paper, the Commissioners say:—"As the result of our inquiries into the polluted waters of this country we are compelled to state that it is a widely-spread custom, both

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* See *Proceedings* of the Philosophical Society of Glasgow, vol. xiii., No. 1, page 177.

in towns and villages, to drink either the water of rivers into which the excrements of man are discharged, or the water from shallow wells which are largely fed by soakage from middens, sewers, or cesspools."

In the same connection they say:—"That such an unspeakably disgusting mode of infection is not only possible but imminent over a large proportion of the inhabitants of Great Britain is conclusively proved by the numerous analyses of drinking water recorded in the preceding part of this Report, and, far from the horrible practice just indicated being exceptional, it is the rule."

They then proceed to narrate numerous cases which prove that "vast multitudes of the population are daily exposed to the risk of infection from typhoidal discharges, and periodically to that from cholera dejections." But in no instance do they refer to epidemics produced by the distribution of these discharges through the manure traffic of our towns and villages. This subject had attracted no attention, and had not been investigated by the sanitarians from whom they obtained the evidence referred to. They do, however, in various places condemn the use of water collected from the surface or the drains of cultivated land, the manure applied to which contained human excrementitious matter —"Indeed," they say, "when any portion of the manure consists of human excrements, the organic matter dissolved in the water becomes not merely disgusting but dangerous." In their recommendations they advocate that, owing to the difficulty experienced in agricultural districts of getting water from any other source—"in any scheme for the utilization for town supply of the pure water of a river basin, the wants of all the neighbouring villages and hamlets should be provided for as far as practicable."

It is therefore quite clear that the Commissioners were quite alive to the dangers of manure poisoning, but were unable to suggest any adequate remedy which would be applicable to the whole community. In the present state of the law our towns and villages cannot be prevented from selling their poisonous manures to the farmer, and the farmer cannot, at present, be prevented from using these poisonous manures as he thinks fit on fields which are the gathering-grounds of water supply. It is only after the poisoning takes place and the mischief is done that any precaution can be taken. We lock the stable door when the steed has been stolen.

Four years ago I advocated the use by the large towns of the

chemical and drying processes devised by Mr. Fryer, of Nottingham, by which the dangerous excreta are converted into a harmless and valuable manure. I pointed out to the Glasgow authorities the dangerous nature of the manure traffic as carried on in Glasgow, by which the excreta of one-half of the population, from the lowest and, in a sanitary point of view, the worst parts of the city, are daily removed to the country districts without any attempt at disinfection; and I asserted that in some of our milk epidemics we were being punished for the recklessness displayed in these methods of disposal—the epidemics related in this paper prove the truth of this assertion. As far as I know, these recommendations and warnings had no effect.

On the other hand, the farmer looks upon such outbreaks as mysterious dispensations of Providence, against which all precautions on his part are useless. He believes his manure-heap to be not only innocuous but healthful; and he can see no difference between the farm-yard manure which he thinks so harmless, and the City manure in which, as we have seen, so many dangers lurk. His favourite idea is—the more muck, the more crop. Unless the strong arm of the Law is wielded for the protection of the community, these periodical poisonings will go on.

Although I still believe that some measure for the enforcement of precautions on the part of the large towns is expedient, not only in the interests of the rural populations, but for the protection of city populations themselves, further reflection has shown me that the adoption of measures of disinfection by the large towns would not be sufficient.

The large towns are certainly the greatest offenders and do most of the mischief, because their railway communications, and the large amount of such matters at their disposal, enable them to disseminate the dangerous manure over very wide areas. But unless some less expensive apparatus than that devised by Mr. Fryer can be obtained, the smaller towns and villages will still continue to get rid of their diseased excreta by the old methods. We must therefore adopt additional precautions in the agricultural districts.

The suggestions I have now to make are, first—that in amending the existing Health Act, a Clause should be inserted prohibiting, under an adequate penalty, the application of any organic manure to the soil within 200 yards of any well, reservoir, or water-course used for domestic or dairy purposes; secondly—that a Clause should be inserted forbidding the deposit or accumulation of

organic manure in any receptacle which has not been rendered impervious to water leakage; and enacting further—that the overflow of any such receptacle for manure must be so conducted from it that it cannot contaminate the soil within 200 yards of a well, reservoir, or water-course.

I think it can be shown that such enactments would not interfere with any public or private interest. With regard to my first suggestion, it would still be open to the farmer to use inorganic manures on the soil so restricted, which chemical manures can be proven not only to be innocuous, but quite as efficacious in fertilizing the ground as organic manures. With regard to the second clause suggested, it is, I think, high time that the traditional manure-heap at the farmer's door should be kept from polluting the soil on which his house stands, and the well which in most cases is within a few yards of the dungstead.

In order to bring about a reform of this kind it is very important to show that the use of inorganic manures has already been adopted by practical farmers, because they have found it to their pecuniary benefit to do so, and not for any sanitary reason. From this point of view, the question of the use of artificial manures, their chemical selection and scientific application to agriculture, has been most carefully investigated by M. Ville. His theoretical conclusions have been tested by practical farmers both in France and England, and found to be substantially correct. In his elaborate work on this subject, he says:—"Till within the last twenty years it was thought that farm-yard manure was the only fertilizing agent. We maintain that this is wrong, and that it is possible to compose artificial manures superior to and at the same time cheaper than farm-yard manure." In his preface to the French edition of his book, he says:—"To sum up, the materials to which plants owe their formation and the earth its fertility being known, we may with their aid manufacture manures which are superior to that of the farm-yard. The march of progress and our own interest oblige us to make a more extensive use of these materials. By so doing we shall increase the fertility of the soil and improve the condition of the people generally."

It is quite impossible within the limits of this paper to enter upon the elaborate experimental proof by which M. Ville supports these conclusions. The following table explains his views with regard to the chemical ingredients in farm-yard manure which he believes to be of value as fertilizers, and those which are useless

because amply provided for in every soil and in common elements, air and water:—

FARM-YARD MANURE, 100 PARTS.

Water,	80·0	= 80 not wanted by plants in manure.
Carbon,	6·80	= 13·29 woody fibre, the elements of which have their origin in the air and water.
Hydrogen,	0·82	
Oxygen,	5·67	
Silica,	4·32	= 5·07 secondary mineral matter, with which the soil is superabundantly provided.
Chlorine,	0·04	
Sulphuric Acid,	0·13	
Ferric Acid,	0·34	
Soda,	a trace	
Magnesia,	0·24	
Nitrogen,	0·41	= 1·64, with which the soil is provided to only a very limited extent, and in which the efficiency of the manure essentially exists.
Phosphoric Acid,	0·18	
Potash,	0·49	
Lime,	0·56	

M. Ville finds as a matter of experiment and experience that, with the exception of the last four, representing 1·64 per cent. of the whole, every other ingredient in farm-yard manure is amply and usually superabundantly provided for even in the very worst lands. As to deciding whether farm-yard or chemical manure can be best employed is, he says, quite a secondary matter, provided the law of restitution in respect of the four exceptional elements be observed. No difference exists between chemical and farm-yard manure except with regard to appearance and bulk. We must, he says, restore to the soil more calcic phosphate, potash, and lime than the crops have taken out, because it is exclusively from the soil that the plants draw them, and we must also make up for the losses due to the solvent action of rain. We only require to restore about 50 per cent. of the nitrogen—part of the nitrogen required by plants being drawn from the air. It has been proven that the leguminous plants draw the larger part of their nitrogen from that source. For our purpose it is only necessary to be informed of the chemicals which M. Ville and those who act on his principles use, and to ascertain whether they are innocuous. He classifies his manures into five varieties, which may be used according to the necessities of different crops and differing soils. But on examination these varieties of chemical manure are found to differ almost entirely in the respective proportions in which the four chemical substances are combined. These substances are calcic superphosphate, potassic nitrate, ammonic sulphate, calcic sulphate.

In some modifications potassic chloride is substituted for potassic nitrate, in others sodic nitrate is substituted for ammonic sulphate. Now these substances, as applied to the soil as manures, do not poison the subsoil water as organic manures have been proven to do.

We find in the 6th report of the Rivers Pollution Commissioners, published in 1874, a series of analyses of the water coming from the surface drains of farms which for many years had been manured solely by inorganic manures. They say that the practice of manuring lands by substances exclusively inorganic, though still quite exceptional, is probably increasing, and therefore the study of water draining from such land in high cultivation is not entirely devoid of practical interest.

It was found, as might be expected, that after such manures were applied to the soil the first rains which fell carried into the drains a considerable amount of those soluble salts, and on plots on which sulphate of magnesia and superposhphate of lime were largely employed the amount of these substances dissolved in the water was at first too great to permit of its use for washing purposes. Taking the most extreme case—a table showing the composition of drainage water from land in a state of high cultivation, manured annually from 1844 till 1874 with a mixture of mineral and ammoniacal salts—the total hardness varied from 76 parts per thousand to 14 parts per thousand, and the permanent hardness from 65 to 7 parts per 100,000.

The high figures are the results of analyses taken shortly after the manures were applied. A certain portion of the soluble salts enters the growing crops; the remainder, at first absorbed by the soil, is gradually washed out of it. Although ammonia is added in large quantities in every case, yet it is present, but in very minute quantity, in the drainage waters. It is evident, they say, that some of the ammonia introduced into the soil as sulphate or muriate is transformed by oxidation into nitric or nitrous acids, and discharged in the drainage water as nitrates or nitrites, which afford in all these cases false testimony as to the previous contamination of the water with animal matters.

The objection of too great hardness for washing purposes which applies to the surface water from the drains of an experimental plot heavily manured annually would not apply to the water of a well situated in a field cultivated in the ordinary fashion and only manured periodically at intervals of years.

On talking over this question with a practical farmer in the

neighbourhood of Glasgow, and discussing with him the suggestions I have made to-night, he assured me that a law such as I have advocated could be enforced in this country without inflicting the slightest injury upon the farmer. This gentleman informed me that on some of the fields of his farm he has put nothing but chemical manures for 10 years, and that, both with regard to the fertility of the soil and the financial results, this method of manuring these fields has been a success.

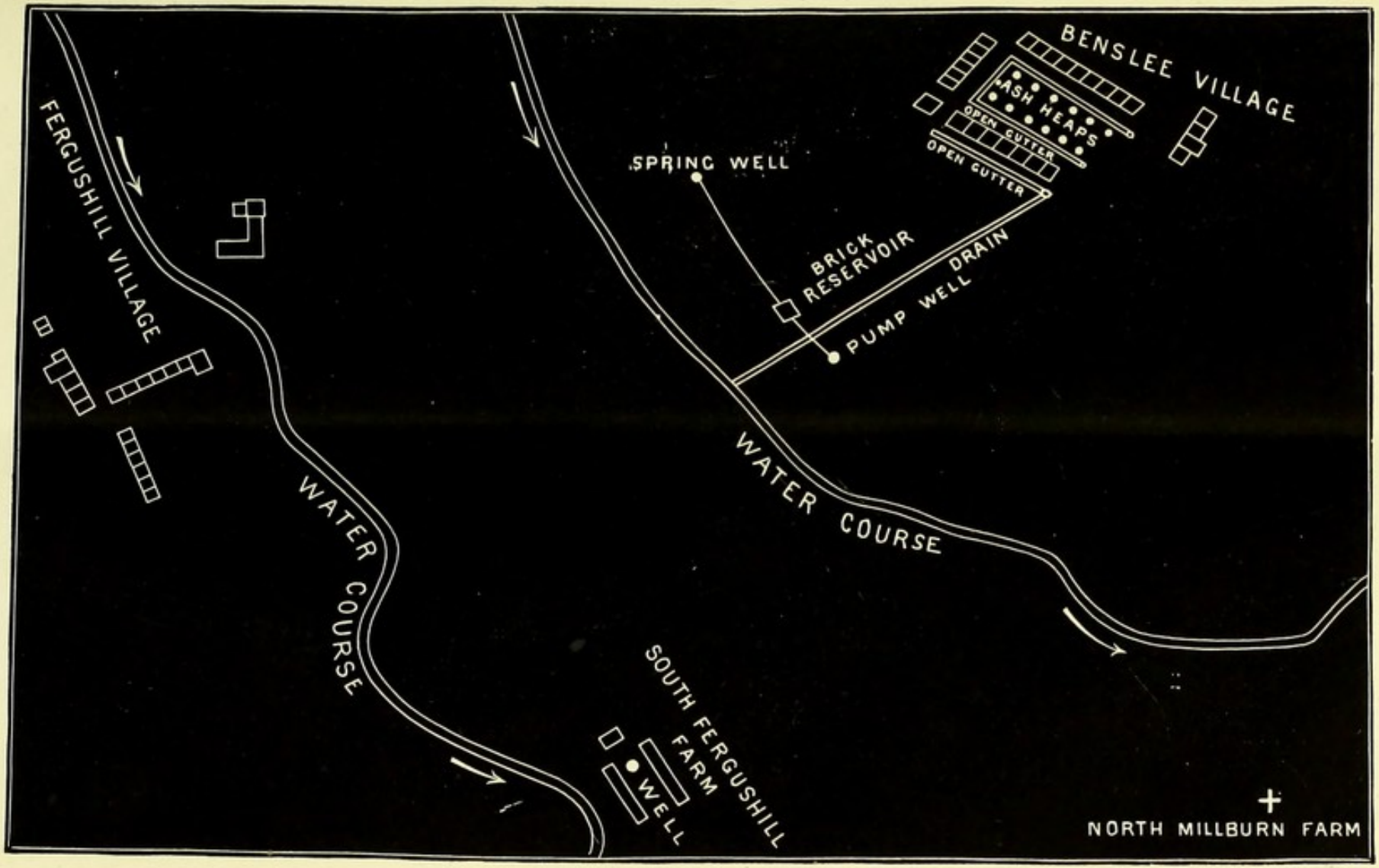
It is not, however, necessary for me to prove that the enactments advocated in this paper would benefit the farmer. Even although it could be proven that chemical manures were not as profitable as organic animal manures, it is still the clear duty of the Legislature to protect the community from the periodical poisonings of which the cases narrated in this paper are examples. I am quite certain that when the attention of the medical practitioners of rural districts is drawn to this subject such occurrences will be found to be very common.

A chemical examination of the water of wells situated in cultivated fields may be of little value, because, except at the time of the periodical manuring, the water may be safe enough. On this point the Rivers Pollution Commissioners say :—"The importance of the history of water as regards its anterior pollution with organic matters of animal origin does not arise from the presence of the inorganic residues (nitrates, nitrites, and ammonia) of the original polluting matters, for these are in themselves innocuous, but from the risk lest some portion (not detectable by chemical or microscopical analysis) of the noxious constituents of the original animal matters should have escaped that decomposition which has resolved the remainder into innocuous mineral compounds. . . . It follows from what has been already stated that chemical analysis cannot discover the noxious ingredients in water polluted by infected sewage or animal excreta, and, as it cannot thus distinguish between infected and non-infected sewage, the only perfectly safe course is to avoid altogether the use for domestic purposes of water which has been polluted with excrementitious matter."

Although the suggestions which I have made in this paper for the protection of the wells from pollution with excrementitious matters were carried out, it would not, in my opinion, relieve the large towns from the duty of disinfecting their disease-contaminated excreta. When such matters are scattered broadcast over the

country there must still continue to be ærial dissemination of poisonous particles, giving rise to scattered cases of contagious disease. Although advocated for quite another purpose, the process devised by the Messrs. Fryer of Nottingham, and adopted by such large towns as Manchester and Birmingham in England, is, in my opinion, the most reliable process yet devised to prevent the dangers of the manure traffic. In the concentration of the excrements by this method, sulphuric acid is mixed with the liquid pulp, after which the pulp is subjected to a high temperature. In this process, not only are the disease germs destroyed, but the manurial value of the excrement is greatly increased.

I can see no valid distinction, as regards criminality on the part of those responsible, between cases of poisoning by arsenic or strychina recklessly distributed and cases of poisoning by typhoid or cholera discharges recklessly distributed, except that in the latter case the sufferings of the victims are more protracted. I think that the person who wilfully continues to disseminate such matters when the mischief of this dissemination is clearly proven, and a means of preventing the mischief has previously been demonstrated to him, should be dealt with as sharply and punished as severely in the case of poisoning by organic manures as in any any other kind of culpable homicide. I hope that this paper will have some good effect in directing the attention of the agricultural populations to the dangers which they run in using these town manures, and to the benefits which may be derived from the use of chemical manures in the neighbourhood of wells and of water-courses.


BENSLEE VILLAGE
ASH HEAPS
OPEN CUTTER
OPEN CUTTER
SPRING WELL
BRICK RESERVOIR
PUMP WELL
DRAIN
FERGUSHILL VILLAGE
WATER COURSE
WATER COURSE
SOUTH FERGUSHILL FARM
WELL
NORTH MILLBURN FARM