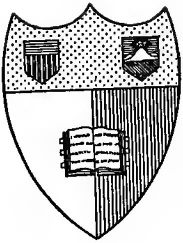
Outlines of
RURAL HYGIENE

Harvey B. Bashore M.D.



OUTLINES
OF
RURAL HYGIENE.

FOR PHYSICIANS, STUDENTS, AND SANITARIANS.

BY
HARVEY B. BASHORE, M.D.,
INSPECTOR FOR THE STATE BOARD OF HEALTH OF PENNSYLVANIA.

WITH AN APPENDIX
ON
The Normal Distribution of Chlorine.

BY PROF. HERBERT E. SMITH,
OF YALE UNIVERSITY.

ILLUSTRATED.

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PREFACE.

THE almost absolute neglect of sanitary rules in districts outside of the great cities, and the absence of special attention to this branch of sanitation in the larger and more elaborate treatises, have called forth this work.

That it may aid in the diffusal of sanitary knowledge where most needed, and that it may assist those who labor in rural districts, is the earnest wish of the author.

Much of the substance of the work has appeared from time to time in various medical periodicals, but all has been carefully revised.

The author has drawn largely from numerous Health Reports, and hereby acknowledges his obligation to all such as are not especially mentioned.

HARVEY B. BASHORE.

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CHAPTER I.

WATER-SUPPLY.

Wells.—Almost the whole of the rural population depends upon shallow wells for its water-supply, and much of the sanitary oversight occurring in these districts centres about this point. Many an epidemic has been traced to such a source,—small household epidemics they generally are; sometimes, however, the "town-pump" becomes infected, and a whole village suffers. A case of this kind lately happened in one of the small towns of Pennsylvania; almost the entire population drank water from a single well; this became infected, and, as a result, sixty out of the eighty inhabitants became ill with typhoid fever and ten died. Another striking case of well-water infection is that reported by Volz, which occurred at Gerlachsheim, in Germany. Here, in three weeks, fifty-two persons were attacked with typhoid fever. On investigation it was found that these had all gotten their water from a certain well, which had been polluted by the discharges of the first patient.

In one of the State Health Reports there occurs the following very instructive note, which illustrates the point in question: "While riding with Dr. ——, on his way to see a patient, he pointed to a farm-house which he said had a strange history. He had practiced in the adjoining village for thirty years; the farm was occupied by tenants, who were changed every few years, and during these thirty years *every* family that lived on the place passed through typhoid fever." Surely here was a house with a "skeleton in the closet"; rather, I suppose we ought to say, in the well; for there can be no reasonable doubt, from what we know at present of the genesis of typhoid fever, that this trouble was caused by an infected well or spring. Almost everyone of us who has an acquaintance with the country can point to certain districts where, year after year, as autumn approaches, we have had one or two fever cases.

The source of infection in these old wells is, of course, the infected ground-water, which, in its turn, has been poisoned by some leaking cess-pool, or privy, or surface-washings; in this connection it must not be forgotten that the discharges from a single case of typhoid may be the source of danger. Such was the fact in the famous Plymouth epidemic, which, while not well-water infection, was in a body of water vastly larger than many wells, and shows how much greater the danger in a narrow, shallow well.

The distance from the well at which a source of infection becomes dangerous cannot be readily expressed in figures without the most careful study, for it depends entirely on the character of the strata and the direction and velocity of the ground-water currents. I recall to mind a very good illustration of this, in which a well, situated hardly fifty feet from a privy, shows almost absolutely no pollution, while another, almost two hundred feet from the nearest privy or other means of pollution, shows thirty times the normal chlorine of the region. In the first instance the well is in a bed of compact impermeable clay, and, in the second, a stratum of loose slate.

It is, perhaps, needless to state that the mere pollution of a well by sewage is likely of no danger whatsoever unless the germs of disease find an entrance; but, when a well is exposed to leakage from human waste, it is so easy for germs to follow, and so easy for them to grow in water laden with organic material, that there is always an element of danger in using a water which is at all subject to privy leakage; the danger may not be very great,—ordinarily it is not,—but it exists, nevertheless. There are wells in every town which, though undoubtedly polluted by leakage from adjoining privies, have furnished drinking-water for many years and have never yet been accused of conveying disease. This, however, is no argument against the case; only a proof that none or few germs have entered the well.

A point of much importance, as indicated before, is the geological character of the strata which are pierced by the well; yet this very rarely receives much more than a passing attention. Modern investigation along this line has shown that, for example, the distinction which the older works on hygiene used to draw between deep and shallow wells is of but very limited value. Deep wells, according to the definition, are those which pass through an impervious stratum and draw water from a deeper layer beneath; but this can only happen in a geological basin, and geological basins are few and far between. At London and

Paris there happens to be just such a formation, and consequently deep wells are a great improvement over shallow ones. On Manhattan Island, however, on the other hand, a well may be a thousand feet deep and still not be a "deep" well in a sanitary sense, for the strata there are more or less perpendicular, which, of course, in a measure, excludes an impervious layer; so it is over almost the whole of the vast Appalachian region. Along the coast, however, the strata are in places, more or less horizontal,—or, rather, they are parts of some great basin,—and are available for deep wells.

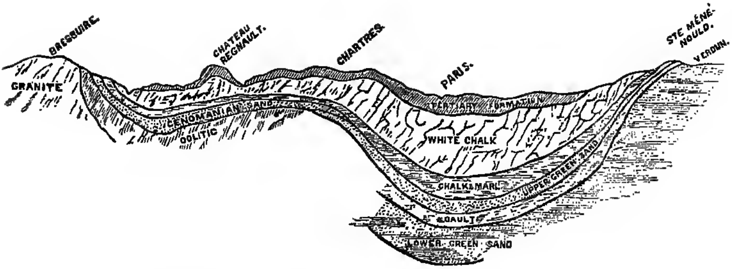

Fig. 1.—Section of the Strata Underlying Paris and its Environs. Horizontal scale, eighty miles to an inch; vertical scale, two thousand feet to an inch. (From Humber's "Water-supply of Cities and Towns.")

Whenever these Artesian wells are possible, they generally yield a very pure water. Much work has recently been done in this subject on the Atlantic-Coast plain, and maps are now being prepared by certain of the State Geological Surveys which locate the water-bearing zones. In New Jersey, for example, there have been found to be three very important horizons. The first, 300 to 400 feet deep, in miocene strata; the second in the cretaceous; and the third still lower. These beds all furnish excellent water, and are used practically in many places along the coast,—especially by large manufacturing plants.

Geological investigation, too, has shown that in a region of upturned strata not only are deep wells impossible, but that wells of any sort are especially dangerous, unless much attention is given to the location of the sources of pollution, for the cleavage-lines of the rock-layers afford most excellent drains for any surface or cess-pool waters which may happen to be in the locality if the strata should incline in the direction of the well. This is shown in the following practical sketch, which represents a region in which the rock-layers are almost perpendicular. In places like this,

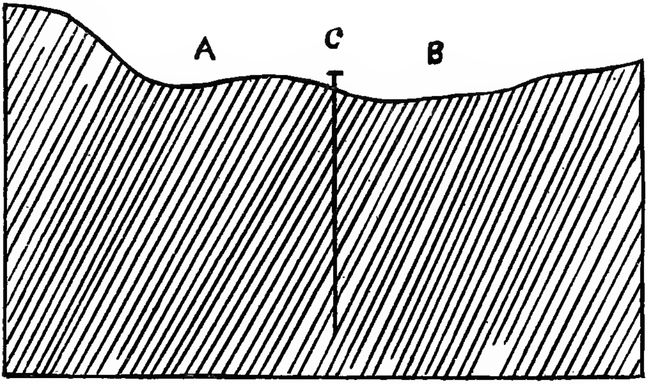

Fig. 2.—Cross-section of a Region of Upturned Strata. (Original.)

if you are going to dig a well, it makes a great difference whether the ever-present privy or cess-pool is located at *A* or *B*. Suppose it is at *B* or in any place within 90° on either side; then the well will almost certainly be contaminated, for the leaking water will only have to follow the cleavage-lines in order to reach the well, and this it will do most readily.[1] The only possible location for a filth-receptacle in the neighborhood of the well *C* is in the direction of *A*, where the cleavage runs away from the well, instead of to it as on the opposite side. The privy, if there is one in the direction of *B*, should be absolutely no nearer than—in fact, not so near as—the calculated distance,[1] for, if it is, there is sure to be pollution.

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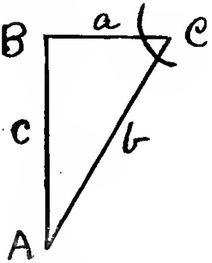
[1] In a region like the one described it is very easy to calculate just how far beyond the well in the direction of *B* (Fig. 2) the danger-line extends. Knowing the depth of the well and the angle of dip of the strata (this is told by an instrument known as the "clinometer"), we construct a triangle as follows :—



B A = depth of well; angle *C* = dip of strata,—*i.e.* the angle made by a horizontal line on the surface with the cleavage-lines of the slate. *B* is, of course, a right angle. To get angle *A* we add *C* and *B*

Important points these are; yet it is very rare indeed that they are considered in making a well; but they must be heeded if one expects to get water at all approaching purity.

The author's attention was recently called to a well situated in just such a region,—a tube-well, about a hundren feet deep, with its upper twenty or thirty feet surrounded by an iron tube, and yet this water yielded 10.4 parts of chlorine per 100,000, while the normal chlorine of the region is only 0.15 per 100,000. Neighboring privies rested on the upturned slates within the region indicated by *B* (Fig. 2), and, of necessity, the well was polluted. That the well was deep only increased its drainage-area without increasing in proportion its filtering properties, for water filters very little in passing through the fracture-lines of a rock-bed. Incidentally I might mention that a number of cases of typhoid fever have been recurring yearly in the vicinity of this well.

In a limestone region wells are likewise dangerous on

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and subtract the result from 180°. Then, according to trigonometric formula, we have side *B A* and angle *A* to find side a. This is solved by the formula $a = c \times \tan. A$. Example: We have a well 80 feet deep represented by *B A* or c. We find the dip of the strata to be 43°; add this to 90°,—a right angle,—and subtract this from 180°, we get 47° for angle *A*. Now, by substituting the figures in the formula, we have $a = 80 \times \tan. 47°$, or $a = 80 \times 1.07 = 85$ feet. That is, that within 85 feet of the well in the direction of *B* there is exceptional danger, as within that distance all the cleavage-lines of the slate fall within the well; beyond this distance these lines fall short of the well, and, of course, the danger is not nearly so great.

account of the many underground seams which transmit water with great facility; when water passes through these caves it is not benefited by the natural filtering properties of the soil, and infection in this way may travel a great distance. A limestone country is generally honey-combed by caverns of vast extent. In the limestone bluffs west of Harrisburg I was once shown a cave into which a dog had disappeared in pursuit of a fox; the story runs that the dog came to the surface thirty miles away, and I think it not altogether impossible. In such regions there are a great many "sink-holes," which are simply surface connections with underground caverns; through these, surface-water pours in its downward course, infecting ground-water which may come to the surface in some far-distant spring. A case of this kind happened some time ago at Bethlehem, Pa. This town suffered from a typhoid epidemic which was finally traced to its water-supply; but how this became infected was a puzzle, for their water-supply came from one of those wild, virgin springs which, to all outward appearances, is the synonym for purity; but at last large water-bearing courses were discovered (it was a limestone region) which had carried the infection from far-away privies.

Another formation worth study by the rural well-driller is the clay; these beds are almost impervious to water, and what does pass through a short distance is generally filtered; many a well owes its freedom from disease-producing germs to the fact that it is surrounded by a stratum of clay.

Gravel, on the other hand, presents directly opposite qualities. The same property which makes a gravel-bed good for building purposes—*i.e.*, because drainage is good and a dry foundation is obtainable—makes it very bad for wells, for it is so porous that there can hardly be any hope of its yielding an uncontaminated water, if there is any means of contamination within a reasonable distance.

Such are some of the considerations which arise when one is in search of a good well-water; but, irrespective of any of these and without care or study, wells have been dug everywhere, and consequently are almost everywhere polluted. The question is at once asked: Can anything be done with these old wells whereby they may be rendered safe as a source of drinking-water? If possible, it would be best to completely eliminate them and obtain some other supply. When this is not feasible, the well, if not too grossly polluted, may be rendered more or less safe by a method devised by Dr. Koch.

Koch's Method.—Suppose that we have one of these wells which yields a polluted water. To begin with, we take out the pump, if there is one, and pour in sand until it reaches within a foot or two of the *lowest* water-level; the lowest level of the ground-water generally occurs at the end of a dry, hot summer, and for this reason such a time should be selected for the application of this method. We now place in the centre of the well an iron tube three or four inches in diameter, with its lower end expanded and perforated. This end of the tube rests on the sand and, while it is held in place, a bushel or two of fine gravel is thrown in immediately surrounding it, and the well is then completely filled with sand. Fig. 3 is the section of such a well, the dotted line representing the water-level. If now a pump is attached to the tube, we have a very good tube-well, which differs from an ordinary one in that it is surrounded by a filtering layer of sand; probably this is the best that can be done with a dug well. For a polluted tube-well our only resource is to seek another supply.

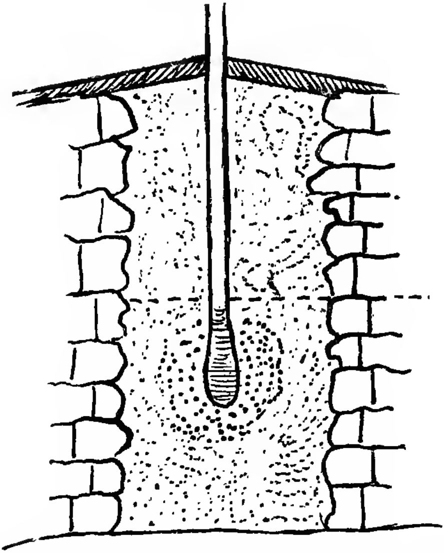

Fig. 3.—Section of Well Treated by Koch's Method. (Original.)

The next question to be answered is: How may a well be constructed, if at all, in order to meet modern sanitary requirements? While we must admit that this is hard to do, in the face of probable ground-water contamination, still, under certain conditions, there are certain kinds of wells which seem to give satisfaction; for example, in some places deep Artesian wells will yield the best possible results; but this, of course, is only over regions in which the strata are approximately horizontal. The ordinary tube-well cannot be recommended any more than a dug well, if the strata incline much from the horizontal; in such a case, if there is no other supply available, a dug well, filled with sand after Dr. Koch's method, would be far safer than any ordinary boring; this is true not only for regions of dislocated strata, but also for beds of limestone, sandstone, or loose rock of any kind.

In other places a shallow well, made according to the directions of Professor Poore, of University College, London, might give complete satisfaction, and, though the places where this could be used are limited, the method is worth some study. The following description of this experimental well made by Professor Poore is taken from the *Lancet*: "The well was sunk in the very centre of a garden which is rather profusely manured with human excreta; it is placed at the intersection of two paths,—a broad, green one, bordering one of asphalt. The situation was chosen for two reasons: (1) that it was, as far as possible, removed from any accidental pollution from the sewer in the street, and (2) that in the centre of the garden it would theoretically run the greatest chance of fecal contamination from the manure used. As the well was sunk wholly for experiment, this was essential. The garden is on a river-bank (Thames) and very slightly raised above the level of the water. The well is only 5 feet deep, and the water stands at a level (which varies slightly) of about 3 feet 6 inches from the bottom. The well is lined throughout—from the very bottom to a point some five inches above the ground—with large, concrete sewer-pipes 2 feet 8 inches in diameter, and these pipes have been carefully cemented at their junction; outside the pipes a circle of cement concrete about four inches thick has been run in. It will thus be evident, the sides being perfectly protected, that no water can possibly enter this well except through the bottom, all contamination by lateral soakage through the walls being rendered impossible. The well is surrounded by an asphalt path about three feet wide and slightly sloping away from it; around this is a hedge about five feet high except at those points where the hedge is cut by the paths. There is a closely-fitting cover of oak, which has an outer casing of lead, and thus all contamination from above is prevented.

"The water is drawn through a two-inch lead pipe which passes through the outer concrete and the concrete lining-pipe, the cut passage for the pipe being carefully closed with cement. The pump is behind the hedge and is provided with a sink and waste-pipe which takes the overflow some twenty or thirty yards to a neighboring stream. In this way the constant dropping of water in the neighborhood of the well is prevented. I regard the question of overflow one of greatest importance, which is too often neglected. The nearest point to the well upon which any manural deposit of excreta is likely to be made is on the far side of the hedge; and the distance of this point from the bottom of the well is seven feet. All water which finds its way into the well must have passed through at least six or seven feet of earth, and, of course, the greater bulk of the water has passed through a far greater length. Three chemical analyses of this water—one by Professor Frankland and two by Dr. Kenwood—testify to its organic purity, and three bacteriological investigations have given similar indications of purity."

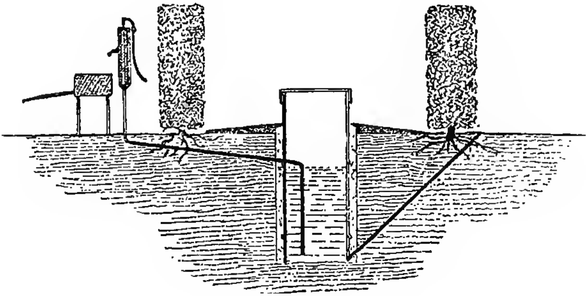

Fig. 4.—Section of Professor Poore's Well, Showing Concrete Lining and Position of Pump. The diagonal line on the right is to mark the distance from nearest garden-bed to bottom of well. (London *Lancet.*)

While this well which Professor Poore constructed yields pure water, it is no proof that all wells so constructed will. The banks of the Thames are composed of an alluvial clay, which, of course, is very impervious to drainage and leakage; and it is very likely that Professor Poore has made his well in this deposit. As he has taken great pains to keep out surface waters, any drainage which may soak through the adjacent soil would, of necessity, be considerably purified. So much for this kind of well when made in clay-beds; but suppose it is dug in a stratum of slate or sandstone; suppose that the strata are tilted on edge, as represented in Fig. 2, which would be a very likely case almost anywhere in Eastern United States. From what has been said before one would hardly feel safe in drinking the water from such a well, if human excreta were scattered over the adjoining fields in the locality of *B* (Fig. 2); assuredly not, if the excreta contained typhoid or cholera germs.

The fact is that one can never construct a perfect well by any given rule; he must make a careful study of the locality and the nature and dip of the strata if he would have a pure water, and even then it is hard to get it unpolluted from wells of any kind except, perhaps, Artesian. Far better to select some other source of supply, preferably the one next mentioned, which seems to the author to be the ideal one for many isolated places.

Cisterns.—In most localities in the United States, rain-water stored in properly-constructed cisterns furnishes a substitute for well-water, which is practicable and easily available, for all we need is a suitable collecting surface and a suitable cistern.

In the Atlantic States the annual rain-fall is about thirty-seven inches,—an amount which, with the ordinary house-roof for the collecting surface, is amply adequate and absolutely reliable; of course, if we live in a district where the rain-fall is less, a corresponding increase in the size of the cistern and collecting surface is necessary to meet the requirements of a continuous supply. If the house-roof is something like one thousand square feet,—and many houses will furnish even more,—the yearly yield of rain-water collectable will be, if the annual precipitation is thirty-seven inches, about 20,000 gallons, which, at ten gallons per head per day, is more than sufficient for the wants of an ordinary family. For this amount the cistern need not be excessively large; one ten feet in diameter and five feet deep will hold 2000 gallons, and this would last, under usual conditions, more than a month; the danger of exhausting the supply would not be great, for it is rare indeed that a month passes, in most parts of the country, without some precipitation.

The construction of the cistern is of the utmost importance, for in its ability to keep out soil-water rests the superiority of the cistern over the well. If made of bricks and thoroughly cemented it will be proof, in most cases, against this contamination from the soil. I have known such a cistern to last many years without leakage.

In the next place, we need a filter, for rain-water, unless it is collected from a purer source than is generally the case, has a peculiar flavor and odor. In order to make a filtering cistern out of an ordinary one it is first necessary to build a partition from the bottom almost reaching to the top; at the bottom there are several openings connecting the two

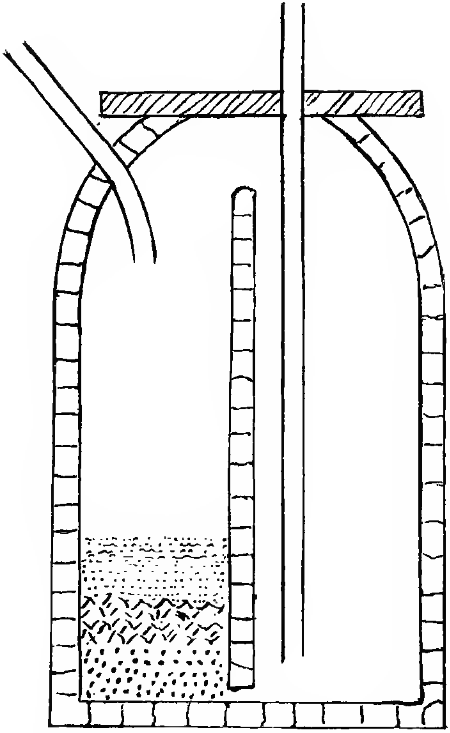

Fig. 5.—Section of Filtering-cistern. (Original.)

sides. Another way to do this filtering is to make two cisterns side by side and connect them by pipes, but the method of having one cistern with a partition is cheaper, and, perhaps, better, as there is less danger of leakage. In constructing the filter, which is placed on either side of the partition, we may use a variety of substances; three or four feet of common sand is probably the best and the cheapest material that can be obtained. When a natural sand-filter is used in the open air the upper layer of sand becomes covered by a film of nitrifying bacteria, which is of the greatest value in purifying the water. Although this sand-layer in the cistern is cut off from sunlight, it gets an ample supply of oxygen, and it is likely that it acts, in a measure, like the open-air filters. Of all the different materials which we may use, the one I prefer is made of three layers, each consisting, from above downward, of sand, polarite, and gravel. Whether this, however, is much better than one made of ordinary sand is a question. Into the side containing the filter the leader from the roof discharges, and into the other is fixed the pump. This arrangement is readily understood by reference to the figure. The water which passes to the pump in a cistern like this is securely filtered, and we get a good, pure, and harmless drinking-water. The sink under the pump-spout may be perforated and empty directly into the side of the cistern containing the filter, so that there is no waste of water.

While this method of procuring drinking-water is less expensive than any other way, it is almost universally neglected by the very people whom it would most benefit,—the rural population. As long as the cistern is impervious to the ground-water, there is no danger of its contents becoming infected except by gross carelessness,—filth is somehow or other gotten in at the top.

One can very readily tell if the cistern leaks by making a simple chlorine examination of the water and then comparing it with the amount of chlorine found in rain-water collected in a clean receptacle somewhere on the surface. It is evident that much deviation of the chlorine from the average of a surface collection will point to leakage in the cistern.

Cistern-water, even without a filter, is vastly better and vastly safer than any well; and if the collection is made from a tin roof kept moderately clean, the water will be almost odorless, fresh, and palatable; such water the writer has frequently used.

The collecting surface—whether tin, wood, or slate—should be protected from overhanging trees, and a "cut-off" should be placed in the spouting, so that the first washings from the roof may be turned into the street gutter; in this way dust, droppings of birds, etc., are washed away before the water is allowed to run into the cistern.

The use of rain-water, too, furnishes a means whereby the rural householder may have water *under pressure* in his house, if he so desires. To have this great comfort people generally think it necessary to have an hydraulic ram, a force-pump, or some other expensive arrangement. By using rain-water all one needs is a tank placed in one of the upper vacant rooms and a series of distributing pipes to the bath, kitchen, or wherever one wishes running water. The tank is large or small according to the needs of the service. Into the tank a branch pipe with a "cut-off" leads from the roof-spouting; when the tank is filled the "cut-off" is turned and the water goes in another direction. The only care necessary is to see, from time to time, that the tank does not get empty and that it is cleaned at proper intervals. In one instance where this kind of water-service was used, the stable-roof was also utilized. A tank was placed in the loft and the leader from the roof turned into it; by this means the stable was furnished with water and there was a plentiful supply for watering the adjacent garden and lawn.

Rivers, Lakes, and Springs.—Many small towns are beginning to seek a public water-supply from neighboring rivers, lakes, or springs. Such a source would seem desirable in a good many cases; but giving a town water-pipes without sewer-pipes is like putting the cart before the horse, unless we first teach the people how to make suitable drains and how to make and use earth-closets; if they use cesspools—and that is what they always do use when there is a public water-service—the polluted soil-water will eventually soak into the water-pipes, and the "last state will be worse than the first."

While any ordinary mountain-stream would seem, on first thought, to furnish a pure and undefiled water, there are certain points to be considered before selecting such a supply. On account of the limited gathering-grounds of a small stream, there is much more danger of infection than in a large river. The discharges of one typhoid patient, placed on the banks of the Susquehanna or the Delaware, is not likely to cause danger to any great extent, but similar discharges on the banks of a narrow mountain-brook caused the fearful epidemic of Plymouth; so, on this score alone, the "babbling brook" is not as ideal a source of supply as some large river. In selecting a stream, lake, or spring, other things being equal, we should take one having a wild, uncultivated, and uninhabited gathering-ground, and this should be, by all means, under the supervision of the people using the water.

The pollution of public water-supplies is an interesting and instructive study; sometimes the water is actually fouled by sewers from the very town itself; the people are, in fact, drinking their own waste. This is the case with Harrisburg, Penna., where the intake of the city-works opens into the river only a short distance from the shore and directly below the mouths of several sewers.

In rivers flowing through coal regions there is another kind of pollution which sometimes enters into the question of a water-supply; while the regions where this occurs are not very numerous, it is still worth noting. This pollution is caused by drainage-water from coal mines; it consists chemically of a solution of protosulphate of iron, and forms, when concentrated, a black, turbid stream from its suspended coal-dust; when more diluted, it is of a peculiar sulphury color, and gives a white deposit on rocks lining its course. In Pennsylvania this goes by the name of "sulphur-water"; but this is a misnomer, for the color is due, not to sulphur, but to oxide of iron. The protosulphate, which is about the only important chemical constituent, decomposes under the influence of sunlight and oxygen, and yields a sequisulphate and a hydrated oxide; so much we know from the laboratory of the chemist, and there is no reason to believe that the result is any different outside of the laboratory. The oxide, however, is not a bad thing, for it assists somewhat in purifying the water, but the sesquisulphate is an astringent which, when it comes in contact with tannic acid of tea or coffee, has a tendency to make tannate of iron, and tannate of iron is popularly known as "ink." For this reason waters contaminated with mine-drainage are not suitable for town-supplies, and not only that, but they destroy more or less the vegetable and animal life in their respective courses.

I have seen small streams in Northern Pennsylvania which were as black as ink, and a good deal thicker, from this drainage. No living thing inhabits their waters nor seeks their banks,—a Nineteenth Century representation of the fabled Styx.

To purify a stream encumbered by mine-drainage, it is necessary to filter it through beds of limestone; by this means the sulphate of iron is changed into sulphate of lime, which is harmless, although it adds some hardness to the water. The excessive amount of free coal-dust which these waters sometimes carry may be removed by any kind of a gravel or broken-stone filter. In some of the large rivers this drainage occupies only a small part of its width, and water for drinking may be obtained by extending the water-pipes beyond the "sulphur-stream."

Examination of Wells and Well-water.—The physician in isolated localities is frequently called upon to give an opinion as to whether or not a certain well is fit for use. He has to depend upon his own resources, and it is necessary that the examination be as simple as possible and at the same time reliable. Each well is a factor by itself, and should be studied as to the geological strata which it pierces, the position of the sources of possible pollution, and the relative amount of chlorine it contains. The old idea that a well drains a cone-shaped area whose base is from fifty to one hundred times its depth approximates, perhaps, the truth, but so much depends on the character of the rock-strata that is is impossible to lay down any definite rule; it makes all the difference in the world whether the well taps the ground-water through a thick, heavy clay, or whether it draws its supply from a gravel-bed, from slate, sandstone, limestone, or a more impervious rock; it makes much difference whether the strata are horizontal or "turned on edge." The proximity of a source of pollution counts for little as to a distance in feet; the position studied in regard to the slope of the strata and the direction of the ground-water currents mean much more in laying bare a source of trouble.

In examining the water we want to find out if it contains pathogenic germs or if it is likely to. The detection of these is probably not available to many country practitioners. Disease-germs only come into a drinking-water through the medium of organic waste, and, in the absence of our ability to detect the germs, we have to be satisfied with the detection of the pollution with which the germs are associated,—sewage, privy, stable leakage, etc. If a well shows that it is not polluted with such material, it is most likely free of pathogenic germs, and is almost certainly not a factor in producing disease.

To find out this kind of pollution a simple chlorine examination is generally all that is necessary. I do not, for a moment, depreciate the elaborate analyses for organic matter, nitrates, etc., but these are not available in the outlying districts, and they are not actually necessary in a good many cases of well-water examination, especially in times of epidemics. If we know the normal chlorine of the region (see "Appendix")—*i.e.*, the amount of chlorine present in unpolluted springs and rivers—we can readily judge the amount of pollution of a given water; of course, chlorine in a water may represent only past pollution, but in a sanitary way this does not count for much, for we can never tell at what moment the old lines of drainage might not be re-established, and for that reason a well once polluted presents an ever-present danger, unless the source of former pollution can be absolutely abolished.

Although we judge the amount of pollution by the variation from the normal chlorine, we should not make this absolute and condemn every well which shows excess, for some excess above the normal, although pointing almost positively to pollution, is allowable and does not necessarily mean *dangerous* pollution.

What each physician should do, if he lives in a locality supplied by well-water, is to ascertain the chlorine normal of the district, and, if a well shows a water containing chlorine much above this amount, it should be viewed with suspicion and judgment passed accordingly.

The following list, taken from several Health Reports, gives an idea of the amount of chlorine in certain waters not excessively polluted:—

Naugatauk River,	0.16	parts	per	100,000.
Charles River,	0.43-0.80	"	"	"
Housatonic River,	0.16	"	"	"
Croton River,	0.44	"	"	"
Schuylkill River,	0.57	"	"	"
Delaware River,	0.25	"	"	"
Spring, Penna.,	0.50	"	"	"
Spring, Conn.,	0.17	"	"	"
Well, Penna.,	0.20	"	"	"

CHAPTER II.

WASTE DISPOSAL.

THE disposal of waste in country places presents features entirely different from that of a city, inasmuch as in the country this duty depends upon individual effort, and individual effort, be it ever so good, is a poor substitute for municipal oversight where sewage and garbage disposal and every other sanitary requirement must conform to a definite rule.

Excreta.—First in order, and perhaps, too, in importance, comes the disposal of human excreta; and this, in the absence of water-service, is very important, for we have learned that one of the most common causes of preventable diseases in the country comes from well-water polluted by leakage from cess-pools and privies. If there is one sanitary necessity which stands pre-eminently above all the rest, it is, probably, the substitution of the earth-closet for these foul privies and cess-pools, which undoubtedly contaminate the ground-water. We know so little about the changes of the water in the soil and so little about the life-history of the germs of certain water-borne diseases, that there is danger whenever the ground-water is exposed to excreta. It is a fact that the privies in most villages are rarely emptied, and one sanitarian has explained this on the supposition that the wells draw a good deal of their water from the urine of neighboring privies; and this can very readily be the state of affairs in many places.

Privies should be absolutely abolished unless they are placed far from any well and made perfectly water-tight. Instead of a privy-vault, it is better to use dry earth-closets. In the average country town not one person in a thousand uses an earth-closet or, in fact, seems to know anything about it. If we could get village dwellers to understand the sanitary value of this method of excretal disposal, it would be a great step in progress. There are very many ways and methods of making these dry closets. The following, which is one of the simplest, is that recommended by the Pennsylvania State Board of Health; it is so easily made that there is no excuse why every rural dweller should not have one:—

"The body is a plain pine box; its sides are 14 inches high, its depth 18 inches, and length about 30 inches. It is divided into two compartments,—one 18x18 inches and the other 18x12 inches. The larger of these compartments has no bottom; the smaller is a tight one. On top are two covers. The lower one, hinged to the upper edge of the back, extends all the way across both compartments. In this lower cover is cut the seat,—over the centre of the larger compartment. The upper cover is hinged to the lower one and may be raised independently; it is made the size of the large compartment, and both have a little edge projecting to facilitate lifting them." The receiving vessel is a galvanized-iron bucket (an old coal-bucket will answer)

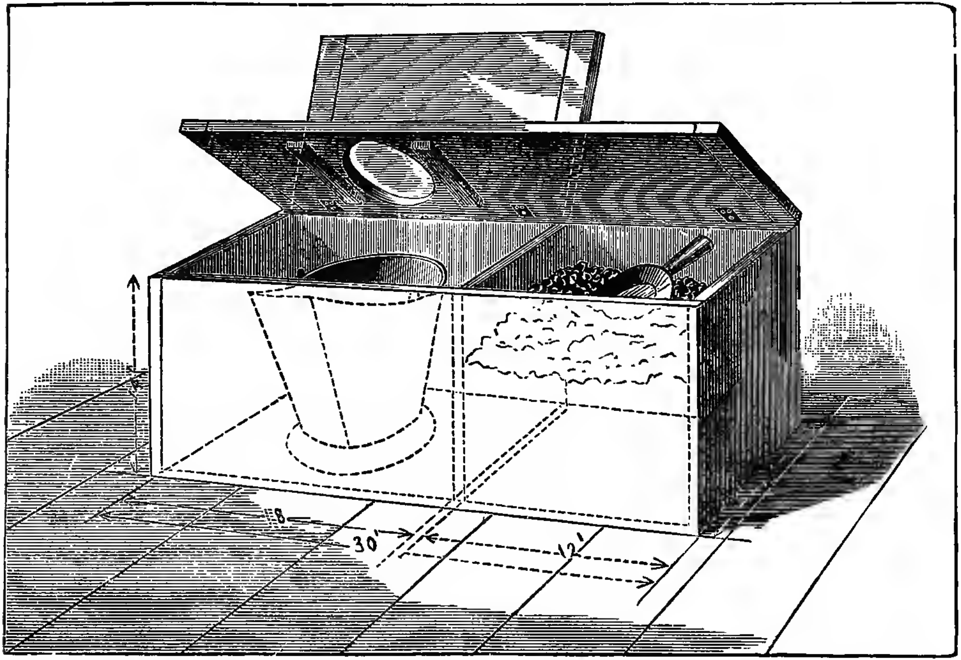

Fig. 6.—Dry Closet. (From Report of the Pennsylvania State Board of Health.)

as large as will stand in the compartment with the covers down. The small compartment is filled with dry, sifted anthracite coal ashes, or whatever else is used, a scoop placed in it, and the commode is ready for use.

After using, the lower cover is raised, exposing both compartments. A small quantity of the ashes is then taken in the scoop and scattered over the contents of the hod. A closet such as this may be placed anywhere in the house or in the old privy, and with proper care is absolutely odorless. The material for use in these closets may be either ashes or dry earth; in summer dry earth may be taken directly from the garden-bed, exposed to the sun for a short time, and, for use in winter, stored in barrels. Ashes—finely sifted from anthracite coal—are perhaps better, if the closet is in the house, for the ashes are lighter and more absorbent; dry earth, if much urine is allowed to pass into the hopper, becomes muddy and heavy.

The disposal of the contents of the closet is, perhaps, the stumbling-block to many. This material, whether ashes or earth has been used, may be placed on a corner of the garden-bed and covered with a little earth, or it may be buried a few inches under the soil; lastly, it may be kept in a dry place, covered with earth and carted away at some suitable time by the farmer for use as fertilizer. In places where earth or ashes are scarce the contents may be allowed to humify in a dry shed and this humus used again; this may be repeated many times. The agent of disposal in all cases is the nitrifying bacteria. To be sure, if too much ash is used, nitrification is delayed; but with the mixture of a little earth the organic matter all disappears in due time.

Last year I made some experiments in regard to the length of time required for the disposal of excreta when buried under four or five inches of soil. In summer the time was about two weeks, which corresponds to the time observed by Professor Poore. In January—in the coldest month of the year—the excreta, when mixed with ashes

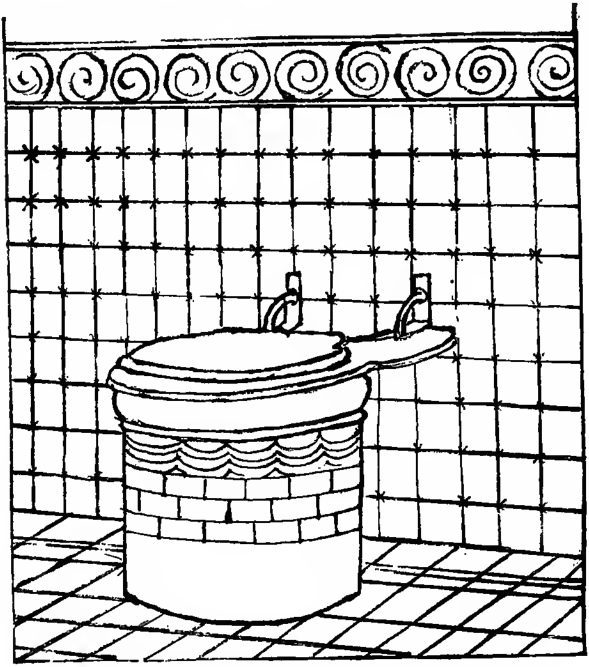

Fig. 7.—A Model Dry Closet. (Original.)

and buried, had completely disappeared in four weeks, although most of the time the surface-soil was completely frozen, and at the time of examination was so hard that I had to use a pick.

If one desires a more elaborate commode it may be made somewhat after the manner of the modern water-closet. A design of this fashion is shown in Fig. 7. The pail is made of ornamental agateware, and upon this rests the seat of mahogany, walnut, or oak, exactly the same as is used in the water-closet. A pail which is open in this manner possesses the advantages of the open water-closet in that there is no hiding-place for dirt. The ashes may be kept in a box beside the pail.

Another way of using the earth-closet, especially for schools or large dwellings, is to have a privy constructed with what is called a "dry catch." A pit is dug, about three feet deep, which has its two sides, front, and back lined with brick; in the back an open space is left for a door of wire netting, and an inclined pathway is made from the bottom of the closet to the surface, unless the privy should happen to be built on the side of a hill, when this would not, of course, be necessary.

The floor of the vault is concreted and inclined as indicated in the drawing. The urine which is voided flows backward into a gutter, which is filled with some absorbent, —sawdust, ashes, or dry earth.

The pan under the seat is made of galvanized iron, and a flap is attached to the lower end to prevent an upward

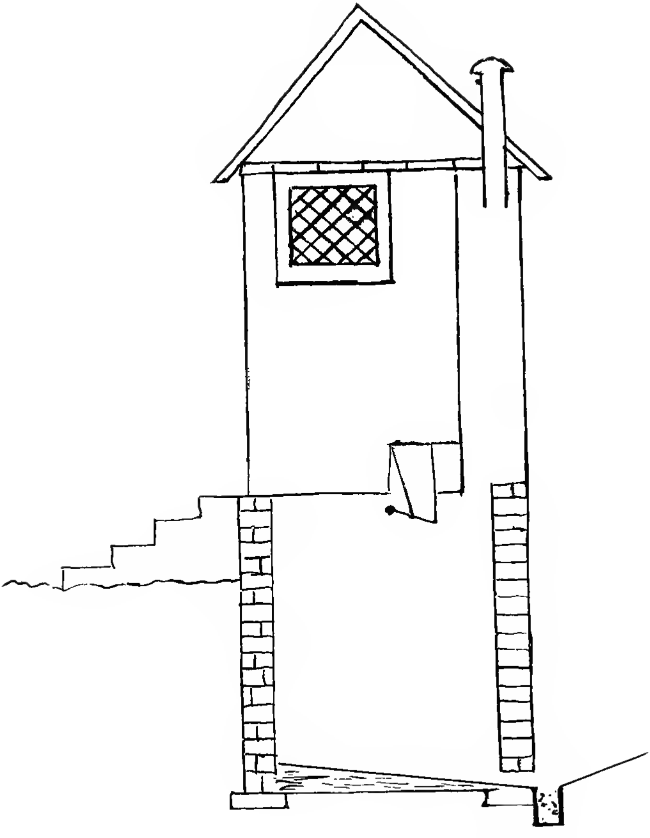

Fig. 8.—" Dry-Catch " Privy. (Modified, after Poore.)

draft; this flap may be balanced so as to work automatically, or may be worked by a chain. After use, earth or ashes is put in the pan just as in any other closet.

In a privy of this sort the humification of the fæces will continue, although no earth is added. Poore narrates a case where, by neglect of the scavenger, the "contents had not been removed for two months; still the bottom of the mass had humified and become inoffensive." The proper way for such a closet to be utilized by country schools would be to have a reservoir filled with an absorbent, so arranged that pulling a chain would throw a sufficient amount into the pan, or what, perhaps, is better, is simply to have the janitor throw earth over the contents of the closet once every day; every week or two, according to circumstances, the mass should be removed.

To get people to use dry closets is more a question of education than of legislation. A town that purposes this innovation should have printed circulars sent to all householders, showing the advantages of the method. Then they might order the construction of all privies after the method shown in Fig. 8, and have a public scavenger clean them every week. The personal influence of the physician and his example in these sanitary matters will do much to enlighten the people to a correct understanding of the value of sanitary appliances; and, until the people are educated to this point, legislation will hardly do much good.

Slop-waters.—For the purpose of studying this part of our subject we have to consider three classes of country houses: First, those which have water-service and use water-closets for the disposal of excreta just as in the city; this, of course, necessitates the use of sewers, in which the slop-waters are also disposed of. With these we have nothing to do, so far as the individual treatment of waste-water is concerned. Secondly, those in which, although having water-service, the excreta are disposed of by some form of dry closet; in this class sewers are not needed, but drains are necessary for carrying the waste-waters from the kitchen sink and bath. Thirdly, those which have no water-service, no bath, etc. This comprises, by far, the greater number of houses outside the cities and large towns. In the latter class all slops—which amount in a family of four or five to about fifteen gallons daily—are collected in buckets and are generally emptied out the kitchen door, irrespective of where the filthy water may flow. In such a house a slop-bowl should be put in some convenient location either in the house, on the porch, balcony, or elsewhere, and connected with a surface- or subsoil- drain, both of which have points of excellence.

In the simplest form of a drain the pipe from the slop-bowl may lead to a furrow in the vegetable bed. A better arrangement is that shown in the accompanying photograph, which was taken from a small drain in actual use. This drain was made for one of our third-class houses, which have no water-service. A box about a foot square, lined with tin or galvanized iron, was placed in a suitable location—in this instance, at the corner of the bed to be used—to serve as a receptacle for the slop-waters which are collected in buckets; from this extends an old tin roof-gutter in any direction available. The bottom of the box is perforated by twenty or thirty small holes, which serve to let the water into the gutter. A number of small holes is better than a few large ones, as the small tend to keep solid particles out of the gutter and prevent clogging. The gutter is twenty feet long; it is nine inches above the ground at the upper end and three inches at the lower, in order to give sufficient fall for its rapid emptying,—a very necessary factor in cold weather. The gutter is pierced every three or four inches by one-fourth to one-half inch holes, which permit the liquid to flow on to the soil, where it is quickly absorbed. The soil needs a little raking now and then to favor absorption and evaporation. Along each side of the drain may be planted a hedge of laurel, a row of sunflowers, or any vegetable which happens to be desirable; only that all *débris* from overhanging plants must be kept out of the gutter. This kind of a drain will do very well in houses having water-service, by simply having the waste-pipe from the kitchen and bath discharge into the gutter.

An important point in the use of this drain—as, in fact, of any drain—is to keep solid and liquid refuse separate,—for a liquid containing many solid particles tends to choke it and to interfere with its efficiency. This separation is readily accomplished by keeping two buckets in or near the kitchen,—one for solids and one for liquids. Over the one is placed a tin basin with a perforated bottom; the semi-

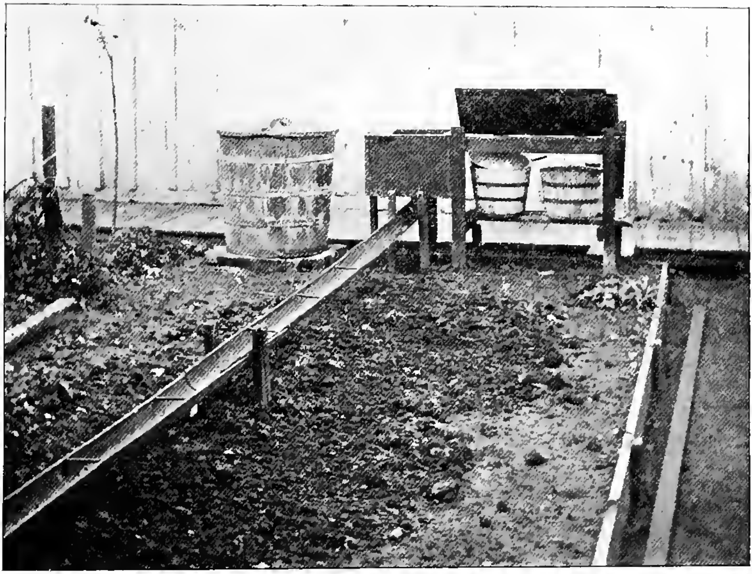

Fig. 9.—One Form of Surface-drain, Made of a Tin Roof-gutter.

liquid waste, as it comes from the kitchen, is placed in the basin, the water drains through, and the solid refuse is emptied into the other bucket. In Fig. 9 these buckets are shown adjoining the drain.

In the winter a surface-drain may cause trouble unless some care is taken. In the first place, it should be kept clean of snow, and, in the next, the liquid must be emptied into the drain before it is chilled by long exposure to the cold; but if proper attention is paid to these points and to the thorough emptying of the drain each time that it is used, it will give complete satisfaction, even in the coldest weather.

Another way of making a surface-drain is to construct a gutter of perforated bricks, the space underneath the gutter being prepared by trenching and filling with small stones, cinders, and the like, to favor absorption. Instead of perforated bricks, the ordinary ones may be used by leaving an interval of half an inch or so between each brick. A drain of this sort has the advantage of being easily cleaned by sweeping. A number of English physicians are said to favor this plan very much.

A very good drain, too, may be made by digging a trench a foot or so deep and a couple of feet wide, and lining it with small, round, cobble-stones, such as are used in some street gutters. The space, of course, underneath the drain should be prepared with some absorbent material, and the waste-pipe should discharge a foot or so above the bottom of the gutter, so as to permit no undue accumulation of ice in winter; the length of such a gutter should be fifteen or twenty feet for a family of four or five. In this, as in all surface-drains, the waste-pipes need not be trapped.

A surface-gutter may be protected from freezing by covering with some old boards and a little earth, making it practically a subsoil-drain, for the time being.

In some places, for various æsthetic reasons, and especially in a very cold climate, a surface-drain may not be practicable. Then we have to resort to a subsoil-drain, which is made as follows:—

For this method several hundred feet of land are necessary if all the waste-water from the house is disposed in one place; but in many instances different places for different drains will be more suitable. In calculating the amount of tiles, we may count one or two feet, depending on the soil, for each gallon to be disposed daily. A trench is dug about two feet deep, and in this ordinary two-inch drain-tiles are placed; it is best to rest the tiles on a narrow piece of board in order to get them on a regular pitch, which should be at least five inches in twenty feet. The tiles are placed about half an inch apart, and the joints are covered with broken stones or half-pipes; then the whole trench is filled with stones, coarse coal ashes or cinders completely surrounding the tiles, and finally covered with earth. The delivery-pipe from the house is connected to the drain by a lead or iron pipe, which projects into the end tile. At the far end of every line of tiling a pipe should be inserted, and project above the ground, so as to allow the free circulation

Fig. 10.—Surface-drain Made of Ordinary Bricks, Showing Delivery-pipe from Kitchen Sink and Bath.

of air through the drain. Subsoil drains, if made in this way, cause very little odor in the room; but, as a precautionary measure, they should be trapped. In a case in which more than a single line of tile is necessary the field may be laid out in a variety of ways; the only point necessary is to have a sufficient interval—two or three feet—between each line.

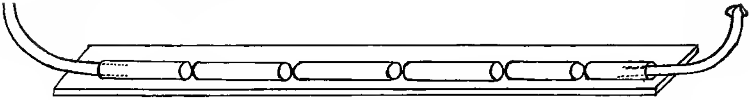

Fig. 11.—Method of Laying Tiles for Subsoil-drain.

The kitchen sink and the bath may be directly connected to such a drain, either together or separately.

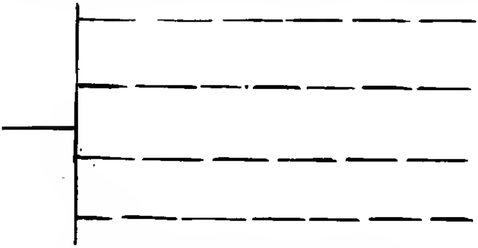

Fig. 12.—Plan of Subsoil Irrigation-bed.

For the disposal of the bedroom-slops a slop-bowl may be placed in the bath-room, or wherever most convenient.

In some such manner as this we dispose absolutely of all the waste-waters of a house just as well, perhaps a good deal better and safer than we could with sewers.

In the first class of houses—those having water-service and sewers—there comes up the question of sewage disposal, which almost invariably means a cess-pool. Instead of a cess-pool, a small shallow tank should be built at some suitable place, more or less distant from the house, and at the edge of some cultivated field, counting about one hundred square feet of land for each individual. There are flush-tanks constructed for placing underground; but this is hardly necessary, unless the location selected should happen to be very near the dwelling. The house-sewer is connected with the tank, and an automatic flush controls the distribution of the sewage, which should be discharged intermittently. A gutter made of cement, or half-pipe, is laid from the tank along the field to be used, and every dozen feet or so there is a little branch gutter to guide the sewage over the land. In front of each of these branches there is a barrier of broken stones, to check the flow and prevent washing, and beyond this the land to be used, which should be planted with corn, as this does not keep out sunlight as much as grain, and sunlight is an important factor in sewage farming.

Garbage.—Sweepings, paper, rags, ashes, and solid refuse from the kitchen make another chapter in waste disposal. In cities this goes under the head of garbage and is disposed by various methods, in many cases destruction by fire giving the greatest satisfaction. In cities under good sanitary control ashes are kept separate from the other material, and we do likewise in the country. Most of the

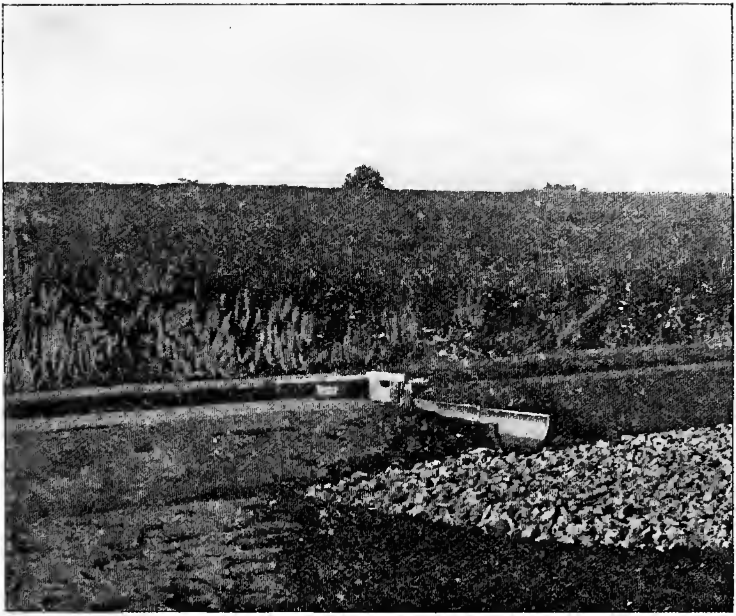

Fig. 13.—Photograph Showing Distributing-gutter and Stone Barrier of an Irrigation-field. (New Jersey State Board of Health Report.)

solid refuse, save the ashes, is probably best gotten rid of by fire, and it is generally recommended that the kitchen range be the medium of disposal. To do this properly there must be a good fire in the range, and too much waste must not be put in at once. With proper care almost all kitchen refuse, orange- and potato- parings, egg-shells, bones, etc., can be destroyed without trouble. The only disadvantage is that this sometimes causes an odor. To obviate this an apparatus has been devised for attachment to the stove-pipe, whereby the material is first carbonized by the heat passing up the chimney, before throwing it into the fire. I have no practical experience with this arrangement, but judge from the various reports that it answers well.

Kitchen waste may also be disposed of by simply burying it a few inches under the soil. A hole several feet square may be dug in the garden-bed and the refuse emptied into it and covered with earth from time to time. In this way the material is disposed of by nitrification,—in a month or so,—and the soil is made the richer. When land is available,—and it does not take much,—this method is the most efficient means, perhaps, for disposing of putrescible garbage. Combustible waste—as rags, paper, sweepings, bones, and the like—can be disposed better by fire.

The following is another method for the destruction of putrescible waste, which may be of value in certain places: "Take a piece of galvanized wire netting three or four feet wide, and with it inclose a circular space about three or four feet in diameter, the netting being fastened and supported by two or three iron or wooden stakes driven into the ground. Into this little wire inclosure throw all refuse from the house and garden which is capable of rotting, the parings and waste of vegetables and other food, the mowings and sweepings of the lawn and paths, weeds, fallen leaves, etc. Such a heap as this, exposed on all sides to the air, is not offensive, and the component parts of it undergo humifaction. When the wire inclosure will hold no more, a little earth must be thrown on top, and the heap must be left for several weeks freely exposed to the weather. It will settle down and diminish in bulk, and finally is entirely converted into fine garden-mold suitable for potting or for enriching the soil. The final act in the management of this refuse heap is to sift it and consign the residue to the garden bonfire. When one netting inclosure is filled, a second must be formed; so that in connection with a house there must always be two heaps,—one forming and the other ripening. Such heaps, if freely exposed on all sides, are not, in the smallest degree, offensive."

The other part of the garbage—the ashes, broken crockery, tin cans, etc.—should be kept separate and used for filling. If an ash-closet is used almost all the ashes will be disposed in this way.

The waste, then, of an ideal country house would be disposed somewhat as follows: The material from the dry closet—which is the only method of *excretal* disposal recommended when there is no water-service—is to be used as fertilizer by burying a few inches in cultivated soil either on the garden-bed or on a neighboring farm. The *waste-water* from the kitchen sink and the bath run into lines of surface- or subsoil- drains. The *garbage*—that is, the putrescible part which comes from the kitchen—is burned in the range or buried in a pit in the garden-bed. The combustible part—rags and paper—is burned. The non-combustible part—ashes, tin cans, oyster-shells, etc.—is put into bags kept for the purpose, and at intervals is taken away and used for filling. In houses where there is water-service and water-closets excreta and slop-waters are disposed together in the form of sewage, and for this the only means of disposal is irrigation. The cess-pool should not be thought of.

CHAPTER III.

THE SOIL.

THE study of the soil and rocks used to belong strictly to the geologist, but lately the biologist and the sanitarian have taken up the work, and we are finding that there are factors in the soil which have much bearing on health. For example, there is the surface-soil, with its peculiar filth-destroying properties; ground-moisture and ground-water present problems to be solved; ground-air, too, is a question of vast importance.

The **surface-soil** is composed of the *débris* of the subsoil mixed with more or less humus; this humus is the black soil, or mold, which is produced by the decomposition of the organic matter of plants and animals; surface-soil, though to a superficial observer apparently dead, is filled with all varieties of lowly life,—worms, bacteria, bugs, and beetles, which work out the problem of their existence vastly better than some forms of higher life.

It is only in the upper few feet of the soil that is carried on all the various processes for the feeding and clothing of the race,—a vast laboratory, as it were, of which we know very little.

As far as sanitarians are concerned, the most important part played by this "living earth," as it has been called, is its ability to destroy waste-material and to break up such matter into its primary elements, rendering them harmless, and fit to be taken up by growing plant-life.

The process of decay and disorganization was noted long ago, but we never knew exactly what it meant until very recently. Now we call it nitrification, and the world has to thank Schloessing, Müntz, Warrington, and Winogradski for the work that they have done; but much yet remains unknown, for not one of these nitrifying organisms has been isolated, unless we except the bacillococcus of Frankland; not one has been cultivated. These bacteria, only known, as yet, by their effects, are the great scavengers of the world, for they are present in all natural and cultivated soils.

The products of nitrification are ammonia, nitrites, and nitrates, and the last is plant-food. It is not just yet settled whether nitration—the formation of nitrites into nitrates—is chemical or biological, but the evidence seems to point to the former, and that it is brought about by the action of the carbon dioxide and the oxygen of the ground-air. Sewage-farms, filter-beds, earth-closets, and all like destroyers of filth depend, for their efficiency, on nitrification. When we add earth to the dry closet we simply add nitrifying bacteria plus an absorbent. Could we isolate these bacteria it might be better to add them separately, but we have not progressed so far; so we add the bacteria in their natural habitat.

The nitrifying properties of different soils depend on various circumstances, such as the nature of the soil, aëration, moisture, and heat, the thermal life-point varying with different organisms. Excessive heat destroys the nitrifying bacteria; so that earth dried in an oven is absolutely useless—save as an absorbent—for the earth-closet.

Germicides kill them; so that adding carbolic acid to a compost-heap or a privy is useles as far as the ultimate disposal is concerned, for, while the acid might kill some pathogenic germs and destroy noxious odors for the time being, it also impedes the nitrifying germs.

Ground-moisture.—If one digs into the earth he finds that the upper layers are moist, containing both air and water. This dampness is derived from percolating waters from above and from the ground-water below, which tends to rise by capillary action and hydrostatic pressure. Ground-moisture is directly proportional to the absorptive power of the soil, and inversely as its permeability, both of which depend on the character of the soil and varies accordingly; for example, humus will retain about 50 per cent. of water; slate, 4 to 10 per cent.; sandstone, 3 to 8 per cent.; limestone, only 2 to 3 per cent. It is evident that by increasing the permeability of the soil we can diminish its dampness; to do this we fill trenches with some loose rock or *débris* of any kind, or we may lay a course of drain-tiles. Water precolating through the soil will collect in these trenches or tiles, flow off rapidly, and the soil will become drier.

This undue dampness of the soil is, no doubt, a factor in certain diseases. The prevalence of rheumatic complaints in rural districts, where the houses are almost universally damp, is a well-known fact, strikingly different from its prevalence in a well-drained city. Of course, there are other factors at work; but soil-dampness is certainly one not to be ignored.

It has been claimed that there is a relationship between dampness and phthisis. According to some English statistics, there seems to have been a great lowering of phthisical mortality following subsoil-drainage in certain localities. We now know that phthisis is a specific disease; but it appears likely that continual exposure to dampness so lowers vitality that the bacilli find a better breeding-ground than in the normal condition.

One other disease—namely, malaria—has much dependence apparently on excessive ground-moisture; this, with heat and organic matter, seems to be a primal factor in the breeding of the plasmodium. It has been noted that increased dryness of the soil, which is brought about by surface- and subsoil- drainage, is a potent factor in the destruction of malaria. Eucalyptus, sunflowers, and other plants which absorb much moisture are great aids to drainage. Sunflowers, especially, as they will grow almost anywhere, are to be recommended for wet places about country homes.

Ground-water, as explained before, is that underground sheet of water which completely fills all the interstices of the soil at a certain depth, extending from several feet to hundreds of feet below the surface; its height is readily told by the height of water in the wells of the district. This ground-water does not flow in rivers, as is generally supposed, but extends underneath the soil in one broad, continuous sheet; it is for this reason that wells sunk almost anywhere yield water.

The origin of the ground-water is, of course, the rain sinking through a porous soil; its level varies from time to time and does not extend in a horizontal line, but in an irregular one, the fluctuations depending on the geological character of the rock and the precipitation and height of adjoining water-courses. At Munich, for example, there is a difference of ten feet between the highest and lowest levels. In summers characterized by long droughts the water-courses become very low, and consequently the ground-water sinks below its usual place; as a result, many wells get "dry." The proper time to dig a well, if such things must exist, is during a dry summer, when the ground-water is at its lowest point.

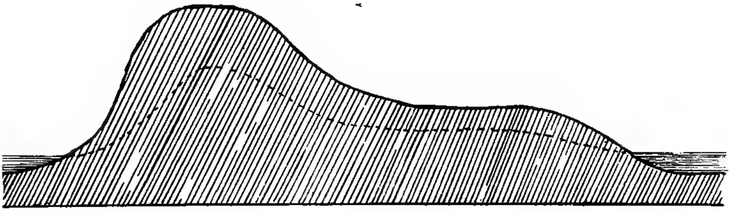

Fig. 14.—Showing Ground-water Level in an Elevated Region Between Two Streams. (Original.)

The sheet of ground-water is also in continual motion toward the nearest water-courses; five to ten feet per day gives some idea of its velocity, which changes with the porosity of the bed. In some regions of limestone, slate, and sandstone there are large underground cavities and fissures, through which water-movement is greatly facilitated.

Much has been said about the relation of the ground-water to diseases, and especially its connection with typhoid fever. The theory of Professor Pettenkofer, that low ground-water and epidemics of typhoid fever occur simultaneously, cannot be verified for all places. The following sketch of these relations for the city of Zurich in 1872 shows the exact opposite. Of course, if a city uses wells or a polluted drinking-water of any kind, Pettenkofer's theory rests on a logical basis, for the increase of drainage and

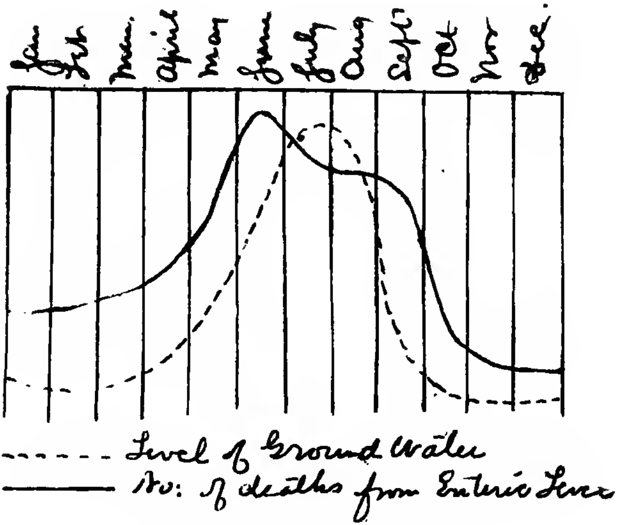

Fig. 15. (From Miers and Crosskey.)

consequent wider area of infection brought about by low ground-water will readily explain the spread of the disease.

The truth of the ground-water question seems to be that unless its level is very near the surface it has little to do with health save in the pollution of water-supplies. I recall a town where the ground-water is generally twenty-five to fifty feet below the surface, yet almost every house in that town is damp and unhealthy, because faulty construction has permitted ground-air and ground-moisture to permeate the foundations. Much has been said about lowering the ground-water by drainage; but ordinarily it is a difficult thing to do this. When people speak of lowering the ground-water by building sewers and drains, they generally mean that they lessen ground-moisture and dampness.

Ground-air.—More important than ground-water is the air which occupies the upper layers of the soil and fills all the interstices as far down, at least, as the surface of the ground-water. The composition of this air and its movements are the two factors which interest sanitarians. Decomposition and putrefaction are constantly going on in the soil, and the gases arising from these processes diffuse through the soil. The carbon unites with the oxygen of the atmosphere, and carbon dioxide is formed, which is always greater in the ground-air than in the atmosphere; for example, at Dresden, where experiments were made, at six feet beneath the surface there was found to be 2.99 per cent., and at eighteen feet 7.96 per cent., of carbon dioxide. Oxygen, on the other hand, is decreased, and falls as low as

10 per cent. in some soils. Nitrogen remains at about the same proportion as in the atmosphere.

These gases, together with certain amounts of ammonia, hydrogen, ammonium sulphide, and marsh-gas, make up the air in the soil. Thus, differing in composition from the atmosphere, it is not suitable for breathing purposes, and is too damp. On the other hand, we are not certain that it does not, at times, contain the spores of certain disease-germs.

The second disturbing factor of the ground-air—namely, its movement—is of considerable sanitary importance. It has been proved that winds blowing against the surface set this underground-air in motion; likewise, too, any change in the ground-water level will occasion fluctuations in the air above. Also during a heavy rain the surface-waters flowing downward press upon the ground-air and compress it; underneath a dwelling, if the cellar is not properly concreted, there is an area of diminished pressure, and consequently the ground-air pours into the cellar and thence into the house. In winter, during heavy frosts, when the frozen ground is more or less impervious, the warm, unfrozen part underneath a house facilitates the ascent of the ground-air; hence the reason for urging more careful building of cellars and foundations than at present.

CHAPTER IV.

HABITATIONS.

Dwellings.—The first thing in the building of a house, not only to the architect, but also to the sanitarian, is the foundation. That very little attention is paid to this will be apparent to anyone who will watch the construction of a foundation, especially in the rural districts. Whether the land to be used is wet or dry, clay or gravel, sandstone, slate, or granite, the method is nearly always the same,—simply a hole in the ground, walled with stone, upon which is to rest the superstructure.

The foundation is intended to serve, not only as a firm support for the building, bu t also as a barrier to the moisture and the damp, unwholesome air of the soil.

After a building site is selected it is necessary to see that it is thoroughly drained by surface- and subsoil- drains; the latter consist of tiles or ditches partially filled with broken stones, gravel, or sand, and is graded, if possible, to a suitable outlet. Colonel Waring, the eminent sanitary engineer, has so well described the details of this work that I take the liberty to quote him without reserve: "In the case of a country house, or of a town house standing in the centre of a considerable area, it is often the most efficient means for securing satisfactory drainage to apply a very thorough system of underdraining to the whole area about it and for some distance away, by laying different lines of drains, not necessarily under the house at all, but so as to surround it on all sides from which water flows toward it, and in all cases at a depth of several feet below the level of the cellar-bottom. In the construction of these drains two courses may be pursued with, perhaps, an equally good result. One is, after having excavated the ditch and cleared its bottom of all loose dirt, to fill in to a depth of a foot with sand or gravel,—and even fine sand will answer the purpose. The other is to use agricultural drain-tiles,—preferably of the smallest size; say, an inch and a quarter in diameter,—laid at the bottom of a well-graded trench and continued to point of outlet. When tiles are used, the joints should be wrapped twice around with strips of muslin drawn tight. This makes a perfect collar, holding the tiles

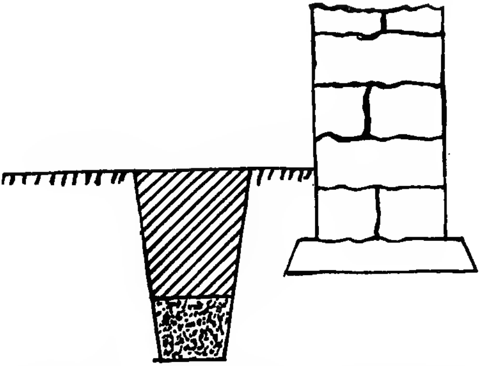

Fig. 16.—Gravel Drain Under Cellar-floor. (From "The Principles and Practice of House-drainage," *Century Magazine.*)

in line and affording much the best protection that has yet been devised against the ingress of sand or silt, which usually finds its entrance at the lower part of the joint, flowing in with the water which rises with the ground-water level, and flows off over the floor of the tile. A tile an inch and a quarter in diameter will carry more water than can usually be collected for a constant flow from the subsoil of half an acre of ground. A body of sand or gravel ten or twelve inches wide and of equal depth cannot be so compacted—provided clay and loam be kept out of it—that it will not afford a free outlet for all the water that can reach it, under these circumstances, from the soil of an ordinary lot. As a rule, the tile will be found to be much cheaper than the other material. It is better always that the depth of the drain should not be less than three feet below the level of the foot of the foundation. The more rapid the descent the better, but even two inches in a hundred feet, with perfect grading, will remove a very large flow."

The ground-air, which nobody wants to have in his house, is also kept out by proper attention to the foundation; and I again quote from Colonel Waring a very effective method of remedying this defect, which is universal in most country houses and in a good many of the older city houses: "One of the safest materials for a cellar-bottom and for the external packing of foundation walls is a clean, smooth, compact clay, one of which may be beaten into a close mass, and which has a sufficient affinity for moisture always to maintain its retentive condition, for, when used in the damp atmosphere of a cellar or about a foundation, it seems to constitute a good barrier to the passage of impure air. In the cellar it may, of course, be covered with concrete for cleanliness and good appearance; but six inches of clay, well rammed while wet, will impede the movement of air to a degree with which ordinary cellar concrete can furnish no parallel. When clay is not available, a good smearing of asphalt over the outside of the foundation-wall, and a thick layer of asphalt between two thicknesses of concrete for the cellar-bottom, will afford a complete, though more costly protection. Asphalt used in substantially the same way, especially if in connection with a solid course of slate or North River blue-stone, in the foundation above the ground-level, will prevent the soaking up, into the structure, of the moisture of a heavy soil."

Another way is to cover the cellar-floor with brick, on edge, and then run melted pitch over this, and finally cover with a layer of concrete or cement.

The ventilation and heating of country houses are points worth considering, inasmuch as the majority of these houses are heated by stoves and, as a result of defective arrangement, the floors are always cold. In these stove-heated rooms the floor is from six to eight degrees colder than it is four or five feet above the floor. This means that one's feet are just that many degrees colder than the head and shoulders.

To obviate this difficulty each room should be built so that it has an open grate or its equivalent,—simply an air-shaft connected with the chimney and opening into the room at the floor-level; by this means good ventilation can always be obtained. Ventilating-stoves, although of value in school-houses, are not necessary in private houses; with an open grate, or an air-shaft, as indicated, a room may be very well heated with an ordinary stove.

In Fig. 17 is shown the effect of heating a room with a stove with and without a foul-air shaft. In the upper room the heated air rises and fills the upper parts of the room, while the floor remains cold; if the heating is brought to such a point that the lower part does become warm, the upper part is too hot, and, if a window is opened, the heated air rushes out without warming the room, and leaves a lot of foul air to be breathed. If now, as in the lower room, there is an open grate, or an air-shaft in the chimney, the heated air creates a partial vacuum, and a draft, consequently, is constantly going up the chimney; in the room this, of course, creates movement toward the opening, and, as a result, the foul air is "sucked up" the chimney and the upper, heated air is more diffused about the room, making the temperature more uniform; in these cases fresh air enters at the windows and doors. If the house is heated by hot air, steam, or hot water by direct or direct-indirect method (if there is no open grate), there should be an extraction shaft at the lowest part of the room near the source of entrance of the heat, as will be apparent from a study of the diagrams in Fig. 19.

School-hygiene.—School-buildings in the country are excessively defective in sanitary arrangements; there are

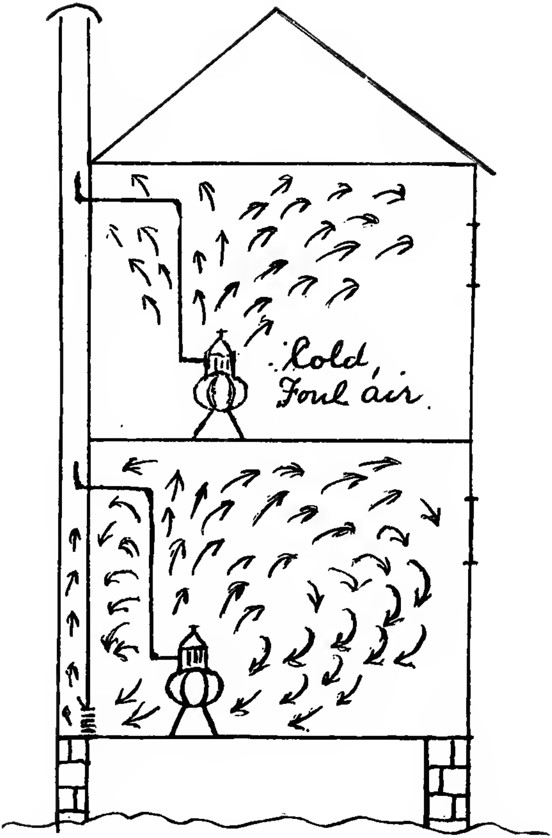

Fig. 17.—Showing Effect of Heating a Room With and Without Air-shaft. (Original.)

very few model schools, even in the great cities. In the first place, the site for a school-house, as for any other human habitation, should be located on a dry, well-drained soil, and this is generally available in rural districts. There should be ample play-ground around the building, and if trees are planted they should not be placed so close as to interfere with the lighting of the room, and the building should be so planned that the windows face north and south, for by this means we get the best light.

In the construction of the building we should be guided by the same sanitary rules laid down for dwellings, and provision should be made for sufficient air- and floor- space. Each pupil should have about 300 cubic feet of air-space with about 20 feet of floor-space; by changing the air in the room—say six times an hour—we would give each individual 1800 cubic feet of air per hour, which is surely not too much. In New York City each pupil gets from 80 to 100 cubic feet of air-space, but it is generally conceded that this is by far too little.

The floor should be of polished, hard wood, with no rugs nor carpets. The walls and ceiling should be painted some green tint, as this is probably the easiest for the eyes; above all, they should not be white.

Each room should not be more than 40 feet long, for beyond this the distance to the blackboard becomes too great. The windows should occupy one-fourth the floor-space, should reach to the ceiling, and should not be covered with shades; inside blinds are much better.

Water should be plentifully supplied, but the usual method of having an open bucket and a common cup for all should be abolished. The water should be kept in a covered bucket or a pitcher, and each pupil should have a small tin cup attached to his or her desk.

Among other faults to be corrected are the seats, which are often too high, and the crowding of too many children in one room, thirty pupils being considered enough for one teacher and for one room.

The ventilation and heating of country schools are yet done in the crudest possible manner. A stove furnishes the heat, and ventilation, such as it is, is obtained through open doors and windows. In winter, when we need heat for the school-room, ventilation and heat may be obtained at the same time by means of a ventilating-stove. This consists of an ordinary stove inclosed by a cylinder of tin or galvanized iron. The front part is movable on hinges, so as to allow opening in order to get at the stove proper. Underneath the stove a hole is cut into the floor,—at least two feet square, if possible,—and this should be continued to the outside air by a shaft made of wood or tin.

For the removal of foul air an opening should be made into the chimney at the lowest part of the room, and not farther removed than is actually necessary from the centre of heat, as indicated in the heating of dwellings. An opening at the top of the room—which is the place usually recommended for a foul-air shaft—only permits the escape of heated air before it has been properly diffused, and consequently does little good; if each room had an open grate—which it ought to have—we would need nothing more.

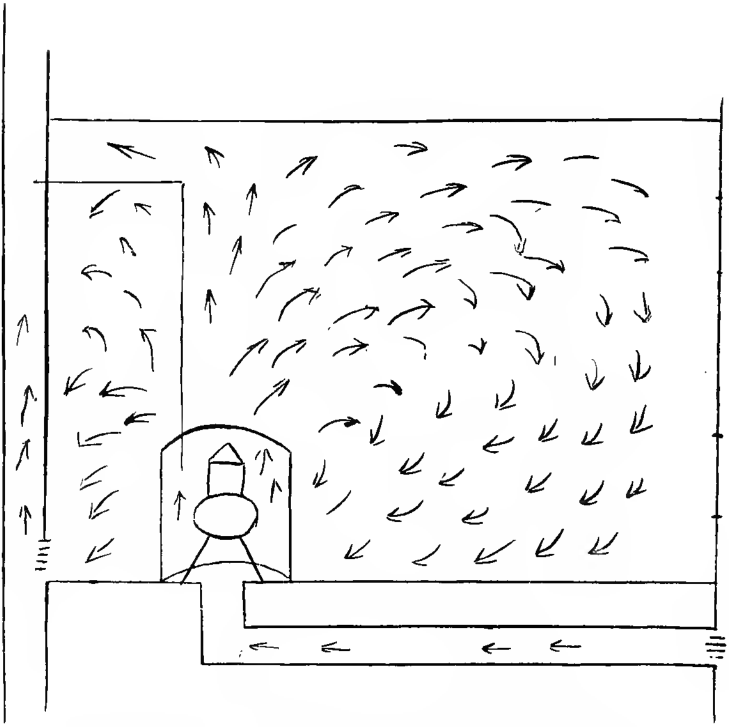

Fig. 18.—Showing Arrangements of Air-shafts for Ventilating-stove.

Heating a room by means of a stove is not an ideal way, but it is the most available for country schools.

The privy attachment of these schools is even more primitive than the heating and ventilation; it is generally situated in the most public place in the yard, without any covered passage-way or any other means to obviate exposure; this is simply abominable. In place of the old-fashioned privy the dry-earth system should be used (such as is mentioned on page 30), and should be connected with the building by a covered path; if there is someone to look after this dry closet, it will yield most excellent results. The material can be disposed to the neighboring farmer for fertilizer.

Emergency Hospitals.—Although in the larger towns and cities a permanent isolation hospital is needed, this is hardly necessary in the small towns and villages, for the simple reason that when such a thing becomes necessary we can use an ordinary tent, which makes the best kind of an emergency hospital,—and tents are always procurable. If the tent has a board floor and arrangements made for a stove, it may be made very comfortable in any kind of weather.

The plot selected for the erection of a hospital tent should be dry and sheltered as much as possible, and the free space surrounding the tent should be as large as is conveniently obtainable, not only for the sake of the fresh air, but on account of the danger of contagion. Contagious diseases, when isolated, do not appear to spread the disease, save in the case of small-pox, and, as this is the one disease which most likely would require isolation in the inland districts, the proximity of human habitations is an important question.

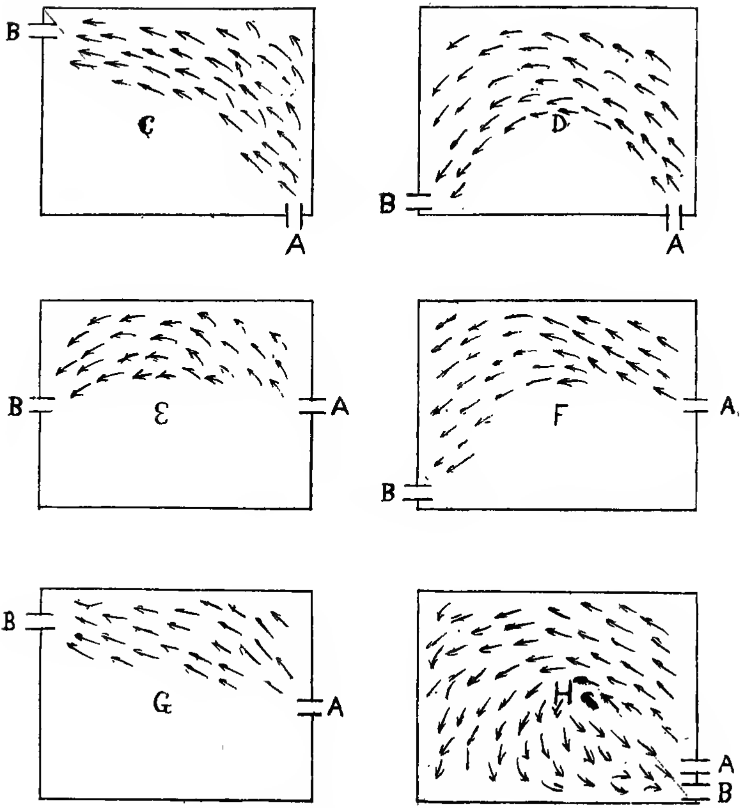

Fig. 19.—Diagram Showing Correct and Faulty Methods of Heating and Ventilation. (From Reports of United States Bureau of Education.)

A, Inlet for heated air.	*C*, *D*, *E*, *F*, *G*, Faulty.
B, Outlet for foul air.	*H*, Correct.

Dr. Powers, of the Local Government Board (England), during an investigation of this subject found that, in the neighborhood of the London small-pox hospitals, the number of cases in the surrounding districts increased almost in a direct ratio to the nearness of the hospital; this increase, too, was independent of the lines of human intercourse.

For diseases like typhus fever, when fresh air is most necessary, nothing is comparable to tents for isolation. I happened to be assistant on Blackwell's Island during the last epidemic of that disease, and, although it was in winter, tents were used for all cases, and they did remarkably well.

CHAPTER V.

Disposal of the Dead.

While in many places cremation of the dead presents some advantages, there seems to be no doubt that in most suburban districts, at least, earth-burial, if properly performed, meets all sanitary requirements of the present, and is ample proof against the transmission of disease.

In the first place, it must be recognized that the main point in earth-burial is not the preservation of the body, but its resolution, as rapidly as possible, into its primitive elements, with the minimum amount of discomfort and danger to the living.

The prevalent custom of constructing a cemented brick vault for the coffin is not desirable, for it delays decomposition; the sooner putrefaction is over, the sooner is the danger past.

It has been found that in *proper* earth-burial the body is destroyed rather rapidly by the action of numerous insects, worms, and nitrifying bacteria. From experiments of Dr. Poore we find that it takes something like two years for the earth to dispose of the carcass of a cow or a horse; of course, it should take no longer for a human cadaver, unless it is protected by the embalmer's art or by a vault.

We hear a good deal about the dangers of graveyards; but all of these may be avoided by ordinary care. One of the dangers seems to come from embalming; for example, the water of a certain creek which flows through Forrest Lawn Cemetery in Buffalo was found, some time since, to be impregnated with considerable quantities of arsenic of the kind used by the embalmer, and had it not been discovered might have been a factor in the death-rate.

Another danger which is supposed to come from graveyards is that of the transmission of contagious diseases. Sir Spencer Wells quotes the following, which is worth repeating: "Some people living in a mountain country and having very little communication with each other were in the habit of quenching their thirst at a neighboring well after the Sunday attendance at the district church. A young man died of diphtheria and was buried in the yard. The drinking from the well continued, and in a short time twenty of those peasants were carried off by the same disease. If asked how we are to account for this accident, but on the presumption that the germs of this disease found their way into the waters of the well, various explanations —such as milk outbreak or personal communication—may be imagined; but none so exactly corresponds with the circumstances as leakage from the corpse." That such danger as the above may exist, and be scientifically possible, it is only necessary to refer to the investigations of Dr. Lössener, who has shown that certain pathogenic germs exist for some time in buried cadavers, even when decomposition is not delayed. His results are as follow:—

Typhoid germs lived 96 days.

Cholera germs lived 28 days.

Tubercular germs lived 95 days.

Tetanus germs lived 234 to 361 days.

Anthrax germs lived 365 days.

These experiments of Lössener were carried on in nitrifying soils; but it must be remembered that a good many graveyards are placed on the cheap non-nitrifying clays, because they are cheap and not good for agriculture. Such soils should not be selected for this purpose, for we are not certain but that pathogenic germs may live much longer in those cases in which decomposition is delayed; and in these soils it is delayed very much, for nitrifying germs are absent. It is recorded that in cutting through St. Andrew's churchyard, Hoborn (England), which is situated on a heavy clay, some of the bodies which had been buried even a hundred years showed very little decomposition.

To have earth-burial effective then

1. There should be no embalming, save for transportation.

2. The body should not be placed, if avoidable, in a sealed coffin or vault.

3. Burial should not be deep.

4. The cemetery should not be placed on a non-nitrifying soil.

APPENDIX.

THE NORMAL DISTRIBUTION OF CHLORINE.[1]

By Prof. Herbert E. Smith.

Water, as it is found in springs, streams, lakes, etc., always contains chlorine in solution, chiefly, if not wholly, in the form of common salt. Sometimes there is much, sometimes little, but always some, even in waters which are entirely free from the possibility of contamination by man. Hence we must recognize that there are natural sources from which water does derive chlorine. But there are also artificial sources, for the waste-fluids of certain manufacturing processes, sewage, and even the drainage from inhabited areas, contain considerable quantities of chlorine. The additions of such liquids to a stream or pond must add to the total amount of its chlorine.

If one knew the amount of natural chlorine in a given water, it would only be necessary to subtract this from the total amount found in analysis to determine the amount of chlorine added from artificial sources. This at once gives, as can readily be seen, a measure of the amount of the contamination to which a water has been subjected, for chlorine

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[1] Professor Smith has kindly permitted the author to use his article for this appendix. The article was originally a report to the Connecticut State Board of Health.

once added to water remains in it, since it is not removed by filtration, by sedimentation, or by the growth of plants, by which means the other constituents of sewage contamination may be largely or entirely removed.

A knowledge of the amount of natural chlorine, or, as it may be better called, the normal chlorine, of the waters of a region is of great importance, therefore, as giving data for correctly interpreting one of the important items of a sanitary water-analysis. That it is possible to determine within reasonable limitations the normal chlorine of a region was first demonstrated by the Massachusetts State Board of Health, as one of the important scientific deductions from the systematic analysis of the drinking-waters of that State. In 1891, in the Report of the Connecticut State Board of Health, there was also published a small map of this State, containing data which had been obtained in the analysis of our drinking-waters. These data showed that the chlorine in the pure waters of Connecticut presented the same regularity of distribution as in Massachusetts. Since that time many more analyses have been made, and from the data now at hand the accompanying map has been prepared.

On this map is shown the average amount of chlorine found in waters which are considered suitable for the purpose in various parts of the State. It will be seen that the amounts vary from about one to six parts per million, and further that the amounts are largest along the southern border of the State, and decrease as one goes north and west. The lines on the map are drawn through places which appear to have the same average normal chlorine,—*i.e.*, they are isochlor-lines. By locating a source of water on the map, therefore, one can determine the amount of chlorine which may be expected to be in it from natural sources.

The limitation of the use of such a map will become evident by a consideration of the sources of normal chlorine, and an inspection of the data on which the map is founded.

The natural sources of chlorine in waters found in springs, streams, ponds, and fresh-water lakes can only be: First, from compounds of chlorine existing in the rocks and soil with which the water has come in contact, and from which it has dissolved them. Second, deposits of chlorine compounds on the surface, as from spray blown in from bodies of salt water. Third, from chlorine existing in rain-water as it falls. What may be spoken of a geological chlorine might come from deposits of common salt, and in certain regions this would certainly be an important source of chlorine in many spring-waters. If the normal chlorine of our waters was derived from small quantities of salt, or other chlorides diffused in our rocks, or from minerals which yield chlorine on decomposition, then spring-waters, after percolating through the soil, would contain more chlorine than small fresh-water ponds supplied with surface-water from adjacent water-sheds. But this is not the case, for the ground-waters do not contain more chlorine than spring-waters of the same region; of course, this does not apply to certain deep waters, which furnish, sometimes, large amounts of chlorine, probably of geological origin. If the normal chlorine of our surface- and spring- waters is not geological in character, we must turn to the sea as its source. That it is of marine origin is clearly shown by a study of the maps, for the amounts rapidly diminish in zones marked by lines approximately parallel to the coast-lines.

Whether the salt is blown up from the surface of the ocean as spray and carried inland by the winds in the form of dust which, falling to the earth, is dissolved by the fallen rain, or whether the chlorine is blown inland during rain-storms, is not significant. It would seem that salt might be carried inland in both ways.

If the normal chlorine of our waters is due to that contained in the rain, it is clear that it must exceed that found in the rain-water in proportion to the concentration effected by evaporation. The amount of this evaporation may be inferred from the relation of the flow of streams of a region to its rain-fall.

The flow of Connecticut streams may be placed at about 60 per cent. of the annual rain-fall; consequently that part of the normal chlorine due to chlorine in rain would be expressed by increasing the chlorine of the rain according to the ratio of 60 to 100. In the following tables is given, in parts per million, the average chlorine in the rain at each of the stations, and also the figures obtained by correcting for evaporation in the ratio of 60 to 100, together with the normal chlorine of the station, as derived from the chlorine map.

The agreement between the observed normal chlorine and the figures calculated from the observations on the rain is rather surprising, considering the errors to which the method was subject.

TABLE SHOWING AVERAGE CHLORINE IN RAIN IN COMPARISON WITH NORMAL CHLORINE AT THE SAME STATION.

Station.	*Rain Cl.*	*Corrected Cl.*	*Normal Cl.*
Canaan	0.8	1.3	1.3
Waterbury	1.2	2.0	2.0
Hartford	1.3	2.2	1.8
Bridgeport	1.6	2.7	3.0
New Haven	2.0	3.3	3.2
New London	2.2	3.7	3.5

From the observations and considerations which have been presented we must accept the proposition that the normal chlorine is of marine origin, and is mostly conveyed inland during rain-storms. This conclusion at once shows us that the normal chlorine cannot be a fixed quantity at any one place, but must vary from time to time with the character of the storms. Rain-storms accompanied by high southeast winds would appear especially favorable for carrying salt inland over Connecticut. That the chlorine found in our uncontaminated waters is not constant at any one place is clearly shown by the various series of analyses forming the data on which the map is based. The results from any one source may vary as much as 50 to 100 per cent., especially when the amount of chlorine is small. Usually, however, the variations from the average are less than this, and for the most part do not amount to more than 0.5 part per million. Obviously samples from small streams which would be greatly influenced by any considerable rain-fall must be less regular in the amount of chlorine which they contain than samples from large reservoirs or lakes in which the rain from many streams will be mixed. From this it follows that, while the true condition of a large body of water may be shown by a single analysis, a series of examinations might be required from a small stream to obtain a reliable average.

It is also obvious that the natural chlorine of a long stream is not that of the locality from which a sample may happen to be taken, but is rather that of the average of its water-shed above the place in question. For instance, the average chlorine in the Connecticut River at Goodspeed's Landing during 1890-'91 was 1.4, while the normal waters of that region show about three parts of chlorine, and yet the river receives large quantities of sewage from Hartford, Middletown, and other towns draining into it.

The natural chlorine of the Connecticut River must be somewhat under one part per million, for the bulk of its water comes from Massachusetts and above. In the light of its normal, therefore, the contamination that exists at Goodspeed's Landing is clearly seen, although the contamination is not great enough to raise the chlorine from a low normal up to the figures which would be normal at that place, this being due to the great bulk of water which flows in the river. Even a large amount of sewage discharged into a stream may not increase the chlorine beyond the natural variations during periods of large flowage. Usually, however, the effect becomes obvious in dry weather. Along the sea-coast the variations in natural chlorine are greater than they are further inland. This is seen in the greater variations in the samples from the same source at different times, and especially in the marked difference in samples a short distance apart. This seems to depend, in some instances, on local conditions which favor the precipitation of the salt-laden rain or spray.

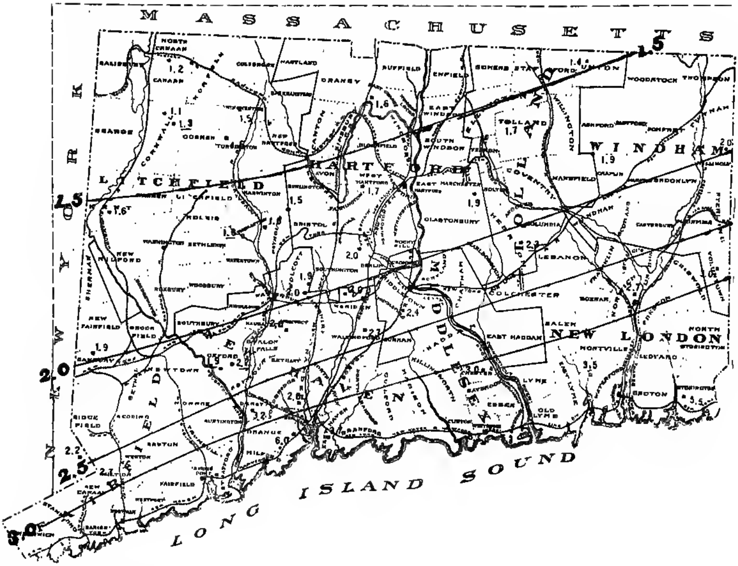

Fig. 20.—Map of Connecticut, Showing Distribution of Chlorine. Chlorine is expressed in parts per million. The heavy lines indicate the normal chlorine. The figures show observed chlorine in waters which are normal or nearly so.

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