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SEWAGE DISPOSAL ON THE FARM,

AND

THE PROTECTION OF DRINKING WATER.

BY

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INTRODUCTION.

The conditions under which homes and their surroundings are kept healthful in the city and in the country differ in many respects, although the principles underlying them are essentially the same. In the city the sanitary condition of homes is maintained chiefly by a system of cooperation and centralization which brings into existence extensive sewerage systems, water supplies, and the collection of house waste by public authority. Regulations are prescribed and enforced under which the individual household must avoid all conditions which are likely to prove dangerous to the health of the immediate neighborhood and of the entire community. In the country districts, and more particularly in isolated homesteads, the conditions affecting the health of the household are largely in its own hands, and more individual effort is required to maintain healthful surroundings than in cities. The farmer must supply himself with his drinking water and must get rid of the waste of the household as best he can. On the other hand, the inhabitant of the country is in many ways better off than the dweller in large cities. Not only has he pure air to draw upon at all times, but he can supply himself often with purer food than is possible in large communities. Though he must procure for himself drinking water, he is, in most cases, able to get a purer water from the ground than the sewage-polluted fluid which is the only water accessible in many cities. While he must get rid of night soil himself rather than have it disposed of by a water-carriage system conveniently located within the house, he may avoid the annoying complications of plumbing, bringing with it the leakages of sewer gas, the plugging up of soil pipes by the roots of trees or by articles carelessly thrown into them. Moreover, he has it often within his power to acquire sufficient land around his house to take charge of all sewage and waste and to utilize it as a manure for enriching the soil. Nevertheless, it must be acknowledged that when the circumstances under which healthful surroundings are procurable are under the immediate control of each individual household they are apt to be perverted through ignorance and neglect. Conditions may then arise which are not only unfavorable to health, but which are likely to lead to severe sickness at any time when the opportunity presents itself.

Standing between the fortunate inhabitant of a large city whose water supply and sewerage systems are above reproach and the farmer who has it within his power to make them so with reference to his own wants, is the half-developed village or town, with its chiefly unsanitary conditions. Here the leaky cesspool still exists, close by the family well, or by the neighbor's well. The absence of any system of collecting garbage and miscellaneous waste shows itself by the littering of the yards, the alleys, streets, and even stream beds with all kinds of refuse. In some towns the premature introduction of a water-supply system causes the ground to become still more thoroughly saturated with diluted sewage, so that the wells of those households not yet connected with the water supply are a continual source of danger. In such communities, appreciation of the necessity for a public control of sanitation has not yet made much headway. The acts of each family violating the laws of health not only react upon itself but upon the immediate neighborhood, often with disastrous results. When typhoid fever has once gained a foothold in such communities it is apt to develop into an epidemic.

The tendency of our population to concentrate in villages and towns makes the sanitary improvement of such communities a most important and vital condition of national health and prosperity. The following pages are not intended for these communities, for they need, in most cases, the advice of sanitarians and sanitary engineers, acquainted with local conditions. Still, they may be of service in pointing out the dangers which may and do actually beset the population that neglects to dispose of refuse and waste in a manner which does not clash with the laws of health.

The chief dangers which threaten rural inhabitants are those arising from polluted drinking water. This is infected from the household excrement and barnyard drainage, as will be described farther on, and its use leads in the main to bowel disturbances, typhoid fever, and dysenteric affections. It might be claimed that in an isolated homestead the danger is absent because the night soil from the healthy household can not contain the germs of typhoid fever, and, therefore, the well water can not receive them from leaky cesspools and surface drainage. This would be true if the family lived secluded from other human beings. As the case stands, there is much more communication than is at first thought supposed. There is more or less coming and going of farm hands and other hired help, of tramps, peddlers, etc. The farmer travels more than formerly. He frequently visits neighboring communities. The children go to school. As it has been shown that there may be mild cases of typhoid fever passing unnoticed, in a farm hand, for example, who leaves on account of ill health, perhaps, and who has meanwhile, in his discharges, deposited the germs of this disease on the premises, it is evident that isolation nowadays does not exist except in remote, thinly settled regions, and that disease germs may make themselves suddenly felt in an unexpected manner in any farmhouse.

There are other important reasons, however, why rural sanitation should not be neglected. The health of the large communities of people who draw their food supply from the country is in a measure dependent on the health of the farming community. There is scarcely a city child who is not, in a degree, dependent for its health on the sanitary conditions prevailing in the house of the dairyman. Milk has been repeatedly shown to be the means of distributing typhoid fever and other diseases. Any vegetable foods from the farm eaten raw are liable to become carriers of infection under unsanitary conditions.

In many parts of our country other causes operate in making the health of many people depend on the proprieties of country homes. The thousands of city people, who flock every summer to the country and bring to the farming community considerable sums of money, should be properly protected against the dangers of polluted water and infected milk by the adoption of suitable methods of sewage disposal. Too frequently those who left the city for the purpose of gaining strength by breathing pure air, drinking pure water, and eating pure food, only return with the germs of an often fatal disease within them to swell the typhoid statistics of our large cities.

DISPOSAL OF SEWAGE.

The vital thing which thus presents itself is the disposal of fecal matter and other refuse so that the wells, upon which most rural families depend for their drinking water, may remain pure. To this matter we will first turn our attention.

Every person who tills the soil is acquainted with the remarkable transforming power of the superficial layers of the earth upon manure and excrement. Out of these offensive wastes harmless substances are produced which are essential to the growth of vegetation. This power, known as decay, is now generally attributed to very minute organisms (bacteria) which are found in immense numbers in the superficial layers of the soil, which diminish in number as we go deeper, and which completely disappear below a depth of 6 to 12 feet, according to the physical condition of the soil. Bacteria are more numerous where waste and excrement are most abundant. When night soil and manure are deposited in excavations or so-called cesspools in the earth, from which the fluid matter may enter the ground at some depth below the surface, where the air or certain kinds of bacteria can penetrate only to a slight extent, the substances, which under the influence of the air (oxygen) and of bacteria near the surface, would have decayed, now undergo partial putrefaction with the setting free of disagreeable gases and odors. The deeper layers of the earth slowly become saturated with organic matter, which is carried by the ground water into the wells or springs near by. There is also some reason to believe that disease germs live longer in the oxygen-free depths of the soil than at or near the surface.

The extent to which the filling up of the soil with excrementitious matter may go on in densely populated cities has been shown by Fodor for the Hungarian city Budapest. By analyzing the soil at different levels from the surface to a depth of about 13 feet, he found, over an

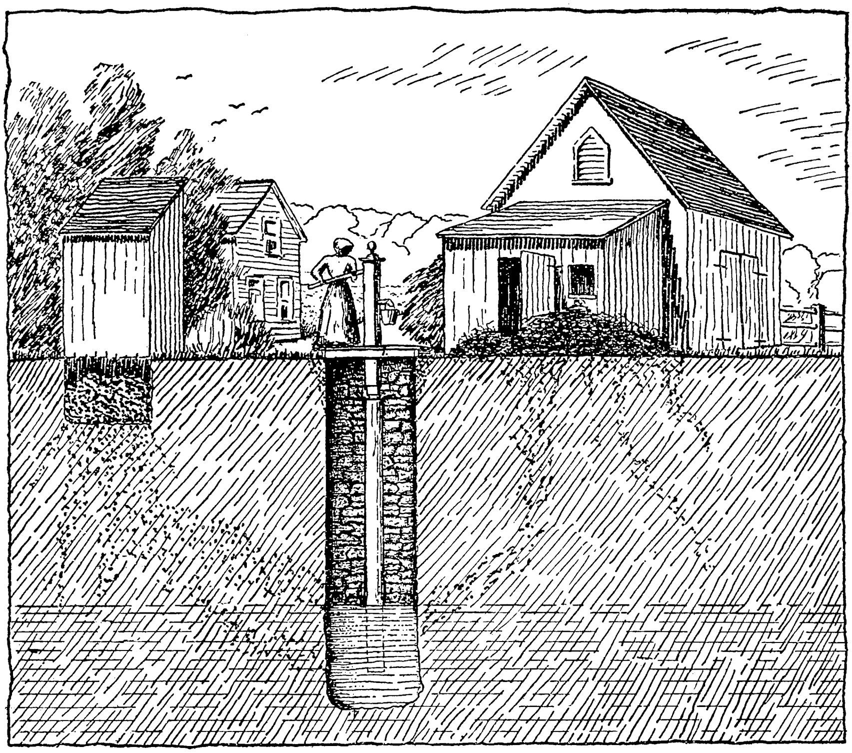

FIG. 1.—The shallow barnyard well, with privy vault and manure heaps near by. The water is likely to receive fluid from these at any time.

area comprising 15 acres, about 1,000,000,000 pounds organic matter, equivalent to the excrement of 100,000 people voided during thirty-seven years.

To the surface of the earth we owe thus a purifying influence whose activity furnishes us vegetation and food on the one hand and preservation from disease on the other. This purifying power is not possessed by the deeper layers, and therefore the percolation of organic refuse into them from deep cesspools is wasteful to agriculture and dangerous to our storehouse of drinking water.

Even the surface of the soil when overloaded with sewage loses partially its power of purifying the organic matter. After sufficient rest, such an overloaded soil regains its original power. The purifying activity of the soil from a sanitary aspect is the same as that governing fertility from an agricultural standpoint, hence any further discussion of this subject is unnecessary.

A hint as to the proper disposition of waste, excrement, etc., is furnished by what is stated above concerning the purifying capacities of the earth's surface. Waste, night soil, etc., should be deposited with proper precautions on or immediately below the surface of the soil, where it may perform the double function of ridding the household of a nuisance and of enriching the soil itself. This leads us to a consideration of the best means of taking care of the household wastes. These are, in general, of three classes: First, fecal matter; second, kitchen and chamber slops; and third, miscellaneous rubbish and ashes.

NIGHT SOIL.

The proper disposition of fecal matter or night soil in the country has been one of the most pressing and vexatious problems of modern sanitation. Many plans have been suggested, much apparatus has been invented to meet the difficulty, but opinions not only differ but change from year to year and have led to different practices in different countries. Moreover, different climatic conditions and the divergent tendencies of rural populations in the various sections of our own country make it impossible to apply the same scheme to the whole country. Different degrees of prosperity and wealth, even in the same locality, will bring into use widely different schemes to accomplish the same end. There are in use several systems—

The privy.—The old-fashioned privy, at present still quite a common thing even in cities, is, perhaps, the most favored method of disposing of fecal matter in the country. A pit is dug and a small building set over it. The excrement deposited in it slowly fills it up. The fluids and the solids dissolved by them penetrate the subsoil and diffuse themselves in the ground. Rarely is such a pit cleaned out. Another is dug and the old one covered up. In this way the ground becomes overloaded with refuse organic matter. It is even stated on good authority that such collections of fecal matter have been found under the dwelling; also, that the privy vaults have been dug until the current of ground water was reached which was to facilitate the removal of the excrement. It is difficult to conceive a more pernicious custom, or one more certain to pollute the drinking water. The privy vault is the most rudimentary way of getting rid of night soil, and its dangerous features are too plain to be referred to.

The cesspool.—Next comes the cesspool, which is usually connected with a water-closet, and may also receive the slops from the kitchen.

These are constructed in two ways, either as water-tight receptacles or as simple pervious pits differing in no way from the privy vault excepting, perhaps, in their more dangerous tendencies. All sanitary authorities agree in condemning the leaky cesspool as a most shiftless and dangerous method of getting rid of sewage. In most countries they are prohibited by law in populous communities. In exceptional cases, leaky cesspools may do no harm, as in an isolated house in the country whose cesspool is built at a considerable distance both from the house and the well. The safe distance from any well it would be difficult to state, because that would depend on the character of the subsoil and the general slope of the land. In any case, the cesspool should be on lower ground than the well, as the current of the ground water feeding the latter, usually but not always, conforms to the slope of the surface. A fair estimate of the least allowable distance between well and cesspool would be 100 feet. Soluble salts from sewage might still find their way into the well water, but it is quite improbable that disease germs could penetrate the soil for such a distance except where fissures and cracks may be present.

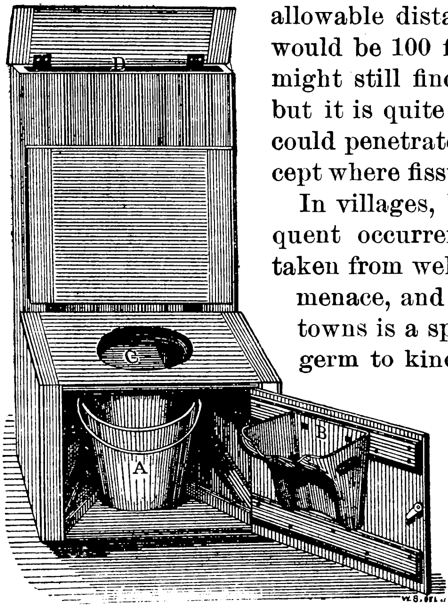

FIG. 2.—Portable earth closet. A, the pail to receive the excrement; B, the urine-separating receptacle hanging on the open door; C, mouth of the hopper conveying the dry earth or ashes from reservoir D upon the night soil in A.

In villages, leaky cesspools are still of frequent occurrence. If the drinking water is taken from wells, such cesspools are a constant menace, and all that is needed in many such towns is a spark in the shape of some disease germ to kindle an epidemic. It is true that years may pass by without the occurrence of more than the usual amount of illness, but even then we have good reason to suppose that in many villages using cesspools the average amount of sickness and mortality is far too high, not to mention the occasional epidemics of typhoid fever. We may sum up the matter of leaky cesspools by the statement that they may do no harm near isolated houses on farms, provided they are sufficiently far away from the source of water supply. In small towns cesspools should be prohibited, or only very thoroughly constructed water-tight ones permitted, according to circumstances. The same holds true for the well-known privies.

The dry-earth closet.—The dry conservancy system is a much better method of disposal of excrement, and is extensively in use to-day even in certain large cities on the Continent of Europe where sewers have not yet been introduced. This consists in the main of the frequent removal of excreta in the country by some man servant or member of the family; in villages and towns according to some cooperative plan.

This system has taken various directions, according to circumstances. Thus there are what is called the pail system, which consists in the daily or less frequent removal of a pail receiving the excreta; and the earth closet invented by the Rev. Henry Moule, of England, the chief feature of which consists in the covering of the excreta with some absorbent substance like dry earth or ashes. In some places the excreta are received into a well-built brick or stone receptacle and covered with earth, from which they may be removed from time to time. Of these systems the dry-earth closet has received the greatest amount of attention and discussion. It consists, essentially, of a pail to receive night soil, which is covered either automatically or with a scoop with dry earth (fig. 2). The earth absorbs the fluids and the odors and keeps the closet inoffensive.

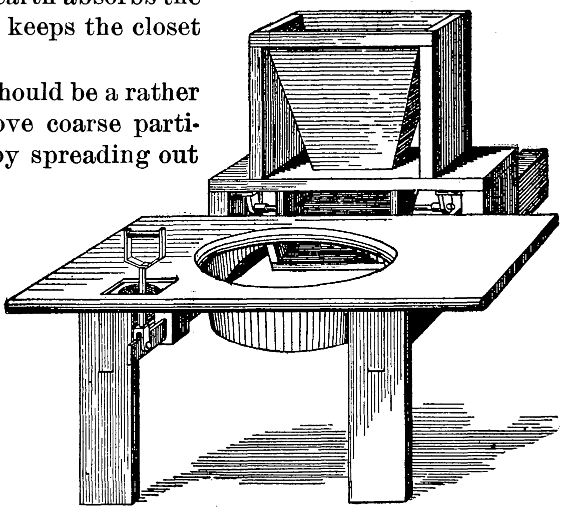

FIG. 3.—The old form of earth closet with frame and pail removed to show the mechanism. The handle on the left when raised throws into the pail a certain quantity of dry earth or ashes from the reservoir or hopper in the rear.

The earth to be used should be a rather fine loam, sifted to remove coarse particles, thoroughly dried by spreading out in the sun or under a shed, and then stored in barrels. The drier the earth the better it is. The finer the particles of earth the greater the capacity for absorbing fluids. For this reason sand is not satisfactory. Coal or wood ashes are quite satisfactory, as they are, after proper sifting, of the requisite fineness and are thoroughly dry. The mixture of earth or ashes and night soil should be removed at certain times, depending on the location of the closet, the season of the year, and other conditions. The more frequent the removal the better. The mixture of soil and excrement is so unobjectionable that it has been used over a number of times after being dried each time. This can not be recommended, however, as it is generally accepted nowadays that disease germs may remain alive in such a mixture for some time.

In place of the movable earth closets, a water-tight, concreted area may be built in an annex to the house, which is to receive the night soil from a closet on the floor above with the necessary quantity of dry soil (see fig. 4). Poore, from whose book the illustration is taken, recommends, in addition, the construction of the floor of such a pit with an inclination sufficient to carry away the urine into some gutter outside filled with absorbent soil. The area should have suitable openings for inspection and for removal of contents, as well as for ventilation. Waring recommended a similar system many years ago. The closet described by him discharges into a water-tight vault in the cellar, which requires emptying only occasionally. The contents remain inoffensive, provided sufficient thoroughly dry earth is used.

In cold climates, indoor closets are especially desirable to obviate the exposure which can not be avoided when closets are out of doors. For invalids there should be a carefully managed earth closet kept in a well-aired room set apart for this purpose. In warm climates, earth closets should be frequently cleaned. To prevent the attraction of flies and insects and the too rapid decomposition of the contents a little unslacked lime added with the earth to the excrement will be of value. The discharges of persons suffering from typhoid fever and bowel troubles should be mixed with thin slacked lime[1] (milk of lime). One-half to one hour after the mixing, such discharges may be put upon the soil, always at some distance from a well or spring, a stream, or a field under cultivation.

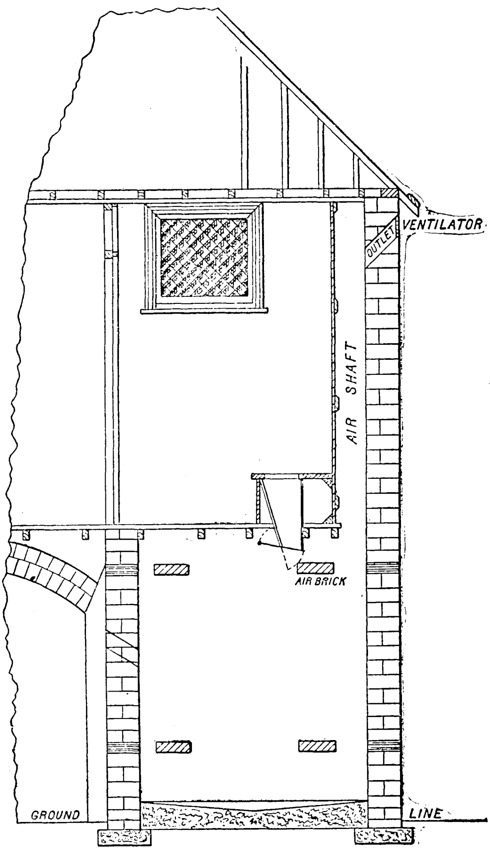

FIG. 4.—Earth closet and dry catch (from Poore's "Rural hygiene," scale, ⅛ inch equals 1 foot). To prevent drafts the earth closet is closed below by a hinged flap which opens and shuts automatically by means of a counterpoise. The catch below is provided with air bricks and an air shaft leading to a ventilator.

In Europe, the use of earth and ashes has been superseded by peat dust. The upper layer of peat is dried in the air and ground in a suitable machine. The coarser particles are removed by sifting and used for bedding in stables. The fine portion, which has a very high absorbing power for fluids and is also capable of preventing odors, is used in dry closets. In Germany there are at present about thirty factories engaged in the preparation of peat moss for the purposes mentioned. Its great advantages over dry earth should bring it into use in our country. (See fig. 5.)

[1] Lime, to be used for disinfection, should not be air-slacked, but kept in tightly covered receptacles to prevent this from taking place.

It does not matter from a sanitary standpoint which one of the dry-earth systems is adopted, provided the necessary attention be given to it. Every system which can be recommended is bad if not properly attended to. The conditions to be observed are:

The night soil should be received in water-tight receptacles.

It should be frequently removed.

It should be utilized in the garden or field by being placed under a thin layer of soil.

To excreta from the sick, milk of lime or unslacked lime should be added before disposal in the soil.

The water-closet.—There can be no doubt that to-day the water-carriage system, as it is called, or, in simpler language, the indoor water-closet, is preferred to all other contrivances. This is true for the open country as well as for villages and the suburban territories of cities. There is much to be said in favor of the present-day perfect contrivance for the rapid removal of excreta and the exposure thereby prevented. But for all rural inhabitants the cost should be carefully weighed before a water-carriage system is introduced into a house, for none but the best will answer, as all others are likely to become nuisances.

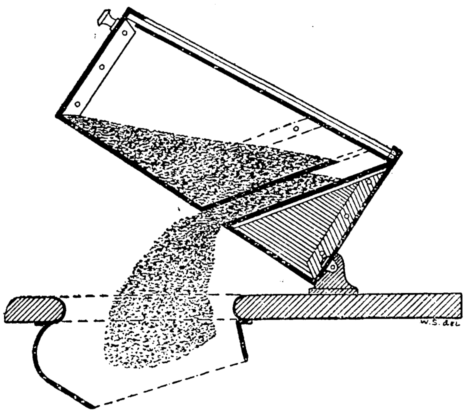

FIG. 5.—Self-acting peat dust closet. The lid is replaced by a hinged reservoir containing the peat dust. Whenever this is let down a certain quantity of peat dust is discharged automatically and thrown upon the night soil. (From Weyl's Handbuch der Hygiene. II, p. 315.)

The supply of water must be sufficient to flush the water-closet thoroughly and keep all the pipes clean; the plumbing must conform to that in vogue in cities, with its traps and ventilating pipes to prevent the odors of the pipes from escaping into the house; and the disposal of the large quantity of liquid sewage, the most difficult problem, must be properly attended to or it is likely to prove more dangerous to the water supply than the old dry privy pits.

LIQUID SEWAGE.

The methods available to dispose of liquid sewage in the country are water-tight cesspools and irrigation

Vaults.—Water-tight cesspools should be constructed of hard-burned brick, laid in cement, and having a similar brick or a concreted bottom. The inside and outside surfaces of the brick wall should be coated with a thin layer of cement, and clay rammed in around the wall, to increase its imperviousness to water. It should be vaulted above, and topped by a square or round central opening, covered with stone or iron plate. Cesspools are also made of cast or wrought iron, the joints being made water-tight. Cesspools must be ventilated by two pipes, one rising several feet above ground, the other carried to the roof of the house, barn, or other structure near by. The current will, in most cases, tend down the short and up the long pipe. The latter may be dispensed with and the soil pipe of the house act as a flue, provided all branches are perfectly trapped.

Irrigation.—The disposal of sewage by irrigation is by far the best method now within reach. Two methods are in use, viz, surface and subsoil irrigation. The first in its most complete form consists in carrying the liquid sewage to a piece of ground set apart for the purpose and carefully underdrained. The sewage is allowed to flow over the ground in shallow channels. The fluid slowly disappears in the soil and enters the drains as comparatively pure water, which may be

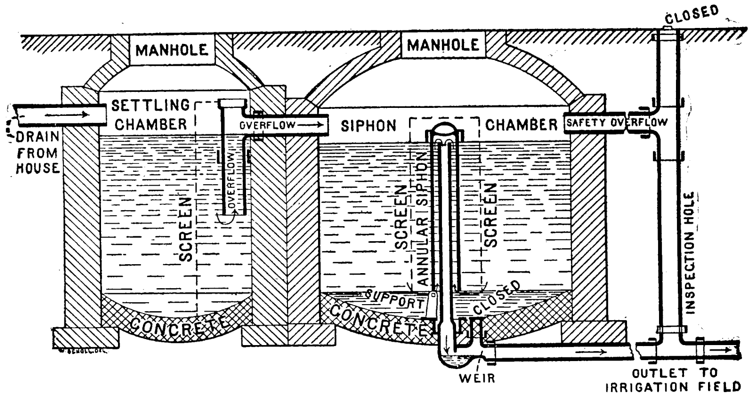

FIG. 6.—Settling chamber and flush tank for surface and subsurface irrigation of sewage. (From Gerhard's "The Disposal of Household Wastes," 1890.)

allowed to flow into a stream. For villages this is the best means of disposing of sewage. Those who as village officials may be interested in this method will find plans of such sewage farms, together with faithful accounts of their operation and the results obtained, in the annual report of the State Board of Health of Massachusetts for 1892, page 559, and same report for 1893, page 563. Suggestions for its application to country houses are given farther on.

For isolated rural homes, or village homes commanding a certain amount of ground around the house, the liquid sewage from water-closets, the kitchen and chamber slops may be disposed of by the simple means of subsoil irrigation, first described by Mr. Moule and subsequently elaborated by Colonel Waring.

The system as used at present in its most successful form consists, outside of the house, of the following parts (see fig. 6):

Two adjoining water-tight receptacles of brick. One of these receives the sewage from the house and is intended to act as a settling chamber for the coarser particles, paper, etc. This communicates with the second receptacle, which receives from it the fluid sewage. This chamber is called the flush tank and is provided with a siphon. When the fluid has reached a certain level, the siphon is set in operation and discharges the contents of the chamber at one time into the subsoil pipes.

From the second cistern a system of subsoil pipes laid over a treeless piece of ground, preferably a lawn, receives and discharges the sewage into the ground. These pipes should consist of porous tiles, 2 inches in diameter and about 1 foot long, laid from 8 to 16 inches beneath the surface of the ground, and with a gentle inclination of 2

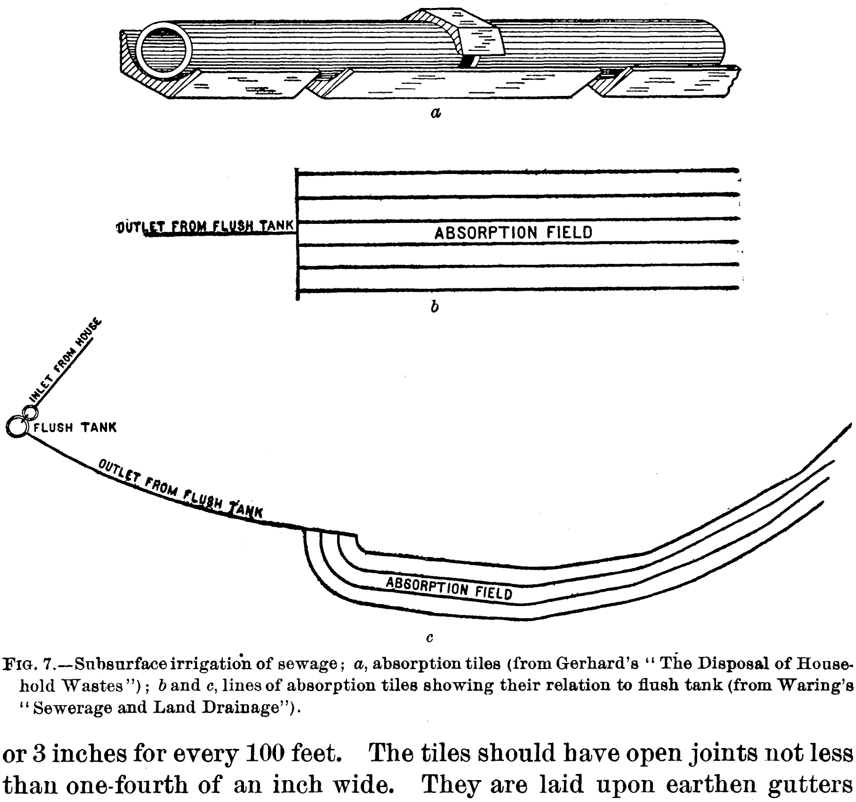

FIG. 7.—Subsurface irrigation of sewage; *a*, absorption tiles (from Gerhard's "The Disposal of Household Wastes"); *b* and *c*, lines of absorption tiles showing their relation to flush tank (from Waring's "Sewerage and Land Drainage").

or 3 inches for every 100 feet. The tiles should have open joints not less than one-fourth of an inch wide. They are laid upon earthen gutters and the joints are protected above by caps from being clogged with earth. The intermittent discharge of the liquid sewage is quite essential to the successful working of this system. If the sewage is allowed to dribble away into the pipes certain portions of these will become supersaturated with fluid and others will not receive any; the purification of the sewage in the soil is thereby rendered imperfect. The discharge of a large quantity of fluid at one time, besides scouring the system of pipes, fills it more uniformly and distributes the work to all parts of the subsoil system.

The successful construction of such a plant requires the services of someone familiar with it, and it is therefore not necessary for me to do more than call attention to it here as a highly recommended system for homes, especially in villages, where the proper amount of land is procurable and where the sewage must be disposed of in a manner both inoffensive and safe. In any case the soil of such land must be porous, not clayey and retentive. Those who wish to familiarize themselves with the details will find descriptions in the Sanitary Engineer for 1883, page 530, by Philbrick; in "The Disposal of Household Wastes," by Gerhard, and in "Sewerage and Land Drainage," by Waring. The entire plant is said to cost $200 to $300, the annual expenditures for cleaning, repairs, etc., about $10.

The method of subsurface irrigation just described may be too complex and too expensive where land is abundant and neighboring houses at some distance. The simpler method of surface irrigation may be resorted to by laying out at some distance—at least 100 feet—from the house a small sewage farm where the sewage may flow in shallow trenches over the surface and slowly sink into the ground. Such an irrigation field must have the same qualities demanded by subsurface irrigation. Its surface should have sufficient slope and the soil should be porous, not retentive. The liquid sewage, including kitchen and chamber slops, is conducted to this field in a water-tight tile drain and then allowed to flow into shallow trenches. To avoid the overloading of the soil with sewage at any one place the main distributing trench should be so arranged that it and the irrigating trenches branching from it may be temporarily blocked at any point to divert the sewage into one or more different trenches every day. In winter the warmth of the sewage will keep it in motion and the filtration will go on although the field may be covered with snow and ice. The use of the flush tank as described above would cause a more uniform distribution of the fluid over the field and make the filtration distinctly intermittent. The ground between the trenches may be cultivated to increase the amount of evaporation. If conveniently situated, an orchard may be used as the irrigation field. It should be distinctly understood, however, that marketable fruits and vegetables should not be carelessly allowed to come in contact with fresh sewage, nor should the irrigation field be near the well unless the latter is fairly deep and tubed or tiled to the surface of the water.

KITCHEN AND CHAMBER SLOPS.

The removal of kitchen and chamber slops is a matter which also requires proper attention, as this liquid frequently gives rise to unhealthful conditions, annoying alike to sight and smell when carelessly disposed of. The simplest way to utilize kitchen slops is to pour them upon plants about the house in summer, in winter upon the soil, each time in another spot, so as not to supersaturate the surface layers of soil in any one place. A means of less trouble recommended by Waring is to partly fill with soil a barrel with leaky bottom and cover this with a layer of stable manure to prevent the puddling of the soil. The slops filter through the soil and leave the barrel below as a clear fluid. The barrel is emptied two or three times a year and the contents used for fertilizer.

House slops may be disposed of by surface irrigation or by subsoil pipes, as already described. The originator of this method, Mr. Moule, may here be profitably quoted as to its simplicity and success:

Where there is a garden the house slops and sink water may, in most cases, be made of great value and removed from the house without the least annoyance. The only requirement is that there shall be a gradual incline from the house to the garden. Let all the slops fall into a trapped sink, the drain from which to the garden shall be of glazed socket pipes well jointed, and emptying itself into a small tank, 18 inches deep, about a foot wide, and of such length as may be necessary. The surplus rain water from the roof may also enter this. Out of this tank lay 3-inch common drain pipes, 8 feet apart and 12 inches below the surface. Lay mortar at the top and bottom of the joints, leaving the sides open. If these pipes are extended to a considerable length, small tanks about 1 foot square and 18 inches deep must be sunk at about every 20 or 40 feet to allow for subsidence. These can be emptied as often as required, and the deposit may be either mixed with dry earth or be dug in at once as manure. The liquid oozes into the cultivated soil, and the result is something fabulous. * * *

On a wall 55 feet in length and 16 feet high a vine grows. A 3-inch pipe runs parallel with this at a distance of 6 feet from it for the entire length. The slops flow through this pipe as above described. On this vine year after year had been grown 400 well-ripened bunches of grapes, some of the bunches weighing three-fourths of a pound. During a period of four years, for a certain purpose, the supply was cut off. To the surprise of the gardener scarcely any grapes during those years appeared; but afterwards the supply was restored, and the consequence was an abundant crop, the wood grew fully 16 feet, of good size and well ripened.

In place of an indoor sink, an upright tube or hopper may be constructed out of doors in communication with the subsurface pipes into which the waste fluids are poured.

WASTE AND GARBAGE.

The attractiveness of a rural home depends largely upon the promptness with which all kinds of waste material are disposed of. The abundance of space around the house is a great temptation for the members of the household to use it as a place for storing rubbish and useless, worn-out things. Sifted ashes are easily utilized in earth closets and upon walks and roads, to make them compact and firm. Other articles of no use, such as broken crockery, bottles, tin cans, etc., can be thrown into depressions and gullies and covered over with earth, or else buried in trenches where subsoil drainage is desirable. The removal of rubbish is a very fruitful theme and might be dealt with at length. Its importance as related to health and disease is a subordinate one, and the reformer must appeal to the love of order, propriety, and beauty in and around the home in order to make an impression.

Garbage is of much less annoyance in the country than in the city, where its collection and destruction is a great expense, and is frequently very unsatisfactorily done. In the country, the household garbage is fed to the swine and poultry, and is in this way profitably used. There are, however, homes where garbage must be taken care of in other ways. It may be buried in the garden or else burned in the kitchen range. Recently a device has been patented which enables the housekeeper to place the garbage in a section of the smoke pipe of the range, where it dries out rapidly, burns, and leaves only a little charcoal behind, which may be used for fuel next day. This device has been well recommended by sanitarians (see fig. 8).

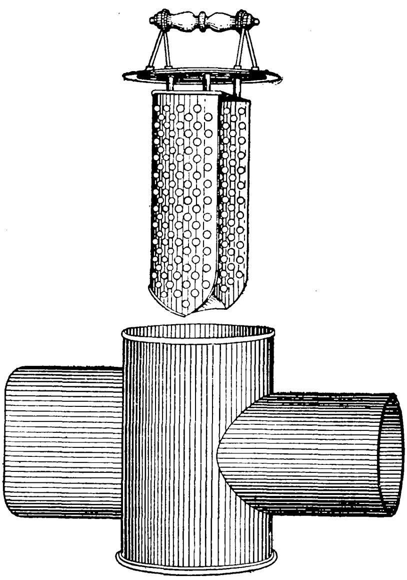

FIG. 8.—Garbage cremator. The garbage is placed in the perforated frame. The latter is pushed into the smoke pipe, where the garbage becomes slowly carbonized.

PROTECTION OF DRINKING WATER.

The next subject to claim our attention is the protection of the sources of drinking water. In the country water is, as a rule, obtained from wells and springs. The important bearing upon well water of soil purity demands a few explanatory remarks concerning the origin of well water. Wells are excavations made into the ground to a variable depth until water is reached. This water is denominated ground or subsoil water. Its origin may be better understood if, for the moment, we conceive the surface of the earth as more or less irregular and entirely impervious to water. The rain would collect on this surface and form lakes, ponds, and streams, according to the configuration of the surface. If, now, we conceive this surface covered with sand or other porous earth to a greater or lesser height, and the top of this be considered the earth's actual surface, the water will remain in the same position, but it will be buried within and fill the pores of the overlying soil as subterranean lakes, ponds, and streams. In digging a well we remove this porous layer of earth until we reach these subterranean streams or reservoirs of ground water. If the above description be thoroughly understood, the condition under which well water may be obtained at different depths will become intelligible, and it will also appear plain why ground water may flow as any surface stream and pick up on its way various substances which have percolated into the ground.

When the bed of porous soil overlying the impervious layers is very deep, wells will have to be dug down to a considerable depth to reach the surface of the ground water. Where this layer of pervious earth is of slight thickness wells will be shallow, and the ground water may appear on the bottom of gullies, trenches, and wherever the porous layer has been dug or washed away.

The movement of the ground water depends on the inclination or slope of the impervious strata, and has been observed to be quite rapid in some instances. By adding common salt to the water in a well its detection in other wells at a short distance has been found a guide in the determination of the rapidity and direction of the underground current.

When the ground water resting on the uppermost impervious layers is near the surface, and therefore not safe or fit to use as drinking water, it may be possible by digging below this layer to find another porous bed containing water. This source will, in general, be much purer since it is less exposed to pollution from above, and since the water has to travel longer distances underground. Such a deep supply must, however, be protected from the superficial supply by a water-tight wall extending to the surface of the deep supply, otherwise the water from the upper layers will simply drain into the well.

WAYS OF CONTAMINATION.

Wells are exposed to contamination in two ways. The surface water from rain, house slops, and barnyard drainage may find its way into the well at or near the surface of the ground. Or the ground-water stream supplying the well with water may in its subterranean movements encounter cesspools or seepings from cesspools, and carry with it soluble and suspended particles, some of which may enter the well. There can be no doubt that a large percentage of the wells are exposed to contamination with refuse matter in the manner described; and it now remains to gauge the danger to health and life which may be carried in the contaminating substance. The danger of typhoid-fever bacteria entering the water has already been mentioned. These may be washed in from the surface or they may pass from cesspools near by through fissures in the ground, passages dug by rats, etc. Whether such bacteria can pass through the pores of a compact, unbroken soil from a cesspool to a well near it is a matter not fully settled. Since, however, the actual condition of the deeper layers of the soil between cesspool and well can not be known, it becomes imperative to prevent all pollution of the ground-water current supplying wells by either abolishing the cesspools or else placing them at a considerable distance from all sources of water.

Beside typhoid-fever bacteria, those organisms which cause digestive disturbances, and severer troubles, such as diarrhea, dysentery, and possibly other unknown diseases, may be carried into well water. During cholera epidemics, polluted wells might form centers of infection. Eggs of animal parasites may be washed in from the surface. Again, the barnyard manure, representing the mixed excrement of various animals, may under certain conditions be bearers of disease germs, and such excrement should, under no conditions, be looked upon as entirely harmless to human beings.[1]

Besides the protection of the ground water near the well from pollution emanating from cesspools, etc., the surface of the ground about the well should be kept free from manure, slops, and other waste water; hence the well should not be dug under or close by the house,[2] nor should it be located in the barnyard, where the ground is usually saturated with manure. It should be surrounded by turf, and not by richly manured, cultivated, or irrigated soil. The ground immediately around it should slope gently away from it and be paved if possible. The waste water from the well should not be allowed to soak into the ground, but should be collected in water-tight receptacles or else conducted at least 25 feet away in open or closed channels which are water-tight.

CONSTRUCTION OF WELLS.

The well itself must be so constructed that impurities can not get into it from above or from the sides. If water can soak into it after passing through a few feet of soil only, it can not be regarded as secure from pollution. To prevent this, the well may be provided with a water-tight wall built of hard-burned brick and cement down to the water level. The outside surface of this wall should be covered with a thin layer of cement, and clay pounded and puddled in around it. Or, tile may be used to line the well and the joints made water-tight with cement down to the water level. Driven wells, i. e., wells constructed of iron tubing driven into the ground, are, perhaps, the safest where the quantity of water needed is not large and where other conditions are favorable.

These different devices are all designed to keep water near the surface of the soil from percolating into the well. To keep impurities from entering the well directly from the top considerable care is necessary. Such impurities are likely to prove the most dangerous because there is no earth filter to hold them back and destroy them before they can reach the water. Adequate protection above may be provided in several ways. The sides of the tiled wells should project above the surface and be securely covered with a water-tight lid. The ordinary well should also have its sides project above the surface and a water-tight cover of heavy planks provided, which should not be disturbed excepting for repairing or cleansing the well. Under no circumstances should objects be let down into the well to cool. A still better method of protecting the water from above is to have the lining wall of the well end 3 feet below the surface of the ground and to be topped there with a vaulted roof, closed in the center with a removable iron or stone plate.

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[1] It is probable that the filth which gets into cow's milk and which appears to be mainly excrement of cows is largely responsible for the severe summer diseases of infants fed on cow's milk.

[2] The water may be carried into the kitchen by running the pipe from the well, horizontally, under ground.

The top should be covered with 12 inches of clay or loam; above this there should be a layer of sand, and lastly a pavement sloping away in all directions.

Too much care can not be bestowed upon the household well. It should be guarded jealously and all means applied to put the water above any suspicion of being impure. This is especially true in dairies where well water is used in cleaning the milk cans, and where steam and boiling water have not yet found their way for this end. Polluted wells in such houses not only endanger the health of the inmates but that of a more or less numerous body of city customers.

In those regions where rain water is the only safe drinking water, the same care is necessary to protect the stored supply from contamination, and no suggestions beyond those already given are necessary here.

CONCLUSION.

In the foregoing pages it has been the aim of the writer to give a few facts and supply a certain number of ideas which, in the mind of any person who has thoroughly understood them and who thinks for himself, may be safely left to ripen into schemes adapted to his own wants and surroundings. How many resources a man armed with correct views may find in the simplest appliances the reader may judge for himself by consulting Chapters IX, X, and XI of Dr. Vivian Poore's very interesting volume on rural hygiene. Whether the means for utilizing household wastes there described and adopted by him would be adequate outside of a limited territory of our own country, I am not prepared to state. For the same reason no definite suggestions can be made in these pages, owing to the wide diversity in the climatic and other conditions obtaining over the vast territory of our country. The writer has, furthermore, omitted all statements of detail which properly belong to the sanitary engineer. The works referred to will, however, supply those more directly interested with the facts and figures desired.

The principles to be kept in the foreground are the disposal of sewage in the superficial layers of the soil in not too great quantity, the disinfection of the stools of the sick with lime before such disposition is made, the digging of wells in places kept permanently in grass and at some distance from barnyards, and, above all, their thorough protection from contamination from the surface and from the soil immediately below the surface.

In every community there are public-spirited citizens who could do much good by taking hold of the simplest and safest methods of disposing of sewage and refuse, putting them into practice, and showing the rest of the community just what good can be accomplished and what harm avoided by a little continuous attention to sanitary matters. In this way many may be led to undertake improvements who, with no definite knowledge of the expense involved and with misgivings as to the final success of the undertaking, would otherwise hesitate to make a beginning.

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