PLAIN WORDS ABOUT WATER.

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NEW EDITION.

Published for the Committee of Council on Education

BY

CHAPMAN AND HALL, LIMITED,

HENRIETTA STREET, COVENT GARDEN.

PREFATORY NOTE.

These pages present a short account of Water in relation to the nourishing of man's body. They have been written with the view of being practically useful to persons unacquainted with scientific terms: it is hoped, however, that exactness has not been sacrificed in the endeavour to attain simplicity of language and description.

The present little guide is one of a set of small books on the Food of Man. The Lords of the Committee of Council on Education have sanctioned the preparation of this series with a twofold object. Their Lordships desire to make the Food Collection at the Bethnal Green Branch of the South Kensington Museum better known and more available for popular instruction: they also wish to bring home to all those persons who cannot visit that Collection some of the most important facts about the sources, constituents, and uses of Food. No part of this subject requires closer attention than that to which readers in town and country alike are directed in these "Plain Words about Water."

A. H. C.

CIRENCESTER, *May*. 1877.

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PLAIN WORDS ABOUT WATER.

CHAPTER I.

WATER AS A PART OF THE HUMAN BODY.

WE are about to say something concerning water, as a part of man's food. Perhaps the best way of beginning this study, will be to find out how much water there is in the human body, and in the different parts of it. But we must not be surprised if the figures we give look too large. For very few persons have any clear notion how much water there is hidden away in nearly everything, and especially in plants and animals, and in most of the substances got from them. If chemists could not prove it by an indisputable experiment, it would be hard to convince people generally, that 100 grains of carded cotton (commonly called cotton-wool) really contain at least 7 grains of water, and this though there is no sign of the cotton being damp. Writing-paper contains even more, so that if you hold a sheet of it over the flame of a candle (not near enough, however, for it to become in the least degree scorched) you will see a mist rising from it, as it loses 1-10th part of its weight—that tenth part being nothing else than water. The dry-looking grain of wheat, also, is not dry, come to other parts of plants or vegetable produce, we find still larger quantities of water present. A loaf of bread one day old, and weighing, let us suppose, 4 lb., contains more than 1½ lb. of water. And if we buy 4 lb. of potatoes, we purchase 3 lb. of water, and no more than 1 lb. of solid and dry substance. But what will be said to the statement that we now make? Ten lb. of turnips contain at least 9 lb. of water, often still more. This fact is stranger than the presence of 93 lb. of water in 100 lb. of watercress, or of 96 lb. in 100 of lettuce. For we can scarcely believe at first that a good, sound, solid, white turnip is so very watery a root, and therefore so poor a food, as chemistry makes out, while it will be admitted that watercresses and lettuces are undoubtedly very full of sap, or juice. Seeing then that even the solid parts of plants may contain 3-4ths, or even 9-10ths of their weight of water, the great quantity of moisture which can be proved to form part of the body of man becomes less strange. If we suppose a man to weigh 11 stones, it will generally be found that very nearly 8 st. of this weight are nothing but water. In other words, we find that a man weighing 154 lb., contains in his bones, his flesh, his blood, in his brain and his liver, and even in the fatty layers of his body, such a quantity of water, that when counted up into a grand total it will amount to over 100 lb.; generally, in a healthy, well-grown man, it will not be less than 104 lb., and may be as much as 112. A small man, weighing 100 lb., will contain about 70 lb. of water, perhaps a little more. As our bodies contain so much water, and as we are continually losing some of this moisture in sweat, and in the vapour of water that we breathe out from our lungs, and in many other ways as well, it will be quite clear that our food must contain a great deal of water, if it is to supply the daily wants of the body in this particular. But before we discuss water as a food, let us look a little more closely into the quantities of water which are found in, and really form a necessary part of, the various structures way of placing the facts about one substance or material forming part of another is this: We are supposed to speak of 100 parts by weight—say 100 lb., or 100 oz., or 100 gr., it matters not which—and we say that in these 100 parts by weight, there are so many parts, also by weight, of the particular solid (such as starch), or the particular liquid (such as water), or the particular gas (such as common air), about which we are talking. Now these parts in 100 are called percentages, or per cents. And so in speaking of the body of man, taken as a whole, we may say that it contains about 71 per cent. of water; 71 lb. in 100 lb.; 71 oz. in 100 oz. Let us adopt the same plan in speaking of the various parts of that body.

The following is a list of such percentages in various important solid portions of the human body, tissues, organs, viscera, &c.:

AVERAGE PERCENTAGES OF WATER IN

Bones	22	Skin	72
Fatty tissues	30	Brain	75
Elastic tissues	50	Muscles (flesh)	76
Cartilages	55	Lungs	79½
Liver	69	Connective tissue	80
Marrow	70	Kidneys	83

In the liquid parts and secretions of the body, with the single and most important exception of the blood, the percentages of water are still higher:

AVERAGE PERCENTAGES OF WATER IN

Blood	79	Serous fluids	96
Bile	86½	Intestinal juice	97½
Pancreatic juice	88	Tears	98¼
Milk	89	Gastric juice	99
Chyle	93	Saliva	99½
Lymph	96	Sweat	99½

It must not be supposed that the proportions of water just at any given moment is present, say in the liver, remains there. There is a constant movement, a constant renewal, going on in the body, and it is water which helps to accomplish this renewal. Water forms at least 4-5ths of all the food we take, and it is by the help of watery saliva, of watery bile, of watery pancreatic juice, of watery gastric juice, and of watery intestinal juice—many quarts of these being daily formed—that the solid nutritive parts of this daily food are so changed and dissolved, that they can pass (along with a great deal of water) into the blood itself, to renew the strength and freshness of that ceaseless current, which is truly the life.

More than this does water perform. For much of the waste of the body, materials out of which all power and use have gone, would load the blood with useless and even poisonous refuse, were it not thrown out in some way or other. Now water has a great deal to do with this throwing out of waste. One of the most injurious of all the kinds of waste material which is got rid of by water is called *urea*. It is made in the body, and represents the worn-out and changed residue of a certain part of our food, conveniently termed flesh-formers. Now urea would accumulate in the blood and poison it, were it not thrown out of the circulation by those organs or glands called the kidneys. These act upon the blood, secreting, that is separating, from it the liquid called urine, which is separated from the blood much in the same way that sweat is separated from the blood in the sweat glands, and other secretions in other glands. Now of what does the urine consist? Of water mainly, namely, 96 parts in 100; and in this water $2\frac{1}{3}$ parts of urea are dissolved, along with 1 part of common salt, and very small quantities of other matters. Thus it is by the help of a great deal of water, about 3 pints every 24 hours, that $1\frac{1}{4}$ oz. of urea is daily washed out of the blood.

But water in the form of vapour also aids in getting rid of another and not less serious waste material, namely, the gas called carbonic acid, every day, in the air which we breathe out from our lungs. This gas is accompanied by about ¾ lb. of water in the form of vapour, which helps its removal from the blood. We cannot now discuss how and where this carbonic acid gas is formed, but we may state that it is a waste material, produced in that slow and gentle burning of those constituents of our food which, having become part of our blood and tissues, are burnt in the body, to furnish us with warmth and with the power of doing work. As coal to the locomotive, so is that part of our food which can be burnt, to the body. Carbon is the chief constituent of both coal and food, both are burnt, both give out carbonic acid gas in burning, both furnish heat and energy.

A third way in which water helps to purify the body and to carry off waste, is in the form of sweat, or perspiration. And it is very important that the skin should be kept clean, that as much waste material may find a way out through the little openings in the skin as is meant to escape in that manner. If the skin is not in good order, more work is thrown upon the kidneys and the lungs. And pure, clear, fresh air, free from injurious floating dust and dirt, is as necessary for the proper working of the lungs, as clean, wholesome water is for keeping the skin in good order, and for all the other duties which it has to perform in the body.

CHAPTER II.

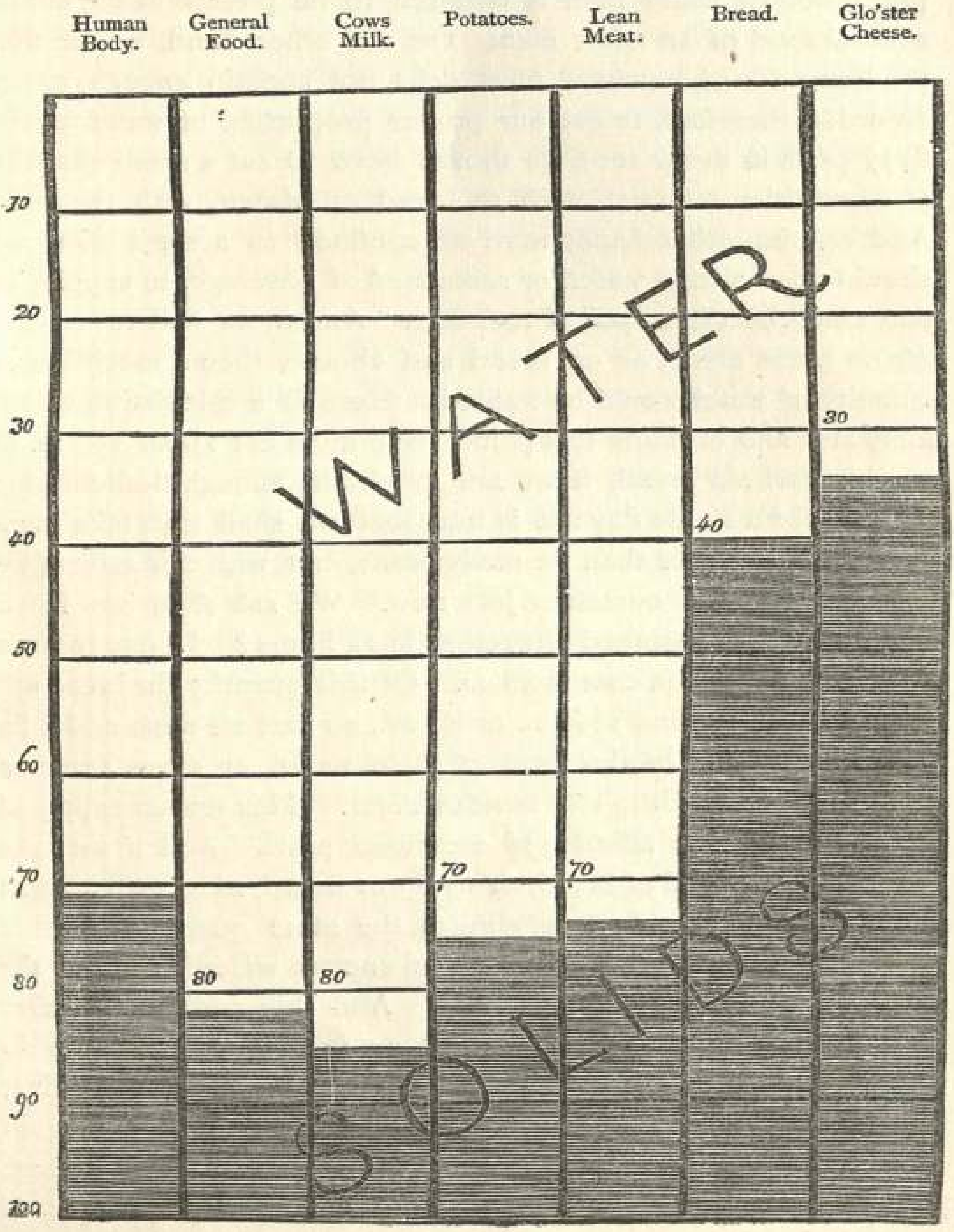
WATER IN DAILY FOOD.

WE have seen how important a part of the body is water, and how many kinds of work it does or helps to do in nutrition. Not only is it an essential part of all tissues, but it is the carrier of nutritive materials and of waste products. Moreover, its escape as vapour from the body keeps down the heat of the body: for water in becoming vapourised absorbs heat. We shall now be prepared to learn that the quantity of water necessary for a man's support during a single day and night is very large. All through the foregoing pages we have supposed the case of a healthy, full-grown man, weighing 11 st.: we shall continue to adopt the same standard. Now such a man will need, every 24 hours, a quantity of water, in one form or another, of 5½ lb., that is rather more than 2 quarts. Of course this water is not all to be taken in what people call drink, such as tea or coffee, milk or beer, but a great deal will be taken in the form of what we *call* solid food. The real solids in 100 parts of several different sorts of food, are shown in the diagram on the opposite page, where each white square means 10 parts of water, and each shaded square 10 parts of dry solid substance, by weight. Or we may write out the same facts in the form of a table, thus:

QUANTITIES OF WATER IN 100 LB. OF

	lb.
General mixed food - - - - - - - -	81½
Cows' milk - - - - - - - - -	86⅓
Potatoes - - - - - - - - -	75
Lean meat - - - - - - - - -	73
Bread - - - - - - - - - -	40
Gloucester cheese - - - - - - - -	34½

WATER AND SOLIDS IN 100 PARTS—



Now an important lesson may be gathered from these few figures. We may see that cows' milk contains a rather larger proportion of water than is required to be present in the mixed general food of an adult man. On the other hand, we see that the lean part of butchers' meat does not contain enough water. In order, therefore, to get our proper proportion of water (about 81½ parts in every 100), we should have to eat a small quantity of some drier material, such as bread or biscuit, with the milk. And on the other hand, were we confined to a meat diet, we should need a little water, or some kind of beverage, to supply, in that case, the slight lack of moisture. And if we had to sustain life on bread alone, or on bread and cheese, then a much larger quantity of water would be wanted. Here is a calculation which illustrates and explains this point. We must eat about 3¾ lb. of good household bread, if we are to obtain enough flesh-forming material for a single day: it is true that we shall thus take more of other substances than we really want, but with this subject we need not concern ourselves just now. We ask then how much water must be consumed altogether in 24 hours? In one form or another it is 5½ lb., that is 88 oz. Of this quantity the bread will furnish no more than 1½ lb., or 24 oz., so that we must add 4 lb. more, or 64 oz., in the form of plain water, or some common drink, containing little else besides water. This further supply of water amounts to about 3¼ measured pints. And if we take other foods instead of bread, or with our bread, as in any common allowance, for one day, very much the same quantity of drink must be added, to supply the lack of enough water in most of the common articles of our daily food. And this addition of water becomes the more necessary, when we use, as we commonly do use, very much of our food in a cooked state. For by cooking, not only by baking, or frying, or broiling, but even by boiling, in most cases our food loses part of its natural moisture. Thus, while the eatable part of a mutton-chop contained 70 per cent. of water before being cooked, it only showed 54 per cent. afterwards, even though all the gravy was preserved and reckoned in with the moisture in the meat itself.

Perhaps this is the place where we can best say a word or two about the feeling or sensation of *thirst.* Now this feeling in a healthy body, nourished on wholesome food, comes on distinctly when the body has lost about 1 lb. of water, this loss being about the sixth part of the daily loss of water, and nearly 1-100th part of all the water present at any moment in the body. Here we meet with a curious fact. Suppose we take in every day, in meat and drink, about 5 lb. 8¾ oz. of water, we shall lose every day from our lungs, our skin, and in the liquid and solid waste of our bodies, about 6 lb. 3¼ oz. of water. How can we give out more than we take in? Why, because about 10¼ oz. of water are actually *formed* in the body. And this formation of water happens thus: The starch, and fat, and sugar, and flesh-formers of our food are partly made up of the very same element, called *hydrogen*, which makes up also 1-9th of the purest water. When our food is really used in the body, this hydrogen is actually burnt, uniting with the only other element necessary to form water, the element called *oxygen*, which is supplied by the air taken into the lungs. Thus some of the warmth of the body, and some of the power of doing work (within the body as well as outside it) are to be traced to the formation of about 10 oz. of water—to the burning of hydrogen in oxygen—within the body.

But we must return to the subject of thirst. If we take violent exercise, or if the air is particularly dry and warm, then the usual loss of water is increased, and must be replaced by a larger supply. If we take a larger quantity of salt than our required allowance, or if we consume certain very savoury foods, or those medicines which increase the flow of saliva, of gastric-juice, and other very watery secretions of the body, then again we must make up the extra loss by an extra supply. And when we are out of health, when our pulse is high, our digestion imperfect, then suffer from a feeling of thirst, which does not always correspond to a real want of the system. It is very instructive to know that the feeling of thirst, when due to a real need for water, is allayed more rapidly by injecting water into the veins, than by merely introducing it into the stomach; though this process could not be carried into actual practice.

Many persons have stated that water may be absorbed or taken into the body through the skin. It is quite true a man's skin, or rather the outside parts of it, may take up several ounces of water, from half an hour's stay in a warm bath. And especially does this happen when the body has before lost a considerable amount of moisture. But, after all, this water does not get absorbed into the circulation, as the water of our food is absorbed: it moistens the outer layers of the skin, which become white, puckered, and sodden, and is soon given off again as the skin returns to its ordinary state.

Before passing on to study the different qualities of natural waters, and other subjects connected therewith, it will be useful to give a small table, showing the

QUANTITIES OF WATER IN 100 LB. OF DIFFERENT KINDS OF FOOD.

VEGETABLE FOODS.

	lb.		lb.
Fresh oatmeal	5	Grapes	80
Maize meal	14	Parsnips	81
Wheaten flour	14	Beetroot	82
Barley meal	14	Apples	83
Peas (dry)	14	Carrots	89
Haricot beans	14	Cabbages	89
Rice	15	Onions	91
Bread	40	Watercress	93
Potatoes	75	Lettuce	96

ANIMAL FOODS.

	lb.		lb.
Butter	10	Lean of meat	73
Bacon	22	Fowl	73
Cheese	34	Fish	74
Eggs	72	Milk	86

CHAPTER III.

OF WATER SUPPLY.

As we are obliged to use water for food, and for preparing and cooking food, and also for many other purposes in the household, it will be useful to know something about the sources of water, about the way in which water is collected, distributed, tested, improved, and, in too many cases, polluted.

Now all the water with which we have to do is going a perpetual round, is circulating upon this earth of ours quite as surely as the blood circulates in our body. From the sea and from the land it is raised as a pure invisible vapour; it forms the clouds, by separating from the air, and it falls in rain, and dew, and mist, in snow, and hail, and sleet. All the rain that falls upon the earth washes out something or other from the land or the rocks, and carries these things down the streams to rivers, and at last to the sea. As nothing but pure water can come out of the sea in the shape of vapour, the sea becomes the great sink of the world, into which everything drains, and in which everything that can remain together of all this refuse does so remain—with this exception, however, that the plants and animals which live in the sea are ever drawing away different kinds of matter from the salt-water, and so purifying it. But we cannot drink sea water, for it is much too full of common salt and other salts for such a use of it. One explanation alone will account for this: sea water is a stronger solution (containing as it does more than 3½ lb. of saline matters in 100 lb.) than most of the liquid secretions in the body which the water of our food has to form. To attempt to prepare water, would resemble an attempt to get out a pencil mark with the blacklead brush of the grate.

Now most people know very little and care very little about the water they or their households drink. Sometimes it attracts their attention, because it looks thick or has a nasty smell; but though these are bad signs, yet some bright and pleasant waters may be quite as bad for the health as thick and offensive ones. More of this presently. Now we wish to say a few words about the different sources of water. We wish to point out some facts about water-supply, whether that be pump water or well water, or tap water from a main or a cistern. Though very few persons can choose what water-supply they will have, everybody can learn how some of the most obvious proofs of badness are obtained; everyone can understand some of the ways in which water becomes unwholesome, and some of the modes of improving it.

Distilled water is steam changed back again into liquid water by being cooled. It may be so prepared in stills and receivers of proper materials that it is quite pure. But though it can be got pure, even from sea water, yet it must be remembered that if you distil a water that smells bad, the bad smell will most likely come over with the steam and be found in the distilled water. But distilled water is not nice. Sometimes it is merely flat and stale, sometimes it has a nasty, oily taste. Its flatness arises from the loss of most of the air or gases which are found in nice fresh spring water, and which sometimes cause them to bubble and foam like champagne or soda water. As very few of us will be able to get or willing to drink distilled water, it need only be stated here that it is very useful for many purposes, as for preparing medicines, and in chemical works, and also as a standard for comparing other waters with. This may be done thus. Look at the *colour* of pure distilled water: it is a pale, beautiful blue, like that of a clear, bright morning sky. Of course you cannot see enough of the colour in a tumbler or a bottle, but if you look through a closed with white enamelled glass at the bottom, then the real colour may be seen. In the Bethnal Green Museum you may see the colour of 8 feet of distilled water, and you may compare it with the tints of other waters in common use in London. A little farther on we shall again refer to the colours shown by different kinds of water, good and bad.

Rain water is generally flat, and often smoky in taste and look, and very frequently unwholesome. If it could be gathered in clean vessels as it falls in the open country, it would be safe to drink and wholesome. But in villages and towns it is sure to gather impurities of many sorts. As the raindrops descend through the air, they take up the floating bits of dust and dirt; they dissolve several gases, some useful—as oxygen and carbonic acid, some useless—as nitrogen and ammonia, and some which may do harm. And thus it happens that rain water, before it actually touches a roof or the land, generally contains of solid impurities (that is substances which are *not* water) nearly 2 grains in the gallon when collected in the country, and still larger quantities when collected in London and large towns.

As all the water we get from springs, wells, ponds, and rivers was once rain water, it will be useful to state the amount of rain which falls in England in one year. In the London district it averages less than 25 inches—that is, if all the rain and snow falling in twelve months were to remain without loss where it fell, it would cover the ground to the depth of rather more than 2 feet, but not quite 25 inches. Less than this falls near the eastern coasts of England, but there is more rain as we go towards the western side of our islands, until we find many places in North Wales, Cumberland, and the north-west of Scotland, where the yearly rainfall is more than 75 inches. Now let us see what *one inch of rain* really weighs. We measure it on one acre (say a square piece of land each side of which is 208·7 feet long), and we find that a depth of 1 inch of rain water over this square then, though some years are wetter and some drier than the average, yet we may reckon on a rainfall every year of 2,525 tons per acre or 565,600 gallons. And supposing we want to know how much falls annually on the roof of our house, we may reckon this as amounting, in London, to 5,193½ gallons for each space of 20 feet by 20 feet which our dwelling covers: this is about 14 gallons a day; but for many reasons we cannot gather all this.

If rain water as it falls is not quite pure, since it washes and cleanses the air through which it falls, becoming itself dirty in the process, much more is it impure when it has fallen. It is best when it falls on a slate roof, but it will generally take up a little decaying vegetable matter from a tiled roof, by reason of the small mosses and other plants usually found growing there. From a lead-covered roof it may take up a little lead, and from a galvanised iron roof a little zinc, both injurious metals when in a drinking water. Further, rain water acts on leaden pipes and cisterns, becoming charged with this injurious metal. In some places slabs of limestone are used for roofs, and then the rain water takes up some carbonate of lime (the same as whiting or chalk) from the stone, and also other impurities. But such water, having become less soft than ordinary rain water, is less likely to act on the metal of leaden cisterns.

River water. The rain flowing over the land and through the land supplies springs, streams, and rivers. And directly rain water touches earth or rock, it gathers fresh impurities, some harmless, some hurtful. Even rain water, stored in tanks or cisterns, may become quite unwholesome; but when, as in most parts of England, rain falls upon grazing land, plough land, or inhabited places, then it becomes much changed, often becoming quite unfit to drink. From the bones and dung applied to farm lands; from the refuse of plants and animals, and particularly from the sewage matter from houses, rain water takes up, not only mineral matters, but decaying organic matters. It is these latter which often prove injurious to health. They are themselves decaying or changing, and they cause changes, like putrefaction or fermentation, sometimes of a hurtful kind, when they are introduced into man's stomach. And sometimes they even contain distinct organic poisons; the seeds, as it were, of such terrible diseases as cholera and typhoid fever. But even in rivers there is happily a natural process of purification going on. Just as rain water gets dirty by passing through earth, and afterwards gets clean-looking again by passing through thick layers of chalk, or limestone, or sandstone rock, so in a river the water gets cleansed often, not always, by the action of the earthy particles suspended in the stream or covering the banks, or by the gas oxygen from the air, which quickly burns up or oxidizes the organic impurities, and leaves what is nothing but a harmless skeleton of them remaining in the stream. But we cannot be sure of this lucky natural cleansing taking place, and sometimes we know that the water of streams and rivers is deadly. Sewers discharge their poisonous contents into rivers, there are foul waste liquids from factories of many kinds, and, in country districts, the droppings of the farm animals which are feeding upon the banks. Thus it is that the use of river water, for drinking, especially when unboiled and unfiltered, is not to be recommended.

Surface-well water. If river water be often unwholesome, the water of shallow wells is likely to be still more loaded with suspicious and dangerous impurities. Many shallow wells are supplied with nothing but surface soakage, and the liquid part of the contents of sewers and cesspits; with drain and wash waters, and slops. These shallow wells are so easily made in an open, gravelly, or brashy soil, resting on clay, and it is so handy to have a well and pump in the yard close by the back-door, that we forget what danger there is in this convenient plan. Indeed some persons get quite angry when home-truths about wells and cesspools are told them. Still for all that we cannot too strongly urge the discovery and avoidance of this danger. Without doubt these and not unfrequently they are in communication with a neighbouring sewer, a leaky drain, or a cesspool. In fact, wherever a clay or stiff water-bearing deposit is found, with a loose, open soil and gravel above it, you have a too-convenient place for making a cesspit for the sewage and slops of the house, and a well for the supply of drinking water—no, not of water, but of filtered sewage, from which the grosser parts have been strained off, but which must still retain many noxious matters. Often it will be found that the level of the liquid in the cesspit and the well is the same, till both have been reduced by pumping, when the well naturally

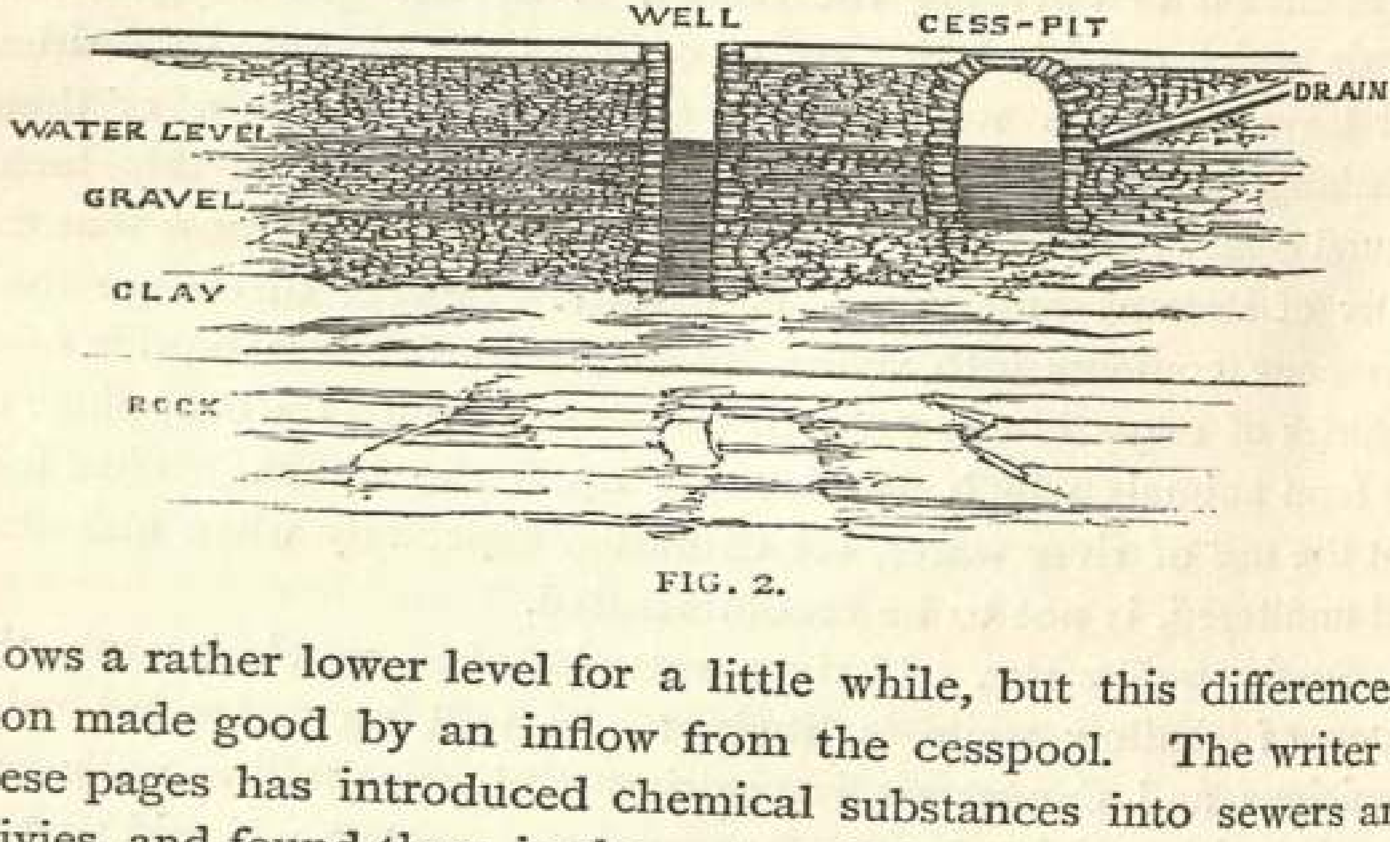


FIG. 2.

shows a rather lower level for a little while, but this difference is soon made good by an inflow from the cesspool. The writer of these pages has introduced chemical substances into sewers and privies, and found them in the water of the adjoining well half an hour afterwards. And another proof of this source of pollution is strikingly shown by a case which occurred but a year or two ago, within ten miles of London. A grand and quite necessary drainage scheme was carried out, at a heavy cost. And as the main drains were laid, so one by one the shallow wells dried up! So that the inhabitants, determined not to lose their favourite beverage, actually dipped their pitchers into the bed prepared for the new drain! And then the local authorities began to see that in a district of shall and new water supply. And we know a case still more conclusive than the last. In a country town in a back lane was a small yard with several cottages. At the end of the yard stood a pump. From this was drawn occasionally a scanty supply of a liquid miscalled water. At last it failed. The explanation was soon found. The owner of the adjoining house had cut off the supply of water from a water-closet, putting an earth-closet in instead. Since that change the water in the yard pump fails, except in very wet weather. Let it be clearly understood that shallow-well waters are scarcely ever safe: that we cannot depend upon the purifying effect of the few feet of gravel or sand through which the liquid filters from the cesspool, the cow-byre, the stable, the pigsty, or the graveyard, to the well. To the eye and to the taste there may be no signs of the disgusting and dangerous pollution, but the pollution may be there, nevertheless. Sometimes such waters are taken for years, without any known bad results, only a sense of weariness or an occasional sore throat, perhaps; but suppose the cholera comes, or a case of typhoid fever. Then it is that these waters may spread, and have spread, death around. The poisons of cholera and typhoid fever are contained in the discharges from the bowels of persons suffering from these diseases; and it has been clearly proved that a small quantity of such discharges, finding its way into waters used for drinking, has been the cause of a frightful mortality amongst persons using these waters. And further, it happens sometimes that sewer-gas poisons these shallow wells; more often, however, it is the water in cisterns and tanks that becomes thus polluted. We ought to add here, that there are some shallow wells that give fair water: this has been found to be the case where there is a sort of current or underground river in the sub-soil, and where the sources of possible impurity are below and not above the well.

Deep-well waters, if soakage from above or leakage through injurious matters, and they are also pleasant in taste. The organic matters which the rain water has carried down with it into the rocky layers below the surface, have been so altered by their passage through great thicknesses of stone, that they have become oxidized, or, in common language, *burnt.* It may seem strange to talk of burning taking place in water; but the process of oxidation, whether slow or fast, whether it occurs when a candle burns in air, or food in the body, or animal and vegetable matter in water, is essentially the same process. The new products formed are harmless, indeed they may be even useful, *but the oxidation must be complete.* The process is not completed in shallow-well waters; it generally is in deep-well waters. The final and harmless products are there. The nitrogen of the animal matters appears at last in the form of nitrates and nitrites; the carbon, as carbonic acid gas; and the hydrogen, as water. The nitrates and nitrites may be regarded as a sign of previous pollution, but they are quite harmless, and must occur in all the deep-well waters of a country like England, where so much of the land which receives the rainfall is under cultivation, and consequently manured. Most farm lands in England receive yearly, in farmyard manure alone, nearly 30 lb. of nitrogen per acre, and such part of this as is not used by the crops, and does not remain in the soil, must find its way into rivers, wells, and springs. Deep-well waters are usually harder than any of the waters before considered, for they will have dissolved out much calcareous, magnesian, and alkaline salt during their long course underground. They will probably, on the average, contain about 30 gr. per gallon of total dissolved substances.

Spring waters are generally palatable and wholesome. They vary in hardness and as to total solid matters dissolved, according to the more or less insoluble nature of the rocks through which they have passed, or which throw them out. The Rabate Fountain at Balmoral contains less than 1 gr. per gallon of dissolved matter, *London waters.* Rain water falling on London roofs becomes charged with suspended and dissolved dirt, and has an unpleasant taste. London shallow-well waters, bright though they may look, are hardly ever quite safe, and often the very reverse. But London, which, with its suburbs, may be assumed to contain about four millions of inhabitants—or four persons out of every thousand now living on the whole globe—is mainly supplied with water by eight private companies, which provide a daily supply of about 114 millions of gallons. The following table gives the names of these companies, the sources of the water which they supply, and the daily amount:

Water Companies.	Sources of Supply.	Daily Delivery in Gallons.
East London	Thames above Sunbury, and Lee	21,000,000
West Middlesex	Thames above Hampton	9,700,000
Grand Junction	Thames near Hampton	12,300,000
Southwark and Vauxhall	Thames near Hampton	17,500,000
Lambeth	Thames near Moulsey	12,500,000
Chelsea	Thames near Moulsey	10,000,000
New River	Lea, and springs, and deep wells	22,000,000
Kent	Deep wells in chalk	9,000,000

Some idea of the vastness of the quantity of water supplied to London may be obtained by comparing its bulk with that of a familiar building. A day's water supply would require a tank equal in area to Westminster Hall, but the walls would have to be carried up to the height of 1,140 ft., or nearly four times the height of the cross on St. Paul's Cathedral. And this quantity of water will not suffice for the increasing population as years go by. In 1850 the gross daily delivery was 44,500,000 gallons; in 1856 it had reached 81,000,000 gallons, and now stands at 114,000,000 gallons.

A great deal has been done towards improving and increasing the water supply of large towns. But there are many difficulties in the way, even when the requisite knowledge and money are brought to bear upon the question. Thames water may continue to improve, as the sewage of many towns and villages is more and more completely diverted from it, but it can hardly ever become a wholly satisfactory source for the greater part of London, however carefully it may be filtered before delivery. But many small towns and villages are far worse off, and many remain in ignorance of their state. It is to be hoped that the knowledge of chemistry and of sanitary engineering will so spread, that local authorities may everywhere see their duty with regard to an ample supply of good water, and be enabled to do it.

CHAPTER IV.

How to Try or Test Waters.

It has been said already, in the preceding chapters, that a very bad water may look like a very good one. Now, though we should condemn a great many unwholesome waters, by using our ordinary senses in looking at them, tasting them, and smelling them, yet if we have no other means but these, we are sure to fail in a great many cases to detect the bad qualities of particular waters. In the next few pages we shall try to show how the most may be made of our ordinary senses in putting waters upon their trial, and further, how a few simple chemical tests may be applied to them, so as to teach us as much as we can learn, without a proper examination of the samples by a skilful analytical chemist. But, while we give the signs that betray a bad water, let us describe the character of a good one.

First of all, a drinking water should be clear and bright. The worst kind of cloudiness it can show, is not that of little sandy or chalky grains, but as if half a drop of milk had been dropped into a glass of it; this milkiness is generally a very bad sign. Then a water should give, when shaken, bubbles which rise quickly and break directly; if they move slowly and hang about for some time, the water has organic matter in it, and is, to say the least, suspicious. Again, a good water, whether it be cold or hot, has no smell, unless indeed it be a slight earthy odour, like that of clay on which rain has just fallen. And the best waters keep free from smell when stored in clean cisterns, or kept in covered jugs or bottles. Yet some waters, which in other respects seem sound, demned on this score alone, yet it is a suspicious sign. This bad smell comes from the action of decaying vegetable or animal matter (that is organic matter in a state of change) on the gypsum or similar substances called sulphates, in the water. A gas—sulphuretted hydrogen—is thus formed, and this gas is not only disagreeable and unwholesome in itself, but it betokens organic matter, that may be of a hurtful sort, in the water from which it comes. Another character belonging to waters, is what we name their taste. Of course if a water tastes nasty it should be avoided, if for no other reasons than for these two : (1) a water with a nasty taste is very likely to contain some unwholesome matter dissolved in it ; (2) water, like all the other parts of our food, should be pleasant, if it is to nourish us as much as it ought. The very purest distilled water is not pleasant or agreeable in taste, being flat and insipid. The cleanest rain water is not better, nor is boiled water ; but where a water is pretty well charged with air, and especially with fixed air, that is carbonic-acid gas, it has a livelier character, which becomes very marked indeed in some natural spring waters, which froth and effervesce like champagne, owing to the escape of some of the excess of carbonic-acid gas originally present. But if much of this lively gas be found in a water, it is often accompanied by a large quantity of chalk or earthy matters dissolved by its aid from rocks, &c. Thus, a sparkling, brisk water is often a *hard* one, that is, full of mineral matter ; and, moreover, the briskness may mask impurities, and may even in part be due to them.

Another character of water may be found in its colour. Ordinary wholesome waters are not only clear, so that we can see distinctly through great depths of them, but they have a pure pale blue tint. The blue of some good deep-well waters has a greenish cast in it, but a green, a yellowish green, or a brown colour in a water, is not a favourable sign. With the exception of peaty waters, which are yellowish or brownish, and often very deeply or greenish blue must be taken as a sign of the presence of impurities, which are not unlikely to prove unwholesome, at one time or another. The colour of water may be tested in a large white jug filled quite full, or better, in the long glass tubes named already on page 13. If a water has a bad colour before it is strained or filtered, it may often be improved, both in look and in reality, as we shall learn in the next chapter, by that treatment.

So much then for the tests which can be applied to water by any person possessing good eyesight, a sensitive palate, and a well-educated nose. Now we will look a little more closely into the testing of waters, describing the nature and the meaning of certain chemical experiments, which can be easily made and easily understood.

Water residues. In order to comprehend the meaning of the term "water residue," we must remind our readers of the difference between two words in common use—melt and dissolve.

We *melt* a substance by heat, without adding anything to it or taking anything from it, as when we melt fat upon the fire. We *dissolve* a substance by mixing it with a liquid, as when we dissolve sugar in our tea. Now drinking waters, even the best, contain certain earthy or mineral matter *dissolved* in them. A little chalk, a trace of salt, and several substances of a like nature are concealed in the clearest water, in fact dissolved in it. But these dissolved solids need not exceed a few grains, and should not amount to as much as 30 gr. in the imperial gallon of water—30 gr. in 70,000 gr., in 8 pints, in 10 lb. In Thames and New River water, when clear, these dissolved substances or "total solids" will not be more than 20 or 21 gr. per gallon—a quantity of solid substance not very different in bulk from that shown in our little woodcut being present in each gallon of water: about 2-3rds of this substance being chalk or carbonate of lime. Now when a water is boiled down, nothing

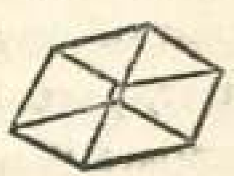


FIG. 3.

vapour, while the solid matters, chalk, and salt, and organic matters, with other substances remain behind, and form the residue, or "solid residue," as it is often termed. It is, moreover, usual to call all the ingredients forming this residue impurities, and in a chemical sense this is a true use of the word, for they are certainly not water. But the *nature* of these impurities is the important point to be studied. Of course, if a water leaves a large residue, weighing some scores or hundreds of grains, instead of 20 or 30 gr. only, the less suitable that water will prove for drinking and for most of the other purposes to which water is put. It will be more likely to be unwholesome ; it will be harder than waters having less

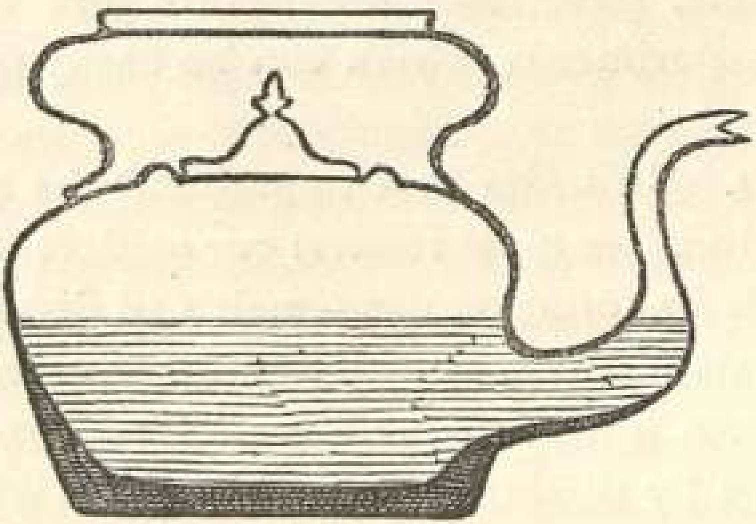


FIG. 4.

residue, and so will use up more soap in washing, without producing a lather ; and it will leave more rock or fur in kettles or boilers, and thus cause the waste of much fuel—the crust or fur preventing the heat of the fire from getting through the metal to the water inside. And generally you cannot boil vegetables properly in very hard water, and you can never extract the goodness of tea and coffee with them. Now by evaporating, that is boiling down, a pint of any particular water in a dish* or bason of thin glass, or better, porcelain, we can see how much residue it leaves, and can compare it with the residues left by other waters. The annexed sketch shows a convenient contrivance for boiling water down to

* Such dishes, 3 inches across, may be bought at chemical apparatus shops.

dryness. A support with gas-burner or spirit-lamp, a saucepan half full of water, a tin or copper plate pierced with three holes 2½ inches wide, and three porcelain basons, filled up each with water from the measured quantity from time to time, is all that we need.

The residues of different waters will differ in other respects besides in mere amount or *quantity*: they will differ in *quality*. So a water residue may be made to teach us more still about a water.

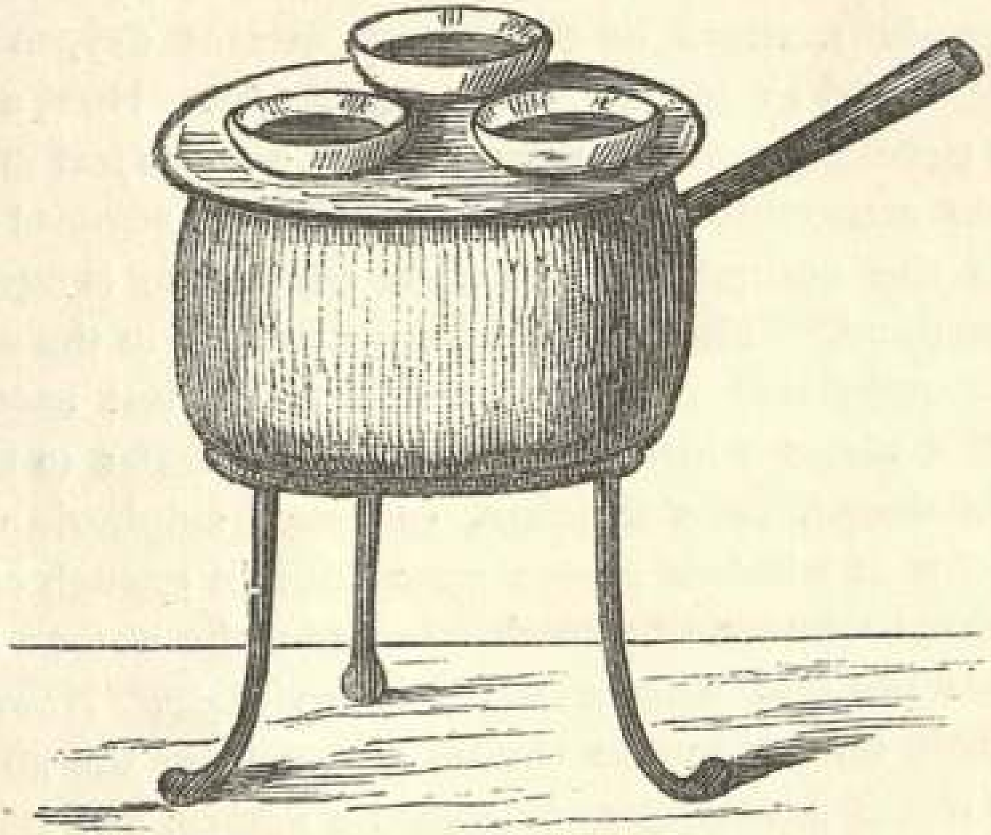


FIG. 5.

Let us boil down a pint, or, better, a quart (always, however, the same quantity or the comparison cannot be made) in a porcelain bason, and then heat the dry residue over a flame gradually hotter and hotter. If the original residue is white and powdery in appearance, that is, so far, a good sign; but if it is partly white and partly yellowish or greenish, and especially if there are gum-like stains round the residue, then on heating these parts of the residue we shall probably see them darken, fuse, and burn away in part, giving out fumes having a disagreeable smell. If the black-ening is considerable, much organic matter is present; but if the smell is offensive (like burnt feathers), then it is certain that the organic matter is of animal origin, and is, therefore, more likely to be unwholesome, or even poisonous.

Another test for organic matter in water may be used with ease. If a water contains substances derived from the decay of animal or vegetable matters, such as those in sewage and manure, and the refuse of plants, then it is found that such a water will destroy the beautiful purple colour of a chemical substance called *permanganate of potash.* The reason for this is as follows: The decaying organic matters of the water attract oxygen strongly when it is presented in certain states or forms. Now, a solution of the above permanganate contains much oxygen just in the right state to be so attracted and removed. By its removal from the permanganate the composition of that substance is altered, and its colour destroyed. The more organic matter in the water, the more permanganate will be decolorised. The test may be thus applied. Fill a clean white teacup with the water to be tested. Add about 60 drops, or a drachm, of weak sulphuric acid; stir with a clean slip of window glass; now pour in enough of a weak solution of permanganate of potash to render the water a rich rose colour. Cover the cup with a clean glass plate. Now, if there be much organic matter in the water, the colour will go in a few minutes, and more permanganate may be added, and still lose its colour. It must be recollected in using this test that peaty matters and iron salts, which are not necessarily unwholesome, give the same result.

The importance of ascertaining the presence and nature of organic impurities in waters cannot be easily exaggerated. But though it is generally easy to find them, it is not at present possible to be quite sure that we have not missed detecting them: and it is also unhappily the case that we have no means of distinguishing the different degrees of unwholesomeness belonging to such organic matters which we do find, and which we regard as indiimpurities, such as sewage contains, should never be allowed to enter into a water-supply. If they have entered in any quantity and remain, we can prove their actual presence, by the amount of carbon and nitrogen in organic union which the polluted water contains; while we can trace their previous entrance, even after they have been changed, by certain compounds called nitrates and nitrites which they yield. If we assume that average London sewage contains 7 gr. of combined nitrogen per gallon (or 10 parts in 100,000), then if we find 3½ gr. in a gallon of water, it may be considered that the particular sample of water examined had received animal pollution equal to just half its bulk of sewage. This pollution may not have arisen from actual house sewage, but from animal matters in decay, farmyard manure, guano, &c. Nor can we say that water which *has been* thus polluted, is necessarily *now* unwholesome. Such changes may have occurred to the offensive and unwholesome nitrogenous decaying matters, as to have turned them into harmless mineral compounds—mere signs of previous contamination. The preceding remarks will, it is hoped, render clear the meaning of the expressions and numbers used in the monthly reports concerning the metropolitan water supply which are published by the Registrar-General.

Ammonia, the pungent gas which gives the strong smell to smelling salts, occurs in many bad waters, and when present in larger quantities than in rain water (which contains a trace) may be easily detected by means of a chemical preparation called "Nessler's test." Add a few drops of this liquid to a clean tall jar of colourless glass, standing on a sheet of white paper: if any shade of yellow, buff, or brown colour be produced, any shade darker than the palest straw or cream colour, it must be taken as a bad sign.

The compounds known to chemists as *phosphates* are hardly ever found, except in very bad waters. To test for them, boil down a pint of water in a porcelain bason, drop enough nitric acid containing molybdate of ammonia, and warm the mixture for some time: a lemon yellow colour or powder will form if phosphates be present.

We have two more tests to describe: the first is for *common salt.* Nearly fill a perfectly clean tumbler with the water, and then add 20 drops of nitric acid and 5 or 10 of a solution of nitrate of silver (lunar caustic), or else a small crystal of that substance. Stir with a clean slip of glass, and if there is more than a slight bluish-white cloudiness, if there is a solid curdy substance formed, then there is too much common salt in the water. It may be said: What harm is there in common salt? We answer, none in the common salt as such, but only in the common salt as evidence of some kinds of pollution. We will explain. Common salt (chloride of sodium) does not occur in rain water or pure well water, except to the extent of a little over 1 gr. per gallon. Of course there is more in waters from salt-bearing rocks, and in waters near the sea. But generally, at all events in a chalk or limestone district, whenever common salt is found in any quantity exceeding 1½ gr. per gallon, which gives a mere cloudiness with nitrate of silver, the salt is derived from sewage; in other words, from the salt consumed in human food, and voided chiefly with the urine. If a water be found to contain both organic matter and common salt, it is probably contaminated by house or town sewage. If organic matter be abundant, but accompanied by a smaller quantity of common salt, then the source of pollution is rather the excrement of farm animals than of man—or it may arise merely from vegetable refuse.

The testing of waters for metallic impurities is generally limited to a search for lead. But other metals, as zinc, copper, and iron, may also in some cases be present; zinc being often found in waters which have been gathered on galvanised iron roofs or stored in cisterns of the same material. We cannot here do more than give a test for lead. This dangerous and deadly metal may sulphuretted hydrogen is added to the suspected water, into which a few drops of hydrochloric acid (spirits of salt) have been previously poured. Lead should always be thus looked for in rain water or very soft water, which has been stored in a leaden cistern or has passed through a leaden pipe; in the water which has been kept in a copper kettle, or fountain which has been soldered with soft lead solder, instead of being brazed; and in soda water and other aerated waters which have been charged with carbonic-acid gas by artificial means.

CHAPTER V.

How to Purify Waters.

When, on testing the water which we have to drink, we have found signs of its being bad; or when it has been authoritatively condemned as suspicious or unwholesome by a competent analyst, then the question arises: Can we render this water fit to drink, or must we try to secure another supply? Before attempting to answer this question, a caution about spoiling good water may be given. The water may be fairly clear and clean when it is supplied to the house, but it is too often turned bad by carelessness in storing it. For it is commonly received in cisterns or water-butts, which may not be properly placed or properly attended to. Perhaps they are sunk in the ground, so that liquid and solid dirts of many kinds get into them, particularly during wet weather, from the ground around. Perhaps the cistern is left month after month without being cleaned out, so that the impurities which are sure to be present one day or another in the water-supply, settle down in the cistern and spoil the good water by becoming putrid. Or a bird or a mouse may get drowned in the cistern, and render the water nasty and unwholesome. Every vessel, large or small, used in keeping water must, then, be cleansed thoroughly and often, or you may get living animals in the water, or dead animal matters, which are often worse for the health. And water-vessels should always be covered, not tightly, so as to keep out air, but so as to exclude dirt. Moreover, no cistern or butt should have a waste pipe connected with a drain or sewer, for the poisonous air from the sewer or drain will find its way thus into the water, will be absorbed by it, and will cause it also to be poisonous or unwholesome. And in the same way the bad air from a water-closet may spoil the water of the cistern supplying it. Water for drinking should never be kept in close cellars, in badly-aired or crowded rooms, or in the chambers of sick people. For use in such places, fresh water should be often brought in, and kept closely covered till wanted.

Now we will consider how bad or doubtful waters may be purified or improved. One way of doing this is by straining or filtering them. So far, little has been here said about those impurities of waters, particularly of river waters, which are not *dissolved* but *suspended* in the water. These impurities are in part earthy and in part organic: if they are in rather coarse particles, they settle of themselves when left at rest, but in the case of most waters they have to be strained off, by passing the water through a strainer or filter of sand or gravel, which holds back the suspended dirt. So in settling tanks, and by passing through large filter-beds, the muddy waters of the Thames and Lea may be rendered clear. Though, unfortunately, clear waters may be as unwholesome as muddy ones, yet thorough filtration does effect some change for the better, even in the worst waters, provided that the water filters slowly, and that the filtering-material is of the right sort, and has not been rendered inert by previous use. An old filter, in which the charcoal has not been renewed, or at least cleansed or re-burnt, may *give* impurities to a water, instead of removing them.

The best materials for filters are these three:

1. Gravel and sand, if sharp and clean.

2. Charcoal, especially well-burnt animal charcoal, or burnt bone.

3. Spongy metallic iron.

Now these materials are not all mere filters or strainers: Nos. 2 and 3 removing not only suspended impurities, but, under favourable circumstances, some of those which are dissolved as well. But even the gravel and sand through which the water supplied to London is filtered, do remove a little dissolved matter, about 1-20th of the whole amount present, or 1 gr. per gallon. But animal charcoal, prepared by heating bones to redness in iron retorts closed from the air, is far more effective in this direction than sand or gravel. It removes, when fresh, much dissolved organic matter as well as mineral salts, from water filtered through it. A good filter, not so much for clearing water, but for removing unwholesome dissolved impurities from it, is furnished by a charcoal block filter of condensed or compressed carbon: these filters

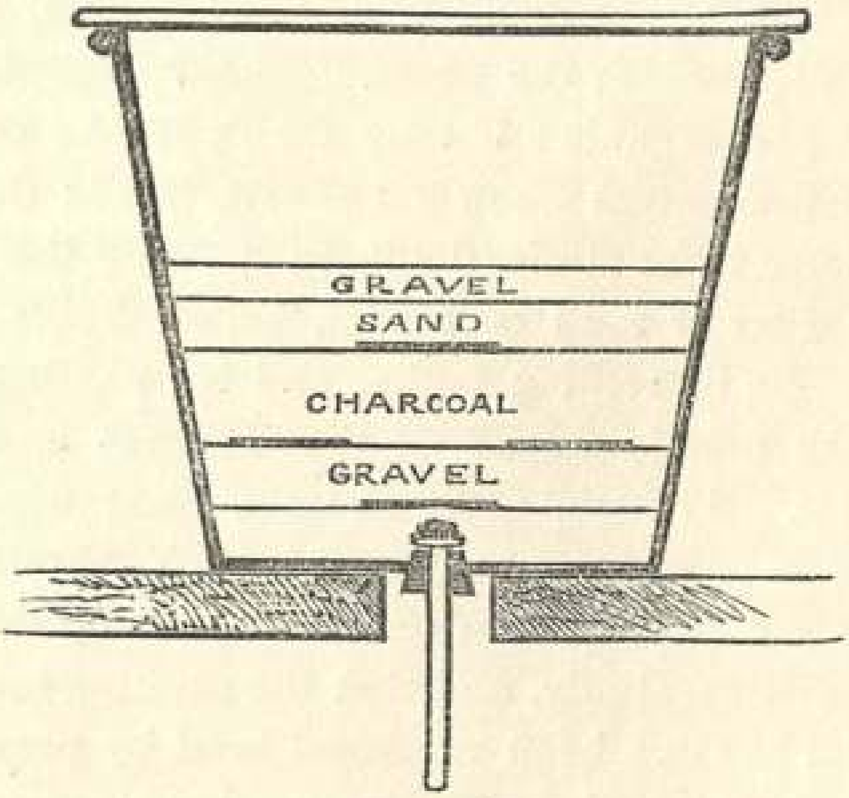


FIG. 6.

may be purchased at a small cost. When clogged up with dirt, they may be scrubbed or gently scraped, and then cleansed by passing some permanganate of potash and hydrochloric acid through them. (See pages 26 and 33.) But a cheap and good filter may be made at home thus: Take a large flowerpot, soak it thoroughly, to begin with, in clean water, and fill it thus: Plug up the hole with a bit of clean sponge, or with a cork and glass tube. If the glass tube be used, a small piece of sponge must be forced into its upper end. Now put an inch of sharp clean sand into the pot, then two inches of clean washed gravel, then three or four inches of well burnt animal and finally another layer of gravel. To prevent the water from running too straightly through the filter, a few slips of glass laid on the different layers (near the spots shown in our woodcut by dark lines) will be found useful. Cover the filter with a large earthenware plate, to keep out dust and bad air. It may stand on a couple of tiles above a hole in a dresser, so that the glass tube below just dips into the narrow neck of a big stoneware jar set beneath. After a time our filter will get choked up, or will cease to purify the water. Then we may renew the materials, or else we may take them all out separately, as far as may be, and boil them in water: perhaps we may not care to do this, except with the charcoal, which should then be dried before being put back.

Another way of cleansing a filter, is to let the following preparation run through it: One quart of water, to which half an ounce of spirits of salt and a small bottleful of Condy's purple fluid (a permanganate, see page 26) have been added. Pour this mixture into the filter at night, and the next morning let plenty of fresh water run through. Throw away all the liquid that filters through, until it has neither colour nor sour taste.

A very good filtering material is spongy metallic iron. It softens the water as well as removes much dissolved organic matter from it. But after all there is some risk in trusting to any filters for the removal of deadly or unwholesome matters from drinking waters; and it is probably wiser, in the case of very bad waters, to boil them first and then to filter them. Water, then, may be purified, though not quite thoroughly or certainly, from suspended impurities, and from much unwholesome dissolved matter, by proper filters. Boiling a water, or adding lime-water to it, are two other ways of improving it of great importance: we will study the effects of boiling upon a water first.

A water becomes *softer* by being boiled, at least this is commonly the case. To what, then, is the quality of *hardness*, which so many waters possess, due? Sea water is hard for two reasons, the chief of which is this, that salt prevents water from dissolving soap—soap is insoluble in salt solution. But in ordinary hard waters the soap is first dissolved and then decomposed or destroyed, white, curdy compounds being formed, which contain fatty matters from the soap joined to the earths previously dissolved in the water, as carbonates or sulphates. The alkali in the original soap unites with the acid part of the lime and magnesia salts, forming carbonate of soda, which has cleansing properties, or sulphate of soda, which is quite useless. If, then, a water be hard from earthy carbonates, however disagreeable washing with it becomes, still the soap, though it will not lather, cleanses. But if earthy sulphates (or nitrates or chlorides) be the chief cause of hardness, then neither lathering nor cleansing can take place until a quantity of soap has been consumed in destroying these salts. We use, indeed, a solution of soap of known strength, to learn the hardness of waters, and to find out how far they are capable of being improved by boiling. So the hardness before boiling is called "total hardness," and that still remaining unremoved after boiling, is called "permanent." We have said thus much about hardness, because of the great importance of this subject, and because it serves to explain the importance of any good plans for removing or lessening it. And we may introduce here a little table of figures, showing how many pounds of soap are destroyed or curdled before any lather will come, by 100,000 lb., or 10,000 gallons of various waters.

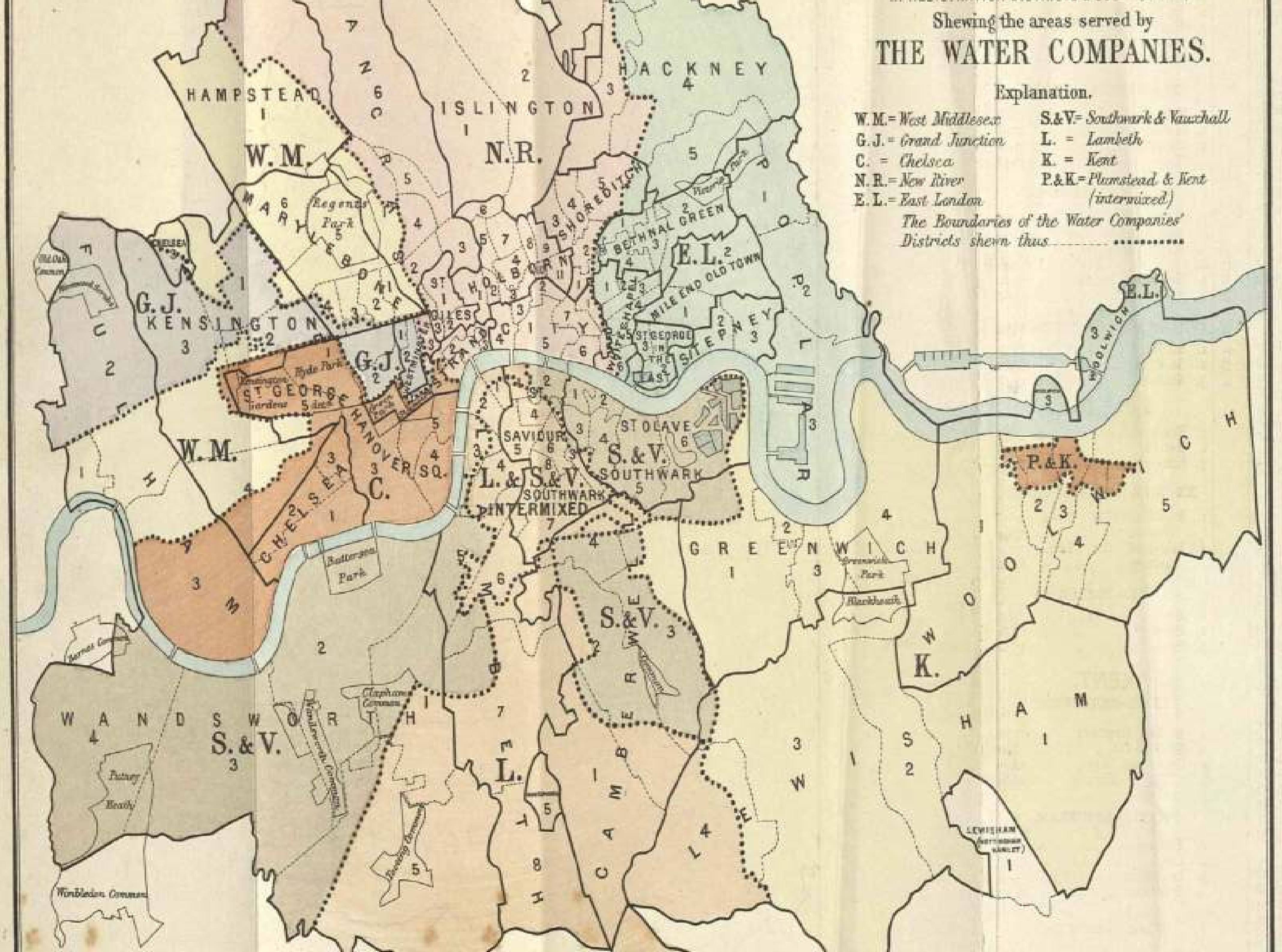
Water.	Soap destroyed. lb.	Water.	Soap destroyed. lb.
Worthing - - -	285	Caterham - - - -	84
Kent Company's - -	265	Preston - - - -	80
Thames - - - -	212	Manchester - - -	32
Lea - - - -	204	Glasgow (Loch Katrine) -	4
Leicester - - -	161	Lancaster - - - -	1

Now as to the effect of heat on waters. When a water is warmed, the gases dissolved in it are set free as it becomes hotter, and are nearly completely driven out by less than half an hour's boiling. Carbonic acid gas, which holds the chief hardening materials of the water in solution, is thus removed, for it is not the limey matters separate from the water, forming a fur on the boiler or kettle (page 24), or else falling as a fine, loose powder. But were this partial removal of lime the only effect of boiling a water, it would not be of much importance as a means of purification. Happily it does more. There separate some organic matters along with the lime, while the heat so changes the organic matters that remain in solution or suspension, that they are frequently rendered quite harmless. That the poisonous matters in polluted waters, which produce diarrhœa and fevers, may be changed and made harmless by boiling, has been proved; that this always happens, is not certain. A good way of using boiled water as a beverage, is to pour it quite boiling upon a thin slice of well-browned toast. The toast and water thus made is pleasant and wholesome.

The other plan of softening water can be better carried out on a large scale than on a small one. It depends upon the use of lime, and was invented by the late Dr. Clark, of Aberdeen. Waters from the chalk, limestone, and oolite formations may be made to lose most of their hardness by this process, just as effectually and to the same extent, as by the more tedious and more costly process of boiling. But if a water is not softened by boiling, it cannot be softened by Clark's process, which can remove the carbonates of lime and magnesia, but not the corresponding sulphates, nitrates, and chlorides. Clark's process may be thus carried out in the case of the East London Company's Water. Slake 18 oz. of freshly-burnt quicklime in a little water: when the lime has fallen to powder, add enough water to make a thin cream with this powder, and stir the mixture in a pail. Then pour this cream into a cistern containing 50 gallons of the water to be softened, rinsing the pail out with more water, but not pouring out any lumps of lime that may have settled. Let into the cistern the remainder of the 700 gallons of water which 18 oz. of lime can soften, and take care that a thorough mingling of the water and lime occurs. The added lime seizes the carbonic acid original carbonate of lime and that formed in the process fall together as a white sediment. This takes some time to settle—from 12 to 24 hours—but the water may be used for washing before it has become quite clear. This process is carried out on a large scale at Canterbury, Tring, and Caterham. At Canterbury 110,000 gallons are softened daily by the addition of 11,000 gallons of lime water, the total impurities of the water being thus reduced from 23½ gr. per gallon to less than 8½. And not only are hardening matters thus removed, but organic substances as well. The process purifies, to some extent, as well as softens; and the method is not only effective, but cheap. It would require 20¼ cwt. of soap, costing £47 1*s.* 8*d.*, or 4¾ cwt. of carbonate of soda, costing £2 17*s.* 6*d.*, to soften the same quantity of water which could be treated by Clark's process for 8*d.*, the cost of 1 cwt. of quicklime.

The hardness of water is a great defect. Already we have shown some of the drawbacks to the use of a very hard water: others may be named. In preparing articles of food by boiling them in water, we find that they do not get so well done in hard water as in soft; indeed it is a good plan to boil the water first before using it for such purposes. Greens, boiled in hard water, acquire a dull gray colour, as the earthy matters of the water are deposited upon them. If they are cooked in boiling water, which has also been boiled some minutes before, and especially if a small pinch of carbonate of soda and a little salt be added, this defect will be remedied. For making tea with hard water, it is allowable to use a little carbonate of soda, but a great deal too much is commonly employed. For cleansing the skin, hard water is not nearly so efficient as soft. If we wash our hands with hard water, we rub the soap between them, but we do not plunge them in the water. For washing linen and for baths, hard waters are objectionable: the linen is of a bad colour, and the skin is clogged with useless curdy matter.

THE LONDON WATER SUPPLY


Shewing the areas served by
THE WATER COMPANIES.
Explanation.
W.M. = West Middlesex
G.J. = Grand Junction
C. = Chelsea
N.R. = New River
E.L. = East London
S.&V. = Southwark & Vauxhall
L. = Lambeth
K. = Kent
P.&K. = Plumstead & Kent (intermixed)
The Boundaries of the Water Companies' Districts shewn thus
HAMPSTEAD
ISLINGTON
HACKNEY
W.M.
N.R.
E.L.
G.J.
C.
S.&V.
L.
K.
P.&K.
KENSINGTON
MARYLEBONE
SHOREDITCH
BETHNAL GREEN
MILE END OLD TOWN
STEPNEY
HOLBORN
CITY
ST GILES
WESTMINSTER
ST GEORGE
HANOVER SQ.
CHELSEA
SAVIOUR
ST OLAVE
SOUTHWARK
L. & S.&V. SOUTHWARK INTERMIXED
GREENWICH
WOOLWICH
LEWISHAM
WANDSWORTH
CAMBERWELL
POPLAR
Regents Park
Hyde Park
Battersea Park
Greenwich Park
Blackheath
Clapham Common
Wandsworth Common
Putney Heath
Wimbledon Common
Barnes Common
Streatham Common
Victoria Park
Kensington Gardens

REGISTRATION LONDON.

(THE "INNER LONDON" OF THE REGISTRAR GENERAL'S WEEKLY RETURN.)

NOTE.—*The Figures prefixed to the names of Sub-districts correspond to the Figures on the Map.*

MIDDLESEX.

WEST DISTRICTS.

I—KENSINGTON.

1.	St. Mary, Paddington	69,785
2.	St. John, "	37,313
3.	Kensington Town	120,127
4.	Brompton	42,797

II—FULHAM.

1.	St. Peter, Hammersmith	7,596
2.	St. Paul, "	64,320
3.	Fulham	42,895

III—CHELSEA.

1.	Chelsea South	30,395
2.	" North West	24,923
3.	" " East	32,783

IV—ST. GEORGE, HANOVER SQ.

1.	Hanover Square	16,858
2.	Mayfair	13,481
3.	Belgrave	59,178
4.	St. John, Westminster	35,482
5.	St. Margaret, "	24,604

V—WESTMINSTER.

1.	Golden Square	11,585
2.	Berwick Street	18,280
3.	St. Anne, Soho	16,591

NORTH DISTRICTS.

VI—MARYLEBONE.

1.	All Souls	26,758
2.	Cavendish Square	14,893
3.	Rectory	24,900
4.	St. Mary	21,122
5.	Christ Church	33,691
6.	St. John	33,640

VII—HAMPSTEAD.

1.	Hampstead	45,436

VIII—PANCRAS.

1.	Regent's Park	39,103
2.	Tottenham Court	27,728
3.	Gray's Inn Lane	30,229
4.	Somers Town	34,355
5.	Camden "	17,406
6.	Kentish "	87,388

IX—ISLINGTON.

1.	Islington, West	121,374
2.	" East	161,254

X—HACKNEY.

1.	Stoke Newington	22,780
2.	Stamford Hill	9,256
3.	West Hackney	37,600
4.	Hackney	76,886
5.	South Hackney	39,878

CENTRAL DISTRICTS.

XI—ST. GILES.

1.	St. George, Bloomsbury	16,662
2.	St. Giles, South	14,862
3.	" North	13,733

XII—STRAND.

1.	St. Martin-in-the-Fields	17,447
2.	St Mary-le-Strand	7,520
3.	St. Clement Danes	8,547

XIII—HOLBORN.

1.	St. George-the-Martyr	18,630
2.	St. Andrew, Eastern	10,706
3.	Saffron Hill	6,514
4.	St. James, Clerkenwell	17,516
5.	Amwell	19,261
6.	Pentonville	14,736
7.	Goswell Street	17,506
8.	Old Street	11,541
9.	City Road	18,626
10.	Whitecross Street	9,217
11.	Finsbury	7,463

XIV—LONDON CITY.

1.	St. Botolph	11,168
2.	Cripplegate	7,185
3.	St. Sepulchre	5,352
4.	St. Bride	8,383
5.	Castle Baynard	9,947
6.	Allhallows, Barking	3,619
7.	Broad Street	5,652

EAST DISTRICTS.

XV—SHOREDITCH.

1.	Holywell	7,370
2.	St. Leonard	14,963
3.	Hoxton New Town	29,921
4.	Hoxton Old Town	28,033
5.	Haggerston	46,278

XVI—BETHNAL GREEN.

1.	Hackney Road	29,766
2.	Green	47,942
3.	Church	29,988
4.	Town	19,310

XVII—WHITECHAPEL.

1.	Spitalfields	22,586
2.	Mile-End New Town	15,474
3.	Whitechapel, North	10,001
4.	" Church	7,489
5.	Goodman's Fields	9,708
6.	Aldgate	6,092

XVIII—ST. GEORGE-IN-THE-EAST.

1.	St. Mary	18,123
2.	St. Paul	20,620
3.	St. John	8,268

XIX—STEPNEY.

1.	Shadwell	10,533
2.	Ratcliffe	15,963
3.	Limehouse	32,004

XX—MILE END OLD TOWN.

1.	Mile-End Old Town, Western	37,946
2.	Mile-End Old Town, Eastern	67,627

XXI—POPLAR.

1.	Bow	37,060
2.	Bromley	64,345
3.	Poplar	55,120

SURREY.

SOUTH DISTRICTS.

XXII—ST. SAVIOUR, SOUTHWARK.

1.	Christchurch, Southwark	13,656
2.	St. Saviour	14,972
3.	Kent Road	21,383
4.	Borough Road	15,951
5.	London Road	21,318
6.	Trinity, Newington	26,647
7.	St. Peter, Walworth	59,562
8.	St. Mary, Newington	21,622

XXIII—ST. OLAVE, SOUTHWARK.

1.	St. Olave, Southwark	3,047
2.	St. John, Horsleydown	8,927
3.	Leather Market	16,271
4.	St. Mary Magdalen	15,669
5.	St. James, Bermondsey	54,662
6.	Rotherhithe	36,010

XXIV—LAMBETH.

1.	Waterloo Road, First	15,171
2.	" " Second	16,346
3.	Lambeth Church, First	19,876
4.	" " Second	39,822
5.	Kennington, First	45,225
6.	" Second	35,295
7.	Brixton	62,817
8.	Norwood	19,017

XXV—WANDSWORTH.

1.	Clapham	36,378
2.	Battersea	107,248
3.	Wandsworth	28,005
4.	Putney	13,221
5.	Streatham	25,545

XXVI—CAMBERWELL.

1.	Dulwich	5,590
2.	Camberwell	59,090
3.	Peckham	71,065
4.	St. George	50,810

KENT.

XXVII—GREENWICH.

1.	St. Paul, Deptford	76,740
2.	St. Nicholas "	7,901
3.	Greenwich, West	22,019
4.	" East	24,604

XXVIII—LEWISHAM.

1.	Eltham	5,827
2.	Lee	21,558
3.	Lewisham	19,859
4.	Sydenham	26,070

XXIX—WOOLWICH.

1.	Charlton	10,930
2.	Woolwich Dockyard	17,650
3.	" Arsenal	18,950
4.	Plumstead, West	14,009
5.	" East	19,243

Total population of Registration London 3,814,571

Total population of Metropolitan London (which includes the Hamlet of Penge in the Registration District [illegible] Registration District of Lewisham) 3,832,441