PROCEEDINGS
OF THE NUTRITION SOCIETY

ONE HUNDRED AND SEVENTH SCIENTIFIC MEETING
THE BARNES HALL, THE ROYAL SOCIETY OF MEDICINE,
1 WIMPOLE STREET, LONDON, W.1

23 MARCH 1957

MAN'S NEED FOR WATER

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The water supplies and water requirements of the modern state

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This is a vast subject and I cannot hope to do more than touch the fringes of it in the short space allotted to me.

Clearly, water is the most important and widely used raw material of all. It is vital in every sense of that word. It is a primary requirement of vegetable life and of animal life (and here I include human life). I need not stress its many domestic uses. Water is essential in providing electrical power in homes and factories, whether that power be generated by means of coal, oil, atoms, or by water itself in hydro-electric installations. It is required in the majority of industrial processes, including the manufacture of foods. It also provides a convenient means for removing the waste products of industry, and does the same for the drainage from our homes and our bodies.

There is another requirement, certainly of the individual, even though it may not be regarded as a requirement of the State. I here refer to the psychological effect of water, by which I mean its effect on the mind and spirit. Most people seem to be greatly attracted to streams and rivers. In the stress of civilization these are places of refuge where peace and quietude can be enjoyed, and the less streams and rivers are spoiled by mankind's activities the more satisfying they are usually found to be. Neither should fish be forgotten, which ought to be able to live there. Too often one hears it said that fish-life is of little or no consequence in comparison with the convenience of industry. Here it is obviously overlooked that where fish cannot survive as a consequence of pollution, the water may be useless for other purposes as well.

Thus, water requirements are many and various, and the harmonizing of these with the availability of water is quite one of the most important of the tasks which confront those who are responsible for directing the affairs of the modern state. This task is by no means a straightforward one, for there are many factors to be taken into account.

It has never been suggested that in Great Britain there is an overall shortage of water. Difficulties result from local shortages in supply, and are mainly due to large seasonal variations in rainfall and to the concentration of population and industry in particular districts. If water could be suitably stored when it is available, and distributed to places where it is most needed, there would be an abundant supply throughout the year. There are examples in this country where certain large cities do, in fact, receive a piped supply from lakes and reservoirs over long distances. Normally, however, the impounding of water necessitates the provision of reservoirs on a large and very expensive scale. This it may be remarked is not always a development that is welcomed by the particular district or section of the community involved. Examples can be cited of intense national feeling being aroused when proposals have been made to transfer water from localities where it is plentiful for use in other regions. There are, thus, parochial as well as economic factors which come into play in attempts to adjust supply to demand.

In some districts it is thought by geologists that it would be practicable to increase considerably the reserves of potable water by replenishing underground supplies, particularly in areas in which over-pumping of ground-water has resulted in a serious fall in water level. It will be appreciated that in areas adjacent to the sea there is a tendency for excessive abstraction to result in saline infiltration. In such conditions artificial replenishment by fresh water is highly desirable if such is possible and economically practicable. The best prospects are probably in districts where the ground is porous from the surface downwards as in the Bunter Sandstone which, when free from impermeable drift, readily absorbs rainfall. There the introduction of extra water from a convenient source presents no great difficulty. Speaking generally, however, the possibilities of this method of storage can be greatly exaggerated. For instance, it is known that some water-bearing underground strata are at present full of water in wet weather, so that full use is already being made of their capacity as reservoirs. Research on recharging is proceeding in various parts of the world, and it may well be that this method may be employed in the future more than it is at present.

The only way in which the quantity of water available to us is appreciably reduced as a result of its being used for domestic purposes or by industry is by evaporation. This occurs, for example, when cooling water is recycled and is passed through cooling towers before being reused. There are also losses which arise from the raising and use of steam—all the water used for this purpose on railways, for instance, is lost to the atmosphere. These losses, however, taken altogether constitute only a small portion of the total volume of water used; the rivers of the country must be discharging into the sea almost as much water as they would if the land were uninhabited. The main effects of civilization are to change not so much the quantity of the water available as its quality. No matter how abundant the quantity made available by the efforts of man, it will be of little consequence unless the quality is safeguarded. It would indeed be a tragic reflection on the modern state if the cry of the Ancient Mariner were to be heard echoing through it—'Water, water everywhere, nor any drop to drink'!

The range of quality of water from which domestic supplies are prepared is in fact quite a wide one. At the one extreme are waters from upland gathering grounds, protected carefully from pollution, which are substantially pure in their natural state and which often receive little treatment (except perhaps some chlorination as a safeguard) before being distributed to the public. At the other extreme are waters from lowland rivers which have already received discharges of sewage effluents, and probably of industrial effluents, but which nevertheless can be converted into a safe public supply, often by storage first in a reservoir and then by thorough treatment at a waterwork. Nevertheless, the extent to which water can be purified economically and safely by these methods is limited, and there are many polluted rivers which are most unlikely to be acceptable as possible sources of raw water for domestic use.

A public supply must, of course, be safe from a bacteriological point of view. Modern methods of disinfection—and particularly chlorination in its various forms—are a very powerful weapon in making bacteriologically doubtful waters safe. Often the objection to a polluted water is not so much that it contains bacteria as that it contains chemical substances. The presence of very small quantities of certain types of organic matter or other chemical substances may impart a very unpleasant taste to water. Although it may be possible to eliminate it, perhaps by absorption on activated carbon, the process is costly and there is always the chance that if the concentration of the material suddenly increases, or the treatment plant is inefficiently operated, the water will acquire an objectionable taste, and the water authority will be inundated with complaints from consumers.

One way in which doubtful waters can be purified is by passing through porous soil, and it may be that in some parts of the country river water at present unsuitable for domestic supply could be used for recharging underground reservoirs if purified in this way. Nevertheless, many places in this country are dependent on shallow wells and these may be contaminated by leakage from dumps of chemicals stored in the open, such as drums of trichloroethylene or from abandoned storage tanks that have contained leaded petrol.

Although, as I have previously remarked, the volume of water available is not greatly reduced by being used for domestic and industrial purposes, there is one industry which is capable of consuming very large quantities of water, namely agriculture. The greater part of the water used for artificial irrigation of crops is lost to the air either by evaporation or by transpiration by plants. At present, of the total volume of water used in America, I believe that something like one-half is distributed for irrigation. In Great Britain irrigation has not hitherto been an important factor, but it has been stated that agriculture in the south-eastern part of the country would benefit if it were adopted. If this were done on a large scale there would almost certainly be a considerable water shortage in the dry part of the country, and presumably water would have to be brought in long distances by pipe or canal. The Ministry of Agriculture and Fisheries published an interesting Technical Bulletin on the subject some 3 years ago, entitled *The Calculation of Irrigation Need* (Ministry of Agriculture and Fisheries, 1954).

In Great Britain, unlike some other countries, natural waters unpolluted by the action of man, do not as a rule contain substances having harmful effects when drunk by man. In saying this, I am excluding pollution by animals, especially rats, with its familiar unpleasant consequences, and waters containing carriers of parasitic infections. There are waters that have to be used in which the content of salts is high; some mine waters are of this type, and so are some from wells near the sea and in certain inland localities. In restricted areas the water may contain abnormally high concentrations of fluorides; where these waters have been used for domestic supplies they have at times given rise to mottling of teeth. Generally, the argument is really whether fluoride should or should not be added to water to prevent dental decay. In some areas the domestic supply contains less than the concentration (about 1 p.p.m.) that has been extensively recommended for reducing the incidence of dental decay. Fluoride is, in fact, added to drinking water supplies in parts of America, and has been advocated in this country.

Analagous, and even more important, is the content of iodine because of its influence on the thyroid, an insufficiency producing such well-known effects as 'Derbyshire neck'. This is also met with in certain Alpine districts.

Poisonous metals do not usually occur in dangerously high concentrations in British natural waters. Where they have occurred in concentrations sufficiently high to kill fish in a river, and consequently have been investigated in some detail, they have been found to be due to the leaching of spoil heaps from mines, long since abandoned. Lead, for example, has at times been present in some of the Welsh rivers in concentrations high enough to kill all the fish and many of the invertebrate animals over long distances. Some metals are known to have come from abandoned mines in the gathering grounds.

It does not follow, however, that because a natural water does not contain poisonous metals a piped supply prepared from it will not do so. Indeed, in considering the possible presence of dangerous metals in potable water, what is usually of the greater importance is not the concentration of metal originally present so much as the capacity of the water to dissolve the metals of which the plumbing system is made. There have, of course, been instances where dangerously high concentrations of lead have been dissolved from pipes. The risk is now very well known and, in assessing the suitability of a water, tests for plumbosolvency would usually be made as a matter of course.

The lower reaches of rivers from which many water supplies are taken, are very liable to contain industrial effluents as well as sewage effluents, and it is therefore extremely important to control the composition of such discharges. The standard of quality required in an industrial effluent discharged to such a river will usually be very high; this is so, for example, in the basin of the Thames. Here, because the water is taken as part of the supply for London, many industries producing effluents which are particularly difficult or costly to treat would be most unlikely to settle. The standard of effluents from those industries which do discharge direct is monitored rigidly.

The position regarding sewage effluents is rather more complex. If the sewage

https://doi.org/10.1079/PNS19570026 Published online by Cambridge University Press

is from a purely residential district it can be treated by known means, and the effluent will be such that, provided there is reasonable dilution in the river and that the works are large enough and properly operated, it will undergo self-purification to such an extent as not to interfere badly with the treatment of the raw water at a waterwork and with the potability of the finished product.

When certain types of industrial effluent are discharged to the domestic sewers, however, difficulties may arise either because the process of treatment of the sewage is interfered with, or because obnoxious constituents of the industrial effluent may pass through the sewage works and be discharged with the effluent. This situation would be dealt with under the Public Health (Drainage of Trade Premises) Act, 1937, and the remedy adopted would often be for the manufacturer to pretreat the effluent before it reached the sewers. For instance, there are many plants in which electroplating wastes are treated in this way. The legal remedy, however, does not apply if substances which cause difficulty are discharged from houses, except as a common-law nuisance.

A difficulty of this sort has arisen from the use of synthetic detergents instead of soap by the housewife, who tends to be extravagant in their use, as does her husband, for that matter. Soap does not seem to have caused any particular difficulty in the treatment of sewage, being no doubt largely precipitated by the hardness of the water and so removed from the sewage sludge, and being also easy to destroy by the biological processes by which sewage is purified. The alkyl aryl sulphonates used as surface-active materials in synthetic detergents, however, are not completely removed by sewage treatment; as much as half the amount initially present may be discharged with a sewage effluent. These materials have begun to appear in water taken from polluted rivers as the raw material of domestic supplies. The concentrations in this country have not been very high—usually not more than 0·4 or 0·5 p.p.m., but occasionally figures of 1 p.p.m. have been recorded. In some parts of America, a concentration as high as 12 p.p.m. in a raw water has been reported.

The situation in Great Britain was examined by a Government Committee under the chairmanship of Sir Harry Jephcott. This Committee took medical advice and although it considered that there was at present no reason for disquiet, it recommended that water authorities should make regular analyses of surface-active materials in their supplies if drawn from polluted rivers, and should furnish the information regularly to the Health Departments (Ministry of Housing and Local Government, 1956). It is obvious that, if for any reason the concentrations increased very much, the whole question of the safety of some of these sources would have to be considered. The Minister for Housing and Local Government has recently appointed a Standing Technical Committee on Synthetic Detergents, the purpose of which is to keep this matter under review.

The impact of radioactivity on public-health services is obviously of immense significance nowadays. It is a subject to which very thorough attention has been given in this country, as elsewhere (Kenny, 1956). Our own activities in this field are being monitored continuously and intensively. The steps which are being taken to safeguard our potable water supplies are in a highly advanced stage, and there is no occasion for apprehension. We are not the sole occupiers of the world, however, and I am informed that every time an atom bomb or hydrogen bomb is exploded the radioactivity of natural waters is raised inevitably throughout the world—the effect is by no means a localized one. The consequences remain to be seen, and I hazard no guess as to what they are likely to be.

Superficial though my remarks have been, I hope I may have succeeded in conveying the impression that, in the modern state, the problem of water supply is a general one. Man's personal need cannot be disassociated from the need of industry and these have to be made compatible. Conditions are such that water must be re-used, often many times, if it is to be available in sufficient quantity. The avoidance of unnecessary pollution from both domestic and industrial sources should be the aim of every one of us in helping those whose business it is to ensure that the quality is of the required standard.

REFERENCES

Kenny, A. W. (1956). *Bull. World Hlth Org.* **14**, 1007.
Ministry of Agriculture and Fisheries (1954). *Tech. Bull. Minist. Agric., Lond.*, no. 4.
Ministry of Housing and Local Government (1956). *Report of the Committee on Synthetic Detergents.* London: H.M. Stationery Office.

Functions of water in the body

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Water, as Henderson (1913) pointed out, was uniquely suited to become the inorganic basis of living matter. Its unusually high dielectric constant helps to bring ions into solution in the lower part of the range of temperatures in which it is liquid, and dissolved ions play a large part in maintaining essential properties of cell membranes and the activity of enzymes. Ions in solution are, moreover, surrounded by mantles of electrostatically bound water molecules which modify their properties in biologically important ways. The great solvent power of water has leached from primeval rocks the elements we now find accumulated in living organisms; and life, as we know it, is only possible between the temperatures at which proteins are denatured and dilute solutions freeze.

Hydrolysing enzymes which catalyse reactions into which water enters as a reactant are mostly found outside cells, reducing foodstuffs to a suitable molecular size for absorption. Within cells, water appears rather as a physical substratum than as a chemical participant in the essential reactions which maintain life. Its other great function in the body is to provide a vehicle for the transport of raw materials, waste products, and the heat liberated by chemical action.

When we say that water makes up two-thirds of our bodies, we do not mean that the body is simply an odd-shaped bag two-thirds full of water. If this were so, the