The importance of hygienic practices during the collection and bottling of mineral waters

E. WINDLE-TAYLOR

C.B.E., M.A., M.D., D.P.H., M.R.C.S., L.R.C.P., F.R.C.Path. Barrister-at Law, England

Introductory remarks

Let me say at the outset that I have had no actual experience of dealing with bottled natural mineral waters, but have considerable experience of dealing with ground water of the highest quality to supply one-sixth of the population of London, that is, a million persons.

In May 1974 I was a member of a group of experts convened by the Commission of the European Communities that met in Brussels concerning the bacteriology of natural mineral waters. So far as I am aware, the results of our deliberations have not yet been made public. You will therefore appreciate that I cannot speak about the conclusions.

In what I have to say, I am assuming that no treatment is applied to the water after collection, but that it is immediately delivered into bottles.

Characteristics of a natural water ideally suited for direct bottling

The water must be clear, colourless and free from objectionable taste and odour. No deposit such as from iron or manganese compounds must appear on standing. The water must be free from dissolved gases except air and carbon dioxide. The pH must be such that the water is not corrosive to metals.

The mineral content of inorganic salts can be variable, but individual salts such as sulphates, chlorides, nitrates, etc. should be within the guidlines set out in the World Health Organization Standards for Drinking Water [1]; if outside these limits, the water should be characterized as a medicinal water, for example, where there is excess of sulphates of sodium and/or magnesium.

There must be no detectable organic matter present. The water must be of the highest bacteriological quality; it goes without saying that pathogenic bacteria, viruses, parasitic ova and cysts must be absent, also bacterial indicators of intestinal pollution such as the coliform group, *Escherichia coli*, faecal streptococci, *Clostridium perfringens*, *Pseudomonas aeruginosa*, etc. The total plate count in freshly bottled waters developing at 37 °C should be of a low order, not more than 1 or 2 per ml, and the natural water bacteria developing at the lower temperature of 20–22 °C should also to be low, not more than 10–20 per ml. Often the natural water bacteria, which are autotrophic, are present in pure culture being of the types *Flavobacterium*, *Achromobacter*, *Alkaligenes*, etc. In fact, the type species of *Flavobacterium*, namely *Flavobacterium aquatile*, was isolated from a well in London, known as the Deptford well, and described in Bergey's Manual of Determinative Bacteriology.

The natural water bacteria may multiply in certain circumstances such as, during storage, raised temperatures or in the presence of any substance that can act as a nutrient for their development. Thus, an increase in the low-temperature or « cool » count may be the earliest evidence of contamination – a very sensitive test indeed.

Some time ago I investigated the bacteriological quality of a number of wells used by the Metropolitan Water Board for water supply. Some 34 wells were consistently free from coliform organisms and other indicators of fecal pollution. Daily colony counts were carried out on these sources for a period of a year at 37 °C and 22 °C using 10 ml volumes in order to reduce the statistical error of sampling and analysis. It was found that the colony count at 37 °C was usually less than 0.5 per ml and in very few cases exceeded 1.0 per ml. The counts at 22 °C showed some variation as might be expected, but a « normal working range » was derived in which more than 70 per cent of the observations fell. This range was found to be comparatively narrow and the upper limit was generally less than 10 per ml.

Geology of the gathering ground or catchment area

Water-bearing formations are usually the chalk, limestone and sandstone strata. For good quality water, the rock must be compact and free from cracks and fissures that would allow water to pass quickly over long distances, and possibly from polluted sources. An essential process in the self-purification of water in the ground is the disappearance of bacteria which usually involves a period of 50 days.

Protection of gathering grounds

The general underground flow of water should be away from the well, and the protected area must include the whole intake area and the catchment abstraction point. The determination of the former has to be made on the basis of maximum abstraction at times of lowest groundwater table. Studies by specialist geologists are necessary to determine this as it will naturally vary from site to site. Professor Nöring of West Germany [2] divides the area into three or four zones, from an outside zone of 2 km to an inner zone of 10 m; his detailed paper is worthy of close examination. Suffice it to say that the area should be frequently and regularly inspected for any evidence of pollution from cess-pools, stables, silos, camping areas, burial grounds, excavations for gravel, etc., intensive farming, surface water soakaways or swallow holes, and from any other sources of possible pollution that may be particular to the area in question; all these should be prohibited in an area within a boundary line from which the groundwater needs 50 days to travel to the abstraction point. Professor Nöring, however, observes that this does not appear to be necessary if the exploited aquifer from the 50-day line to the abstraction point is covered by an impermeable stratum e.g. clays of sufficient thickness. It is clear that to be explicit about protection is difficult and confusing, but the essentials are constant vigilance, surveillance, and close touch with planning authorities and other official bodies in the district. The ownership of the gathering ground is of the greatest importance and value so that intense control can be applied.

Hygienic considerations in the construction of the well

The well or borehole should extend through at least one impermeable stratum to below the lowest water level. It should be lined in stainless steel or cast iron, and this lining should be carried up as a coping for 1 metre above ground level and sloped away from the top. The well-head should be situated within a building, and the well must be covered, the surround sloping away and drained to avoid flooding into the well or boreholes. Watertight flooring within the building is essential and this must be maintained free from cracks, etc. Drainage in the building and curtilage should be in cast iron, with watertight inspection covers, and both surface water and soil drainage must be subjected to regular inspections and pressure tests.

In a modern installation with a 25 to 50 cm borehole, the pumping arrangement will be a submersible pump with a rising main, preferably in stainless steel, passing through the side or top of the shaft by means of a watertight seal. There should be special provision for overflow or pumping to waste through a purpose-built main delivering the water at a safe distance from the well; this is especially necessary for cleaning out and disinfecting operations.

With regard to the pump itself, oil from the moving parts must not contaminate the water and there should be no materials incorporated in the construction of the pump of such a nature as to encourage the growth of bacteria (this precaution will be mentioned several times again and will be the subject of a special paragraph at the end of this paper).

Collecting tank

If the source is a spring or if the well is artesian, the water should flow into the factory straight into a glass–lined or stainless steel tank that has arrangements for dealing with overflow; for example, it could discharge into the well waste–water system, but not, under any circumstances back into the well or locally where any contamination could be conveyed into the ground–water.

A similar tank will be required for pumped water. The tank should be completely covered and protected, but not to the extent of being airtight. Any ventilators should be fitted with fine screens and air–filters, renewable from time to time as necessary.

Bottling room

Machinery should be of stainless steel, mild steel, or other inert material wherever possible.

Bottles receiving the water must be of clear glass, chemically clean, finally washed with distilled water, then autoclaved. Sealing must be at the time of filling, within the same machine process and with caps of metal or other material not susceptible to bacterial growth.

Filling should take place under hoods in a room air–conditioned with incoming air passing through bacterial filters, similar to those used in a water–treatment plant in Denmark to free air from bacteria for the aeration of high–quality groundwater polluted only by methane and hydrogen sulphide gases. A further refinement would be the installation of ultra–violet lamp units close to the nozzles delivering the water into the bottles.

Floors in the bottling rooms should be covered with a continuous material in ceramic or plastic that could withstand daily cleansing — by means of steam or an odourless detergent followed by a disinfectant such as 1 % sodium hypochlorite.

Personnel

All working–operatives engaged on tasks within the bottling room should be clad in overalls, footwear, gloves, headgear and masks, preferably sterile and renewed at least every day.

There should be medical examination of employees working in such places where a risk to the purity of the mineral water is likely to arise. The clinical history of each person, particularly with reference to any infection capable of being water-borne, must be thoroughly investigated and bacteriological examination of faeces and urine carried out on at least three occasions at weekly intervals in all cases. This procedure is essential to exclude, as far as possible, any chronic carriers of waterborne disease. Furthermore, if any employee is certified as having any disease that might be waterborne, or is suffering from an illness associated with looseness of the bowels, or any illness necessitating absence from work for more than five days, there should be standing arrangements to ensure that he or she is not employed on work likely to risk the quality of the mineral water until seen by the Company's medical officer who will decide whether bacteriological examination on the lines indicated above is necessary to demonstrate that it is safe for him or her to be employed. Ideally, each member of the staff involved in the collection and bottling of mineral water should be examined by the Company's medical officer at intervals of not more than three years [3].

Storage of bottled waters

Refrigerated storage will minimize bacterial multiplication in bottled waters, and the consumer should be advised to keep it under cold conditions until used [4].

Sampling procedures

Water. — Frequent bacteriological examination of sample bottles of mineral water should be made as it comes from the filling-line, and distribution of these batches should not be made until satisfactory results are shown. This is the only way to ensure that the finished product can be used without risk to the public health, but of course, all along the line to the consumer, the utmost care must be taken to avoid contamination.

In addition, at least daily sampling and bacteriological examination of water direct from the well or borehole should be carried out. For this, a special tap should be fitted on the rising main. On each occasion of sampling, the tap must be cleaned and then flamed to sterilize it; the water must then be allowed to run to waste from the tap for at least two minutes before the sample is collected with aseptic precautions into a sterile glass bottle and then sealed with a ground glass stopper which is then protected from contamination by a suitable cover of paper or thin aluminium foil [5].

Finally, sampling and testing of the well water itself, from source and at various points in the plant (collecting tank, bottling apparatus, etc.) should be carried out during and after shut-down periods.

Air. — Total bacterial counts on air samples taken at various points in the factory are valuable, and a norm will be obtained for each point; any increase may well indicate contamination or failure of air-conditioning, air-filtration, air-sterilization processes, etc.

To end this lecture I will mention a relatively new source of water contamination, mostly bacteriological in character. There are an increasing number of manufactured materials which, when placed in contact with water, will provide sufficient nutriment to encourage multiplication of bacteria, in particular the natural water organisms.

For a number of years certain materials such as leather tap washers, jute and hemp packings in pumps and water mains, have been known to encourage bacterial growth in water, including coliforms and, experimentally, pathogenic organisms. But in recent years there has been a great increase in the number of non-metallic materials produced that, when in contact with water may cause a deterioration in its quality, resulting, for example, in taste and odour, discolouration, turbidity and evidence of microbiological growth, in the form of bacteria, actinomycetes and microfungi. Examples are various plastic materials, rubber products, anti-corrosive paints, jointing compounds and lubricants. These materials should be used with caution and two courses of action should be borne in mind:

1) Any such materials for use as fittings or part-fittings in a natural mineral water plant should first be tested as to their potentiality to promote bacterial growth in water, or to cause other forms of deterioration in quality, such as taste and odour.

2) If there is a deterioration in the physical, chemical or microbiological quality of the water in or from a natural mineral water plant, then part of the effort of investigation must be into any materials in contact with the water during its passage from source to sealed bottle.

It is emphasized that the extent of this problem is not yet delineated and laboratory tests are still evolving. The latest work and methods in use are given in the last report of the author of this lecture as Director of Water Examination, Metropolitan Water Board, London [6].

Finally the whole process of preparing natural water for human consumption must be carried out under strict standardized aseptic conditions. The code of practice to be laid down that will achieve this end for each plant may sound somewhat ideological, nevertheless it must be maintained by constant surveillance and vigilance by those in charge.

Summary. — Natural water suitable for direct bottling must be clear, colourless, and free from objectionable taste and odour. The mineral content must be limited in amount, otherwise the water would come within the medicinal water category. There should be no detectable organic matter

present and the water must be of the highest bacteriological quality — virtually sterile — and should remain in this condition during the collection and bottling processes.

In order to achieve and maintain this high quality, the gathering grounds of the source must be protected from pollution; the construction of the well or spring must be such as to prevent external contamination, as also should be the collecting and bottling apparatus.

Personnel employed in the factory should wear protective clothing and be regularly checked as to their freedom from waterborne infectious diseases. Control of the water as to its hygienic quality should be by regular and frequent analysis of samples of the water and the air at various points in the process and in the factory. A new problem that has arisen and has to be faced in this situation is the risk of contamination by certain materials in contact with the water that may contain substances that encourage the growth of saprophytic bacteria which would contaminate by the production of taste, odour, discolouration, cloudiness and definite evidence of microbial growth. It is emphasized that the extent of this new problem is not yet delineated and that methods of laboratory control and safeguards against such happenings are still evolving.

Résumé (*L'importance des pratiques hygiéniques pendant le prélèvement et l'embouteillement des eaux minérales*). — Pour être mise directement en bouteille, l'eau minérale doit être claire, n'avoir aucune couleur, ni goût, ni odeur qui ne soit pas désirable. Le contenu minéral doit avoir un dosage limité, autrement l'eau tomberait dans la catégorie des eaux médicinales. L'eau ne doit pas contenir aucune matière organique discernible; elle doit être pure du point de vue bactériologique — c'est-à-dire pratiquement stérile — et devrait rester dans cette condition pendant toutes les phases du procès d'embouteillement.

Au but d'arriver et de maintenir cette haute qualité, les lieux d'origine de la source doivent être dépourvus de toute contamination: pas seulement les puits et les sources, mais aussi toutes les installations du tirage de l'eau et de l'embouteillement doivent être capables de prévenir toute contamination extérieure.

Le personnel employé dans l'usine devra être habillé avec des vêtements protectifs et sera périodiquement contrôlé pour les maladies infectieuses qui pourraient être transmises à travers l'eau. Le contrôle de l'eau en ce qui concerne sa qualité hygiénique devrait être accompli par des analyses regulières et fréquentes d'échantillons de l'eau et de l'air à des différents points du procès et aussi dans l'usine même.

Un nouveau problème qui se presente et qu'on doit resoudre dans cette situation est le risque de contamination par certaines matières en contact

avec l'eau qui pourraient contenir des substances capables da favoriser le développement de bactères saprophytes. Ces bactères contamineraient l'eau en produisant un goût, une odeur, une décoloration particulières et en rendant l'eau trouble, preuves evidentes de la présence de bactères. L'on souligne que la magnitude de ce nouveau problème n'a pas été encore éclairci et que les méthodes de contrôle de laboratoire et les sauvegardes pour empêcher ou prévenir ce danger sont encore à l'étude.

REFERENCES

1. World Health Organization. 1970. *European Standards for Drinking Water*. 2nd. ed. Geneva. WHO.

2. Nöring, F. 1974. Protection Zones for Groundwater Catchments. *Proc. 10th. Int. Water Supply Ass. Cong.* pp. 49-52.

3. Ministry of Housing and Local Govt. Welsh Office. 1967. *Safeguards to be adopted in the Operation and Nanagement of Waterworks*. London. HMSO.

4. Geldreich, E. E., H. D. Nash, D. J. Reasoner & R. H. Taylor. 1975. *J. Amer. Water Works Ass.* **67**: 117-124.

5. Dept. Health & Social Security. Welsh Office and Min. Housing & Local Govt. 1969. *The Bacteriological Examination of Water Supplies*. 4th. ed., Report 71. London. HMSO.

6. Windle-Taylor, E. 1974. *45th. Report Director of Water Examination, Metropolitan Water Board*. London. pp. 132-142.