The usefulness of water quality standards*

Synopsis

Water distributed through a communal pipe system and used for human consumption should be of good and safe quality. The desired quality is often expressed in standards. The oldest standards bear on the microbiological quality.
As chemical substances increasingly occur in the environment, standards for these substances are being laid down. In most cases the intake of certain chemical substances through drinking water is part of man's total consumption pattern. It is not easy to derive drinking water standards from standards for the total daily intake through food, water and air. As the quantity of water that people drink depends on climate and drinking habits, drinking water standards should necessarily have a regional character.
It makes no sense to try and establish a standard for every possible chemical substance. A few essential standards should be sufficient for an effective control of the water quality.
The safety of drinking water is not necessarily increased by establishing more standards and performing more control tests. Although this may be useful under certain conditions, it remains an indirect control of the performance of the water supplier.
It is essential for a good water quality that the technical procedures to process drinking water are effective and include up-to-date equipment, efficient management, good working conditions, adequate safety measures and possibilities to attract personnel of the required level.
It is equally important that the best quality ground or surface water is available as a source for producing drinking water. Therefore, abatement of pollution is necessary before wastewater is discharged into river or lake. Standards for the quality of surface water should be consistent with drinking water standards.

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Introduction

The question of establishing water quality standards is a regular topic nowadays. This holds for drinking water standards as well as for standards for surface water. What is the value of such standards?
The aim of this paper is to investigate that question. First some general remarks.
When speaking of water, one has to bear in mind the different situations that exist in various countries and regions in the world.
In some areas water is plentiful and therefore not a limiting factor in development. As there are no serious problems to overcome, water supply is taken for granted.
In other areas water is so scarce that it is valued above all other things, which sometimes is reflected in religion.
Water, in large or small quantities, may be available as ground water or surface water and be of good quality, or polluted to a poor quality. In some highly industrialized countries water may be plentiful but at the same time heavily polluted. A quantity problem does not present itself in such a case, but there is a quality problem.
In agricultural regions water may be scarce and of good quality; then a reverse situation presents itself.
Problems of water management and water supply and their solution depend so much on local situations and conditions that it is hardly possible to discuss them in a general way. I will try to differentiate wherever possible, although some generalization is unavoidable.

Standards

Why are standards necessary in water management? Why are standards necessary anyhow? What are standards?
Since we are concerned with water, I will try to answer these questions in relation to it.
Water is essential for the life of plants and animals, man being no exception.
He needs his daily quantity to keep him alive. Water replenishes the human cells and is necessary for a number of essential functions in the human body. It acts as a cleansing fluid, draining the human body of useless or harmful substances.
In natural conditions, that is before man polluted water to any significant extent, water in nature had the function of providing drinking water. As a rule it had the quality that is necessary to fulfil this purpose.
Exceptionally surface water was or is undrinkable e.g. because of a high content of inorganic matter. Nature provided man with a sense of taste to help him avoid naturally unsafe water.
Problems, however, arise when large concentrations of people discharge their natural waste in surface water or, by dumping it through the overlying soil layers, into a deeper aquifer. The situation deteriorates when, due to industrialization, the quantity of waste material increases sharply and hitherto unknown chemical substances are added to it. Natural water is no longer 'as God made it'; it is polluted. The question is: is it still drinkable? When does it start to be harmful or even dangerous?
In the past natural water was polluted in many cases to such an extent, that it could not be safely used without purifying it.
Since then we distinguish 'surface water' and 'drinking water'. Ground water generally is still of natural quality. What should be the quality of both drinking and surface water?
It is at that moment that man starts to set standards. A standard for water quality means *in this respect* an accepted level of polluting substances which below this standard are believed to be harmless.
Thus the quality standard is licencing a certain degree of pollution rather than really promoting quality.
By establishing standards and denoting them by exact figures the degree of acceptable pollution is fixed.
When the actual pollution has gone too far, standards of water quality turn out to be beneficial.
There is a tendency to shift the standard to values where the highest possible pollution is accepted.
Why, one might ask, are we so lenient to pollution in our present society? Maybe it is because we replaced moral concepts by materialistic ones. In terms of money pollution is highly attractive economically, because one gets rid of a lot of dirt easily and without great cost. But in that case we accept that there are no moral barriers against such action. Only if his health is at stake man is prepared to take action.
It is possible to set *real* quality standards for drinking water. They should indicate what composition would be the optimum for human health [1].
This is not an easy matter. We simply do not know what the ideal composition of drinking water should be.
Many medical men for instance consider a fluorine content of 1 mg/l the optimum for human health. If we accept this as a standard it would mean that when the natural fluorine content is lower, fluorine should be added until the specified water quality standard is obtained. When the natural fluorine content is too high, then it should be reduced to 1 mg/l. Similar quality standards may be set for other substances (see fig. 1).
The difficulties in determining an optimum quality standard for drinking water are many.

* On June the 4th, 1975 the author read a paper on water standards at the Regional Conference on Water Supply and Pollution Control in Swaziland, Africa. The following article is an extended and revised edition of that paper.

First of all the optimum daily total intake per (kg) person should be known. This in itself is extremely difficult, since it is not accepted practice to do tests on man. This means that a difference of opinion may easily arise, as is shown in the case of fluorine. Also, each person will react individually, so that the optimum will not be a finite number but a certain range that has to be interpreted.
Secondly, this permissible intake should be divided over the different components such as food, air and water through which such intake comes to man. This varies per region, however, depending on e.g. climate and eating habits. This is a crucial aspect. What counts is the (daily) intake of a certain substance through food, water and air. Therefore standards should apply to this intake, e.g. the daily intake in mg. Consequently figure nr. 1 should be replaced by graph nr. 2.
For a number of substances the optimum intake should be zero (fig. nr. 3).
I assume for the sake of simplicity that we know what is health and that man wants to live in optimum health conditions. Standards for drinking water should be derived from the intake standards. As the quantity of water that people take in depends on the climate and on their drinking habits, drinking water standards necessarily should be set regionally. International drinking water standards are only realistic if they allow for regional interpretation. It is questionable if Europe can be treated as one region, if we take into account the different eating and drinking habits in that area *).

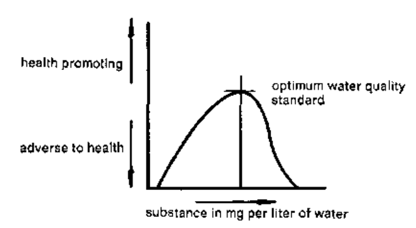

Fig. 1.

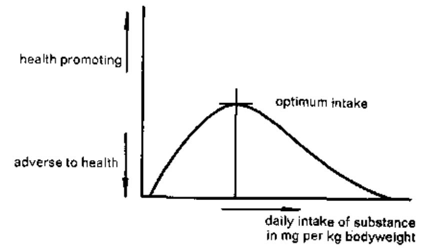

Fig. 2.

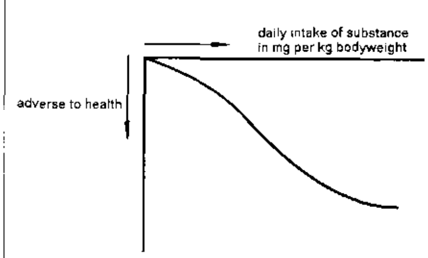

Fig. 3.

Table 1 (2) gives some information about the drinking habits among Europeans.
The estimated mean direct use of tap water varies between 70 - 420 l/cap/year, with Italy at the top of the list.
Considerable quantities of drinking water are used for making coffee and tea.
Table 2 (2) presents the result of an orientating test on the changes in trace element concentrations which occur when making coffee and tea.
The described procedure, difficult as it is in itself, is only possible for a limited number of substances. To do this for all the chemical compounds that exist as waste material penetrating food, air and water, thousands of standards would be required. To do this and to extend and revise the list of standards yearly as new chemical processes are being introduced and new research material becomes available, would be impossible.

The conclusion must be that it is only possible to work with drinking water standards if they are looked upon as auxiliary tools with limited meaning. Moreover, they should be confined to a limited number in order to be measured and controlled effectively.
It would be wrong to think that standards are an aim in themselves. They should be used as an instrument to realize one's objectives. Essential is the effectiveness of the technical operations applied to purify water and to produce drinking water.
I would now like to deal with some more detailed aspects of quality standards for drinking water and for surface water.

Drinking water

Water, distributed through a communal pipe system and used for human consumption should be of good and safe quality. This is the direct responsibility of the water supply company that produces and distributes the water.
Originally, the main task of the water supplier was to transport potable or very

* The WHO report on European Standards for drinking water wisely states: the proposals set out are intended for guidance only; they are recommendations and in no sense mandatory.

TABLE 1 - *Difference in water consumption in the European Community.*

	Water intake routes (Quantities in liter/capita/year)						
	Coffee	Tea	Beer	Milk	Wines	Soft drinks	Mineral waters
Belgium	165	10	126	78	14	55	31
Denmark	300	20*	100	112	7	44	0,5*
France	127	67	40	71	124	19	50
Germany, Fed. Rep.	137	16	140	77	18	53	13
Irish Rep.	50*	400	48	213	2	20	0,5*
Italy	85	5	12	67	113	23	20
Luxembourg	165	10	125	78	41	50	29
Netherlands	250	250	60	107	6	55	0,5
United Kingdom	50	410	74	140	2	22	0,5
Average in E.C.	110	125	65	90	65	29	21

* estimate

TABLE 2.

Type of Water	Average trace element concentrations (microgram/liter)							
	As	Cd	Cr	Cu	Mn	Ni	Pb	Zn
The Hague tap water	2	0,3	< 1	46	< 10	2,5	< 2	20
Water after coffee extraction *	2	0,6	< 1	56	100	7,5	8	150
Water after tea extraction **	4	0,3	< 1	100	1000	12,5	4	10
Number of experiments	1	3	1	3	2	1	3	1

* 50 grams coffee/liter
** 5 gram tea/liter

nearly potable water from regions where it is abundant to places of scarcity. Especially in the last century piped supply to densely populated, mostly highly industrialized areas became more and more necessary. It was not only because the growing demand could not be satisfied locally due to lack of sufficient water, but also because the available water became too polluted to drink owing to the increased discharge of waste into the local water resources.

An example is the city of Amsterdam. Originally, water for all purposes could be taken from the canals in the city along which the houses were built. When the canal water became too polluted to be safe, drinking water was partly collected from the rain-water falling on the roofs of houses and churches and taken from some fresh water lakes in the neighbourhood and brought to the city by boats. In 1853 the first pipeline was laid to a sand dune area near the sea and abundant in good quality ground water.

A similar situation, apart from the technical details, developed sooner or later in many other regions.

The steeply increasing pollution of surface waters has forced the water supplier to constantly intensify the water treatment processes. Initially, it was sufficient to kill the pathogenic bacteria or other biologically harmful organisms by adding chlorine to the water or by using slow sand filtration. Nowadays, more and varied treatment process steps are necessary to cope with present-day conditions. The heavily polluted water of the river Rhine in Western Europe may serve as an example. In some places the raw river water is treated in 7 or 8 different treatment processes before it is considered to be drinking water.

There is a curious interdependence between the advancement of water treatment processes applied by the drinking water suppliers and the pollution of available water resources. Although the results obtained in purifying water are impressive, this development has, on the other hand, given a free hand to pollution of surface water. This is a highly undesirable situation. created by the authorities who allowed pollution instead of punishing the polluters. The water supplier moreover finds himself now in the precarious position that he has to determine to what extent he has to remove substances that are now added by waste to the raw water. The situation that drinking water was available as water in nature ceases to exist. The question as to what the quality of drinking water should be now has to be answered. The answer is, as we said before, expressed in standards.

The oldest standards are those on microbiological quality. All pathogenic bacteria and viruses are harmful or dangerous to man. There should be no such bacteria and viruses at all in drinking water. If they are, water might be the carrier of disease. In practice a certain statistical allowance is made, based on microbiological experience over a large number of years. It has been difficult to devise quick and safe tests to control whether water satisfies the microbiological standards. This is all the more striking as brilliant work has been performed by microbiologists in developing research methods and tests.

To produce drinking water that, first of all, is microbiologically safe, effective treatment methods are necessary. Therefore, the primary means to obtain such water is to make sure that such treatment processes are applied and are fully and continuously effective. This requires not only the right choice of process and equipment but also an adequate operation. Good working conditions, trained labour, clear instructions and adequate pay are perhaps as important as anything else. To ensure this is the duty and privilege of the management in charge of water supply. A high professional and moral standard *of the people involved* is one of the best guarantees for a safe water supply.

This, of course, is equally true if chemical impurities threaten to deteriorate the drinking water quality. The field here is much wider. There are a number of chemical substances (organic and inorganic) which, above a certain extremely low level, endanger public health. They include heavy metals such as mercury and lead, basic substances like organic chlorine compounds and organic chlorine pesticides, cholinesterase inhibitors and other compounds. The occurrence of these substances should be avoided or strictly limited; their presence should be as close as possible to the zero level.

Standards for drinking water for this first group of substances should be based on promoting human health or at least eliminate any danger to it. Such standards might be bacteriological standards (including viruses), toxic standards (such as lead, cadmium, mercury, hydrocarbon etc.) and standards for other substances affecting health on a short- of long-term basis (such as cancerigenous substances).

A second group of standards might be called organoleptic and esthetic. These are standards of taste, odour, colour, temperature, turbidity, oil etc. Copper, which may cause a green discoloration in bathtubs and washbasins below the tap, might be included in this class of standards, too.

To make water a good product, these standards are of primary importance.

A third group of standards might be called technical standards. They should ensure a quality of water that does not cause technical difficulties e.g. in the distribution system. As examples I mention aggressiveness, pH, hardness, chloride, manganese, iron, ammonia etc.

Various international organizations and countries have established standards, (or are in the process of doing so) that can be classified in the three categories I mentioned. Some of them (WHO, AWWA) are well-known [3].

It is not in the scope of my paper to discuss these standards themselves.

I would like to stress once more that they are not an aim in itself.

As I said earlier in this paper the list of standards should be restricted to the most essential ones. Besides there are two other, at least equally important, aspects.

Firstly, full attention should be given to the choice and effectiveness in the widest sense of the production and distribution methods of public water supply, technically, socially, administratively and legally. The water supply industry in any country or region, in any circumstance, should be a stable, well-run, well-equipped and well-financed organization, held in high esteem by its customers and manned by responsible and trained women and men. In other words the *standard of performance* should be high.

Secondly, the water resources from which drinking water is supplied should be as unpolluted as possible. In the case of ground water this is often so, but not always. Highly industrialized countries are suffering increasingly from ground water pollution. It is even much more difficult to prevent open surface water from being polluted.

In the next paragraph I shall set out in detail why surface water should not be polluted.

Surface water

The increase in population and consumption of water per capita forces us to turn more and more to surface water as a water resource for piped water supply. Increasing population and industrialization also cause increasing pollution of fresh water rivers and lakes. The water supplier is faced with the dilemma of high standards for drinking water and low standards for surface water quality [4]. There is some belief that present-day technique can bridge that gap, no matter how wide this gap may be, and that drinking water may be produced directly from sewage water. I do not share the opinion that it is wise to do so, unless we have no other choice.

The following is a quotation from a report by H. A. Hartung, [5], representative of the AWWA to the EPA Drinking Water Standards Advisory Committee, concerning the old and new Drinking Waters in the United States. Willing Water, Vol 17, no. 8, August 1973:

'Both the 1962 Standards and the proposed standards are based on the use of water supplies from the best available sources. The standards are not intended for direct application to wastewater effluents used for a drinking water source. There is a lack and there are gaps in technical, epidemiological, and toxicological knowledge necessary for the development of standards which would provide for any condition of raw water contamination. Additional research and appraisals are necessary concerning contaminants which accumulate and develop when wastewater and municipal sewage are continuously recycled.
Furthermore the standards do not attempt to prescribe specific limits for every toxic or undesirable substance which could be dumped into a public water supply. The limits are confined to substances recognized as being detrimental to the health or wellbeing of the consumer and which are likely to be present. The Drinking Water Standards should not be used as a negation of responsible pollution abatement for drinking water sources.'

Is the useful research on purification of waste water for the production of drinking water of no importance? The contrary is true. In the Netherlands we spend much money on research in this field. First of all, there may be the extremely rare cases where one has no alternative or is forced in that position. Secondly, in order to have good quality surface water these processes are necessary to clean the waste water before it is discharged into the river.
It is there where the waste water is produced, that we should apply our most sophisticated treatment processes, leaving rivers and lakes as near as possible as nature made them. Why?
As we know water is being constantly recycled. Some materials, such as human and animal faeces, can be dealt with to a certain extent by the natural biological self-cleaning capacity of surface water. Sometimes this waste discharge is too much to be handled by the river itself; besides there are a lot of chemical compounds which are not reduced at all. These substances have to be removed by some artificial cleaning process. In the circle of recycling this might be done at any point between the stages of waste water and drinking water.
The appropriate place is at the end of the waste water stage.

The advantages are:

1. Producing waste water at a certain place is part of the total process going on at that place. The people involved with the process should know best how to deal with this waste water and treat it in the proper way. Besides they are in a better position to find out whether a different process with less harmful waste might not be preferable. It is their primary responsibility.

2. The surface water would thus be kept as pure as possible to the benefit of all living creatures, man included.

3. Drinking water can then be produced from a far safer source. The surface water technologically acts as a safety barrier between pollution and man. Especially those substances that are poisonous or in any other way adverse to man's health, should be kept as far away from him and his food and drinking water as possible.

4. Using waste by recycling it as much as possible instead of discharging it in open water, will in the end prove to be the better economic solution.

Attempts have been made to express good river water quality in terms of standards. As in the case of the drinking water standards I do not think this paper should go into details on this point. For your information, however, I refer to the standards that have been proposed by the joint waterworks in the catchment area of the river Rhine in Switzerland, Germany, France and the Netherlands (IAWR) for this river [6]. Two standards are provided for. Standard A is the ultimate goal; B is an intermediate step, to be seen as a first stage.
Standards for river water quality and river quality management should be consistent with drinking water standards. Since river water may also serve ecological, fishing, recreational and other purposes, some river water quality standards might be even sharper than those for drinking water.

Water management to realise surface water standards

Once surface water standards have been set, it is up to water management to realise them. Let us take a simple example: a certain substance should not occur in the surface water at any place along a river. Then water management in this respect implies prohibiting the discharge of that substance at any place and by anyone in the river catchment area. In order to ensure that this goal is reached, all polluters or groups of polluters in the river catchment area should be known and registered. Each of them should be forbidden to discharge that substance.
This should be done through the authority in charge of the river management.
It should be controlled at every spot where discharge of that substance is likely to occur. An indirect control is the water quality measured in the river.
More difficult is the case where a river quality standard is aimed at that is higher than zero, e.g. chloride content of 100 mg/liter in the estuary of the river.
In this case it would not be strictly forbidden to discharge chloride; however it should be limited to such an extent that it remains below the standard threshold.
As the discharge of the river varies with the seasons, the standard of 100 mg/l should be related to a certain, low river discharge. Therefore the standard will be more explicit if it is expressed in a load, for instance 150 kg/sec.
This would mean that every second the total group of chloride discharging polluters is allowed to discharge 150 kg. These 150 kg then have to be divided and split up into individual discharges.
The easiest way is to allow each one a certain load, e.g. a factory A at B is allowed 5 kg/sec. The load is then divided on an emission basis. How should one be able to give everyone his fair share?
And what if the standard has been reached and new factories apply for a building and discharge permit? It is extremely difficult to give rules. The best method for the time being is that the water management authority assess the licences for each individual discharger, provided the river water quality standard is met. It would be wise to aim at a value below the standard in order to have something up one's sleeve for urban and industrial extension. If the standard is reached, either the individual licences should be lowered or no further extension of industry should take place in the river basin.
An excellent instrument in river water quality management is charging polluters financially for the polluting substances they discharge into a river.
The purpose of this is not to enable polluters to buy off their sins.
The principle is to allocate the costs of cleaning the river to the price of the product. The consumer then pays the total cost of production, which seems only fair.
The rates should be so fixed that they equal the costs of the treatment required to reduce the polluting substances entirely. This method has three advantages:

1. it will compel the producer to apply treatment processes to the waste water produced; preferably it should force him to change the production process itself so

that recycling takes place. In the ideal situation nobody pollutes and therefore nobody pays charges.

2. the nasty problem of treating different industries differently is solved: each industry pays its part: partially in charges and partially by waste water treatment. Also if in some area river water quality standards are lower, it will make no difference to the production costs if the charges are based on the complete elimination of the polluting substances.

3. the charges are an economic instrument to gradually reduce pollution. For the sake of efficiency, the charges should be the same in the whole of a relevant region, such as the European Common Market. Ideally, they should be fixed on an international basis.

Emission standards and pollution charges should serve to attain a certain optimum surface water quality, be it expressed in standards or otherwise taken care of. Without a competent river basin water authority, vested with power and means, this goal cannot be reached. In the case of international rivers, close co-operation between the riparian countries is essential.

Conclusion

Standards for the quality of surface and drinking water should be applied to promote the living conditions and health of mankind. They should be confined to a workable number and used in addition to measures to promote a high standard of ground and surface water management and of water supply. Good quality ground and surface water are indispensable for producing safe and palatable drinking water.

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