Selection and Relevance of Parametric Values for the Safeguarding of Drinking Water Supplies

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1. Introduction

With the adoption of Directive 98/83/EC on the quality of water intended for human consumption, the intensive debate over the selection of parameters and the establishment of parametric values is far from over. It has reached an advanced stage, though, when compared to the previous Directive 80/778/EEC. It was assumed at times that once the selection of parameters has been completed it would actually be possible to characterise drinking water exhaustively and adequately. The fact that in the revised version of the Directive (98/83/EC) the total number of parameters is smaller although new ones had been added might support this assumption, but it also gives rise to doubts as to whether a parametric regime is appropriate. There are two further aspects which reinforce these doubts:

1. Suppose none of the parametric values prescribed in the Directive are exceeded in a given water sample, but for most or even all parameters the measured values correspond to the parametric values prescribed. Conformity with the Directive would have to be confirmed for this water sample and yet no hygienist would declare such water to be of a quality fit for long-term human consumption. The belief evidently is that for most parameters the measured values will be substantially lower than the prescribed values and for only a few will the prescribed values be reached.

2. No scientific explanation can be given for why this particular list of parameters should be correct and complete. There can never be such an explanation, nor should we strive to produce it. The list has been compiled by consensus between the experts involved, and with the Council's consent. It could be longer or shorter without any fundamental gains or losses in scientific quality. The imprecision of the list is particularly striking in the case of the parameter "pesticides", which is listed with a number of footnotes. Of the multitude of organic chemicals with pesticidal action, the intended targets are only those which are actually, or have in the past been, used as pesticides. When such a substance is detected in water at 1 µg/l, then the water's quality complies with the Directive if the substance has arisen during disinfection (chlorination). If, however, the same substance was found as a result of its use as a pesticide, the water is objectionable and remedial measures must be

initiated, for in this case the parametric value of 0.1 µg/l applies. In other words, the determinant is the substance's application, and not its chemical nature.

This shows that in addition to the parametric regime there are other things to be taken into account in the assessment of water intended for human consumption. Directive 98/83/EC points this out indirectly by referring in Article 1 to the measures to ensure that the water is "wholesome and clean".

2. The importance of hygiene for safeguarding the quality of water intended for human consumption

The doubts about the overriding importance of the Directive's parametric regime, as raised above, help us see the assessment of water intended for human consumption from the perspective of hygiene. Certainly, without quantitative determinations and without measurements, an assessment will in many cases be impossible. Yet, without knowledge of

- the origin,
- the protection of catchment area,
- the treatment, and
- the distribution, including pipe maintenance,

of water intended for human consumption, all measuring data will be useless and the assessment of its quality a mere speculation.

Already the ancient Romans knew that

> when people are healthy and of strong build, the water they drink is of good quality and trustworthy (Marcus Vitruvius Pollio, 25 B.C.).

Modern hygiene qualifies this simple epidemiological observation by requiring the following:

> Water from filtering soil layers that is unimpacted by human beings or animals and abstracted from the natural water cycle shall serve as the yardstick for the assessment of water intended for human consumption.

This maxim is laid down in the *Leitlinien für die Wasserversorgung* (guiding principles for water supply) (DIN 2000) and is the reason why in Germany water disinfection may be dispensed with if the water is naturally of good hygienic quality and if its microbiological quality does not deteriorate within the pipe system.

The image of an unspoiled resource as the yardstick for water purity might appear somewhat naive in an industrialized world. Yet, there is nothing wrong about the idea of using modern technology to safeguard water quality in the spirit of precautionary action. This is precisely the task which hygiene must fulfil, without making excessive demands which lead to price increases and thus having a counterproductive effect. In no. 28 of its rationale, the Directive recommends that "priority should be given to action which rectifies the problem at source" and in no. 8 demands that "appropriate water-protection measures be applied to ensure that surface and groundwater is kept clean", not however without drawing attention, in no. 9, to the necessary coherence of European water policy. This shows that the requirements on drinking water are also requirements to be met by an appropriate European Framework Water Directive.

So, hygiene raises its voice for an extensive safeguarding of water purity with an eye for the doable and taking into account the possibilities that exist in the individual case. A fact which lends support to this position is that the costs of the pipe systems account for 80 percent of the total water supply costs. Even when subject to high standards, the additional costs incurred for protection and treatment of the resource are low. The continual improvement of the techniques is a further contributor to water quality meeting stringent standards without these entailing excessive costs.

If the parametric regime assumes a place second to that of hygienic requirements, then the picture becomes complete and the Directive free of the inconsistencies discussed in the introduction:

> The purpose of the selection of parameters and the establishment of parametric values should be to help keep water intended for human consumption clean.

In the framework of subsidiarity, the member states are free to formulate hygienic requirements while taking into account regional particularities, for the requirements laid down in the Directive only constitute minimum requirements. In that respect, the provisions of the present Directive are considerably more practice-oriented and flexible than those of the Directive of 1980.

3. Relevance of the parametric values to human health

Even if hygienic requirements are observed and the parametric values reflect technical progress, it is necessary to subject the parametric values to toxicological verification in order to ensure that the consumption or use of the water does not result in health damage. There must be certainty that any health risks are excluded even when consumption or use takes place on a life-long basis (see no. 13 of the rationale). When the substance concerned is a carcinogen or a mutagen, a residual risk will remain. This residual risk should be as acceptable as possible to each individual person and must have been accepted by his or her democratically elected representation (the parliament).

This means that the parametric values established should not be higher than the maximum safe concentrations. In this regard, the Directive in its rationale (Article16) refers to the World Health Organization.

The duration of exposure and share of drinking water in the total intake of undesirable or harmful substances are also relevant factors when considering water safety. Finally, toxicological findings should be taken into account. These are obtained from either animal experiments or epidemiological studies in occupational medicine. Rare are epidemiological studies focused on the area of low concentrations, typically present in drinking water. Derivation of the parametric values for the area of low concentrations from higher concentrations used in animal experiments is mostly questionable. The less reliable are the initial data, the larger must be the safety span between the toxicologically still ineffective load, as established experimentally or in epidemiological studies, and the supposedly safe load for the most vulnerable population group. When calculating the maximum safe concentrations on the basis of scientifically obtained data, the safety factors have to be agreed upon that reflect the safety span requested.

Another important thing in the drinking water supply, associated with the hygiene and toxicology control, is that in case of exceedance of one or more parametric values, it is not possible to simply stop the water supply. If water for human domestic purposes is not further supplied, the epidemiological and hygiene risks increase in the given area, even if the part of water necessary for preparation of foods and drinks is available in other forms, e.g., if supplied as bottled. According to the circumstances in each individual case, the Directive allows to continue supplying water for further three years, and then for three more years and in particularly justified cases, for three more years again (i.e. for up to nine years, see Articles 8 and 9). It is necessary to take effective measures without delay to meet the requirements of the Directive and it must be ensured that any unjustified health risk for consumers be avoided despite exceptions.

While sanitation of the water supply system is in progress, it is necessary to evaluate the exceedance of the limit values according to the toxicological criteria. For this purpose, in the new countries of the Federal Republic of Germany, a graduated system of immediate, mid-term and long-term measures proved useful in ensuring the drinking water supply. It is necessary to start with the measures focused on the most important exceedances from the point of view of safety (cadmium, nitrates) and then to proceed to those coping with the less important exceedances (iron, manganese). Such a graduated approach made possible to take into account all circumstances of each individual case and to ensure higher efficacy of the preventive measures (co-operation with agriculture in reducing the pesticide and nitrate loads).

Apart from the maximum values relating to

a) the life-long intake, toxicologically should be derived the values to be safe at exposure lasting

b) more than 10 and less than 70 years and even long-term measures should not lead to risk for health. Furthermore, it is necessary to derive also the values that are

c) safe within up to ten years, for which it is admissible, in the light of toxicological considerations, to take mid-term measures. Finally, also the values that are safe within up to

d) 1.5-year exposure and needing immediate measures to be taken when these levels are reached.

This graduated system requires accurate knowledge not only of the value derived from the TDI but also of the accumulation of the toxic substances in the organism. Such a derivation fails with carcinogens and mutagens. Higher acceptable risk is applied that should be considered in the light of the benefits to result from the time-consuming and thus effective sanitation.

Practical importance of the graduated maximum concentrations is shown in Table 1 (H.H. Dieter, A. Grohmann and W. Winter, 1998).

4. Chemical and indicator parameters of Directive 98/83/EC

The Directive "Quality of water intended for human consumption" also tries to differentiate between different parametric values.

The first Directive (88/778/EEC) attempted to define the guide levels and maximum admissible concentrations. Nevertheless, when implemented into the national laws, these guide levels had no significance. The member states, all without exception, took the maximum admissible concentrations as the limit values and did not pay attention to the guide levels.

Therefore, the guide levels are not mentioned in the revised Directive 98/83/EC. The parameters for which the Directive requires regulation without exception (chemical parameters) and those for which the regulation is not obligatorily established if there is no risk for human health (indicator parameters) have been differentiated. Nevertheless, misunderstandings are not avoided. The levels of chemical parameters are often erroneously believed to be identical to the maximum safe concentrations. In these cases, the parametric values were established to ensure water purity if technically feasible. This is true particularly of the group of pesticides. Only in isolated cases where technology has not been sufficiently sophisticated yet, the parametric value established is consistent with the scientifically derived maximum safe concentration, which, for instance, is true of bromate.

The parametric values in the Directive are not identical to the WHO guideline values and should not copy the safety-based values. They should rather reflect technological capabilities for preventing pollution. In this regard, there is a rather small difference between the chemical and indicator parameters. The difference consists in the following: chemical parameters are mandatory to a higher degree and the principle of subsidiarity is applicable only for the indicator parameters.

In practice, it can be often seen that the measures to be taken to meet the values of the indicator parameters for iron and manganese are more exacting and therefore more expensive than the preventive measures if taken in co-operation with agriculture to observe the chemical parameters for pesticides.

When implementing the Directive, there is no difference at the end of this procedure between the chemical and indicator parameters since all parametric values should be observed and consequently, necessary measures are to be taken. Let us put aside whether some member states leave out certain individual indicator parameters when taking into account local conditions, e.g., water coloration in the Scottish lakes or the sulfate content in the regions with certain geological conditions.

Problems can be expected if, for instance, one of the member states establishes a different value for the indicator parameter of iron and will offer brownish bottled water, which is safe even if colored, to another member state as the water compliant with the Directive. Such problems should finally lead to establishment of such indicator parameters that would be mandatory for all member states.

To finish this digression, an adequate approach would be based on the relation of the parametric value established to the maximum safe concentration (see Table 1), rather than on whether a parameter is considered as a chemical or indicator one.

5. Examples of the parametric values established

5.1 Value of the parameter for pesticides

When the Directive was amended, one of the questionable points was whether the limit value of 0.1 µg/l, considered by the representatives of agriculture as too stringent, should be met in drinking water for each pesticide. Answers to this question widely varied. If the rules for the use of pesticides, as set by the environmentalists, were observed, the protection of the environment would be actually sufficient and it would not be necessary to establish the limit values for pesticides in drinking water. Nevertheless, another question arises whether the efforts to reach a high level of protection would continue if the limit value for pesticides in drinking water were not applied any more.

Another criticism concerned the fact that the limit value of 0.1 µg/l is substantially lower than the maximum safe concentration. This argument is also justified. For instance, atrazine was listed within class B (up to 3 µg/l) according to the principles of derivation from the levels recommended by the WHO (Guidelines, WHO). This level is 30 times higher compared to the limit value of 0.1 µg/l (Bundesgesundheitsblatt, vol. 32, p. 290, 1989). In the introduction, it was explained why lower parametric values were established for these substances than admissible from the point of view of their safety. It is fully legitimate to use any approach (co-operation of water management with agriculture) allowing to establish the limit values as low as possible for preventive reasons.

Initially, agricultural activities were considered with full confidence, and continued to be regarded as such when a high content of the pesticide endosulphan (thiodane) was detected in the Rhine in the Netherlands in 1969, causing fish kill. After two years of investigation, the Hoechst Company situated near Frankfort on the Main was found to be responsible for. Various receptacles were regularly cleaned in this company and coincidentally, for several consequent days empty receptacles that had contained endosulphan were washed (WaBoLu Report, Federal Environmental Agency, D-14191 Berlin, 1970). These activities resulted in accumulation of endosulphan residues in wastewaters, and consequently in both the Main (up to 14.6 µg/l) and the Rhine (up to 1.6 µg/l).

This case made believe that the levels exceeding 0.1 µg/l would be associated with accidents rather than with an adequate use of pesticides. That is why this level was adopted for the EU Directive (besides, at the suggestion of France), and consequently for the Directive for drinking water of 1980 (80/778/EEC). Later, this seemed erroneous. High pesticide levels were more and more frequently detected in ground and river waters. A fierce conflict arose between the representatives of agriculture (Vlahodimos, K.P.: Industry Statement. European Crop Protection Association, Ave Albert Lancaster 79 a, B-1180 Brussels) and water management (EUREAU, Chaussée de Waterloo 255, B-1060 Brussels) and those of environmental protection (e.g., the standpoints of the GREENPEACE, Friends of the Earth, London; Europäisches Büro für Umwelt, rue de la Victoire 26, b-1060 Brussels). Numerous projects were focused on possible removal of pesticides from water (A. Grohmann and H. Dizer, 1989). Many other research and collaborative studies conducted by water management and agriculture and based on mutual confidence allowed to evidence that the level of 0.1 µg/l is justified, can be met without requiring any additional treatment of water. The conflict ceded to co-operation in reaching the same goal. The stringent limit level of 0.1 µg/l for any pesticide in drinking water could be taken into the amended Directive for drinking water (98/83/EC).

There was no doubt any more that the joint efforts of agriculture and ecology could lead to the observation of the limit level of 0.1 µg/l for any pesticide in the ground water present under cultivated soil. Meanwhile, this level became a sign of a good agricultural practice.

5.2 Parametric value for lead

In untreated water, lead is present only in negligible safe concentrations, if not taking into account some few exceptions, e.g., water from former mine adits in the Ore Mountains. The presence of lead in water may be also due to industrial wastes. Nevertheless, no case is known where lead would be present in treated drinking water at the outlet of a water treatment plant at a concentration harmful to health.

Lead is a nerve poison causing mental disorders and motor anomalies. It is responsible for learning disorders in children (Smith, Grant and Sors, 1989). The World Health Organization specifies the following three risk groups: unborn children, small children and patients with high consumption of drinking water. Particularly in England, low correlation between the presence of lead in drinking water and the lead content of blood in small children was supposed, and consequently reduction of lead levels in drinking water was not required because of costly measures to be taken. When leaded fuel was not used any more, drinking water became the major portal of entry of lead into the human organism (Umweltbundesamt: Umwelt Survey), if occupational exposure is not taken into account. From the toxicological point of view, for the highest acceptable safety span, it would be possible to limit the concentration of lead in drinking water to 2 to 3 µg/l (Müller and Dieter, 1993). For this reason, it is comprehensible that the parametric value of the EU Directive for drinking water, which is 50 µg/l at present, should fall to 10 µg/l.

If it is not difficult to reach the levels under this low limit value in drinking water at the outlet of the water treatment plant, how drinking water can become contaminated with lead?

Knowing that the lead piping is responsible for this contamination, we can formulate the question differently: would it be sufficient to suppress the use of lead piping and lead containing solders in drinking water supply? The expected limit value of 10 µg/l actually means the interdiction of the use of lead piping in water supply since this limit value is regularly exceeded if water stagnates in lead pipes.

Neither knowledge of the health risks due to lead present in drinking water nor the requirement for stopping the use of lead pipe are new (XIXth century literature: Bolley). Conversely, it has been known for centuries that lead is dangerous; even the idea that the use of lead dishes and pipes in ancient Rome was detrimental to health of the population cannot be disproved as a pure speculation. Anyway, the mean levels of lead found in the bones of Rome legionnaires were as high as 65.7 mg/kg to 112.7 mg/kg and markedly exceeded those reported for other cultures of the 1st to 3rd century after Christ (1.8 to 3.4 mg/kg in Poland, 2.6 mg/kg in Denmark) (Waldron, H.A.; 1976).

On the other hand, lead is an important raw material. It is easy to process, lead pipes are flexible, resistant to corrosion and have a long service life. People could not imagine better material for transporting drinking water for centuries. Based on risk - benefit analysis, the generally known harmful effects of the presence of lead in drinking water were counterbalanced by the usefulness of this material.

What was acceptable for centuries may not continue to be used at present under different technological conditions. Nevertheless, the conclusions to be drawn from this observation have not a direct impact on practice. Long-term toleration of lead piping together with the cases of acute lead intoxication reported only in waters with low pH led to a hypothesis that in hard waters, calcium deposits create a protective layer preventing the release of lead. This idea enhanced the tolerance to lead piping although its trueness had never been proved. And just the opposite is true: no calcium layer is formed. The fine white layer, possibly also slightly brownish – due to the presence of iron, consists of alkali lead carbonates (lead white), the solubility of which determines the lead content of drinking water: thus water stagnation in lead piping is responsible for permanent exceedance of the limit level of 10 µg/l. Acceptance of drinking water contamination due to lead piping also played a role in amendment of the EU Directive for drinking water (98/83/EC). For instance, the mayor of a French city gave priority to the social needs of population rather than to the replacement of the old lead piping when allocating funds designated for improvement of population health. This delayed the implementation of the new parametric level for lead by 15 (say fifteen) years, hoping that by then the old houses would be renovated and the lead piping would be replaced with that of more appropriate material at this opportunity.

When solving the lead issue, attention should be paid to renovation of old houses since no renovation should be authorised or even financially supported, if not involving a complete replacement of lead piping. Until now, it could be sufficient to recommend to the population living in such houses to let the water run until fresh water from the water system outlet of the street reaches their tap.

A partial solution is also imaginable: to replace only the kitchen risers to provide with lead-free water at least one tap per flat. This would be feasible at low costs, estimated at about 300 EUR per flat. The only means for total removal of lead contamination is a complete replacement of the water piping. Phosphate dosage, supposed to lead to formation of less soluble lead phosphates and thus to permanent reduction of the lead levels under the required limit value, should be considered as a partial solution to be followed by the total replacement of the lead piping.

To say it in a clear way: a complete replacement of all lead piping used for distribution of drinking water is urgently needed and any other solution cannot be envisaged under any circumstances.

6. Conclusion

The parametric values that should not be exceeded in the drinking water supplied to the consumer are called differently in different member states. In German, they are called Granzwerte (limit values) regardless of whether these are chemical or indicator parameters. This would clearly mean that in a mid-term or long-term perspective, the concentrations of the given substances should remain under the limit values.

When establishing these parameters, attention is not paid only to the derived toxicological values. For preventive reasons, sophisticated technology is used to maximally reduce contamination, even if not representing direct risk for health. As for the mutagens and carcinogens, there are individually acceptable risk and socially acceptable risk based on the democratic consensus of the EU Parliament or the European Commission. Therefore, there may be significant differences between the maximum admissible levels as derived by scientists and the parametric values (limit values in Germany) as democratically set. When establishing the limit values, the objectives and motives of that should be clearly defined. Adequate measurement methods and analyses with specified accuracy should be used. These conditions are not determinative for scientific derivation of safe levels.

Finally it should be taken into account that the drinking water supply cannot be simply stopped if the prescribed levels are exceeded. Directive 98/83/EC allows a period of three years for taking appropriate measures and in justified cases even longer periods (up to three more years and possibly three more years again). Meanwhile, population health must not be compromised. When evaluating the situation, the scientifically derived values and exposure duration should be taken into account. The background data are given in Table 1.

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Table 1

The parametric values of Directive 98/83/EC and maximum safe concentrations are related to the following duration of exposure:

a) over 70 years, b) over 10 years, c) under 10 years and d) about 1.5 years.

Carcinogens and mutagens are marked with an asterisk. Instead of the maximum safe concentrations for these substances, acceptable risk associated with the concentration indicated and expressed as $1x10^{6}$ ($3x10^{5}$ for bromate) is used for the daily intake of drinking water up to two litres for 70 years and body weight of 70 kg. This risk must be counterbalanced by the benefit from the delayed but effective preventive sanitation.

Parameter mg/l		Parametric value	Maximum safe concentration (* acceptable risk)				Infants and small children
			a	b	c	d	
Aluminium		0.2	1	1	-	-	1
Arsenic		0.010	0.010	0.010	0.015	0.020	0.010
3,4-benzo(a)pyrene	*	0.00001	0.00007	-	-	-	-
Benzene	*	0.001	0.001	-	-	-	-
Lead		0.010	0.025	0.025	0.040	0.080	0.003
Boron		1	1	5	10	10	-
Bromates	*	0.010	0.010	-	-	-	-
Cadmium		0.005	0.002	0.002	0.003	0.005	0.003
Chromium (VI)		0.050	0.020	0.200	0.200	0.200	-
1,2-dichlorethane	*	0.003	0.003	-	-	-	-
Fluorides		1.5	1.5	1.5	3	3	1.5
Manganese		0.050	0.100	0.100	-	-	-
Nickel (if allergy)		0.020	0.020	0.020	0.200 (0.050)	0.200	-
Nitrates		50	50	130	130	130	50
Nitrites		0.5	1	7	7	7	1
Mercury		0.001	0.001	0.001	0.002	0.002	-
Tetrachloromethane		-	0.003	0.020	0.020	0.020	0.003
Tetrachloroethene and trichloroethene		0.010	0.100	0.100	0.200	0.500	-
Trihalomethanes		0.100	0.050	0.050	0.140	0.200	-
Vinyl chloride	*	0.0005	0.0005	-	-	-	-