Health Hazards from Drinking-water

Report on a Working Group

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Note

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This report is also issued in French and Russian.

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1. INTRODUCTION

A Working Group on Health Hazards from Drinking-Water was convened in London from 26 to 30 September 1977 by the WHO Regional Office for Europe, in collaboration with the Government of the United Kingdom. Three particular aspects were considered: the concept of "health hazard", health effects arising from increased lead levels in water, and nitrate concentrations in water in relation to health risks.

The meeting was attended by 21 participants from 11 countries, 1 staff member from WHO headquarters, 2 staff members from the WHO Regional Office for Europe, and 2 from the Commission of the European Communities. (See Annex for list of participants.)

Sir Henry Yellowlees, Chief Medical Officer, Department of Health and Social Security, welcomed the participants. He said that there was widespread recognition of the many environmental pollution problems and, in particular, of the effects to health which could result from exposure to some pollutants. Lead was one of the commonest of these, and there was an urgent need for advice on safety in relation to exposure. The meeting was important because it provided an opportunity for recommendations integrating expert medical and technical views to be formulated, and these would subsequently be of considerable value to medical and health administrators.

Mr J.I. Waddington, Chief, Promotion of Environmental Health, WHO Regional Office for Europe, opened the meeting on behalf of the Regional Director, Dr Leo A. Kaprio. He described the development of WHO policy on health aspects of environmental pollution, in accordance with which water contamination was one of the subjects covered by the study and evaluation programme. As the meeting brought together both medical experts in the field of environmental health and persons with technical expertise in the production of drinking-water, it would be possible for the Working Group to establish recommended upper limits of contaminants in water, and to consider the feasibility of obtaining or estimating accurately such proposed levels. Where the Working Group came to the conclusion that the present recommended levels needed to be changed, each recommendation would have to be considered in terms of the degree of priority which should be allocated to its implementation. That was a matter which would have to be considered by each country, and he hoped that the proceedings of the meeting would assist Member States in making the proper decisions concerning implementation.

Dr F.A. Fairweather was elected Chairman of the meeting with Dr V. Beneš as Chairman of the Medical Group and Dr D. Kerin as Chairman of the Technical Group. Mrs J. Forslund and Dr J.R. Reid were appointed rapporteurs for the Technical Group and for the Medical Group respectively. Dr R. St.J. Buxton coordinated the group reports and prepared the final report.

In 1963 WHO headquarters published the second edition of *International Standards for Drinking-Water*, in which an upper limit of 0.05 mg/l for lead in drinking-water was recommended. The second edition of *European Standards for Drinking-Water*, published by WHO in 1970, proposed 0.1 mg/l lead as the upper limit in the supply, but regarded 0.3 mg/l of lead as permissible in the standing overnight sample where lead pipes were used. In 1971 the third edition of *International Standards for Drinking-Water* came into line with the proposed European standard of 0.1 mg/l. The WHO Working Group on the Hazards to Health of Persistent Substances in Water,[a] 1972, concluded that no new information had become available which would justify an increase in the permissible level of lead from 0.05 mg/l to 0.1 mg/l.

The US Environmental Protection Agency (EPA) proposed a value of 0.05 mg/l for lead in drinking-water at the tap in 1972 and confirmed this in *Interim Primary Drinking-Water Standards*, published in 1975.

The EEC Draft Directive on the Quality of Water for Human Consumption, which appeared as part of the EEC Environment Action Programme in 1975, proposed an upper limit of 0.05 mg/l for lead, but this is still being discussed and has not yet become official EEC policy.

In 1976 the WHO Regional Committee for Europe expressed the view that there should be further discussion of the recommended limits for lead in water and that the concept of "health hazard" should be considered on a broad basis.[b] This Working Group was therefore convened in response to the Committee's recommendation.

2. OBJECTIVES

The Working Group was asked first to consider what it meant by the concept of "health hazard" and how the assessment of health hazard should be made. In doing this a number of questions might be posed which would be relevant to these considerations:

(a) Has a risk to man or animals been demonstrated?

(b) What is the nature of this risk?

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[a] **WHO Regional Office for Europe.** *The hazards to health of persistent substances in water.* Report on a Working Group. Copenhagen, 1973 (document EURO 3109W(1) (two parts))

[b] **WHO Regional Office for Europe.** *Report of the Twenty-sixth session of the Regional Committee for Europe* (unpublished WHO document EUR/RC26/13 Rev.1)

(c) Can a dose-effect relationship be demonstrated?

(d) Is there a "no-effect" level?

The recognition of a health hazard should be followed by the setting of standards. These would take into account whether the exposure source under investigation was the sole source, and whether any section of the population was particularly at risk or especially sensitive. Although it was basically a medical problem, the setting of standards also involved technical, political, economic and social factors. However, the Working Group was composed only of medical and technical experts, so that the proposals would relate only to expertise in their particular areas.

The first of the specific objectives for discussion concerned lead in drinking-water. The booklet *Environmental Health Criteria 3: lead*[a] was provided as background information. The members of this Group were asked to review the existing data and, on the basis of their findings, to decide whether scientific evidence supported the existing WHO-recommended limits or whether there were indications on health grounds that they should be modified or changed.

Next, the levels of nitrates in drinking-water were to be considered. The summary report of a Working Task Group meeting held in Lyons in February 1976 on environmental health criteria for nitrates, nitrites and N-nitrosocompounds was provided as background information. The Working Group was requested to review existing data, and to determine whether there was sufficient information available on the basis of which limits for nitrates in water could be proposed. If so, they were to consider whether the data were in accordance with existing WHO recommendations or whether new proposals should be made on health grounds.

3. THE CONCEPT OF "HEALTH HAZARD"

The role of epidemiology was discussed in terms of techniques for determining associative or causal relationships. It was appreciated than an appropriately designed experiment was necessary to elucidate these relationships. The nine factors proposed by Bradford Hill[b] were accepted for this purpose and it was noted that the first five quoted were particularly relevant in this connexion, namely:

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[a] **World Health Organization.** *Environmental health criteria 3: lead.* Geneva, 1977

[b] **Bradford Hill, A.** Principles of medical statistics. *Lancet*, pp. 313–318 (1971)

(a) the strength of association,

(b) consistency,

(c) specificity,

(d) the relationship in time,

(e) the biological gradient.

The Working Group considered the question of health risk, and recognized that an effect due to exposure either in man or animals should be demonstrated. If no effect was seen in the occupational setting, where the pollutant concentration was likely to be higher than in the domestic environment, studies of the general population were felt to be unproductive. Negative studies could be helpful in setting no-effect levels in man.

In assessing data, it was essential to ascertain whether there was a true dose-response relationship, and whether this was causal in nature. The most vulnerable sections of the population should be identified. In many cases, no field studies on man were available, so that criteria could only be based on animal studies. In the drawing up of standards, extrapolation to man was fraught with difficulties, but the adoption of the "weight-for-weight" principle and incorporating an assumed safety factor were often the only courses open on which to base advice on the health risk.

When preparing standards, it was desirable first to ascertain whether a no-effect level had been shown. A total intake could then be recognized, but it was necessary to elucidate what proportion of this came from the source under discussion. This would provide an opportunity to consider what effect setting standards for this source would have on the overall intake. At this stage, the medical and technical aspects having been considered, the political, economic and social implications of a particular choice of standard could be assessed.

Two further points required attention, namely, how urgent it was to achieve the standard set, and how far its introduction would be of overall benefit to the individual and the community. The degree of priority accorded to securing compliance with proposed standards would to a large extent vary on a regional basis and was thus not a matter of direct concern to the Group.

The participants expressed some concern over the presentation of standards as a maximal limit for the element, since this simple form was liable to be a misrepresentation of the real state of affairs. As metals were present in water in different chemical forms, identification might in some cases prove difficult and biological behaviour might not be what was anticipated in the light of the total estimated concentration. For example, certain foods with

high lead concentrations were found to contain only 5–10% in the ionized form. The cooking of vegetables in water was reported to affect the nature and concentration of trace metals in vegetables and cooking-water.

4. LEAD IN DRINKING-WATER

Estimation of lead levels in drinking-water requires an agreed standard procedure so that the figures obtained are comparable. The technique used must refer to the site of sampling and the time of day at which it should be carried out in relation to the domestic routine. However, it is difficult to take samples in proportion to individuals' water intake, although this would be of scientific interest. In practice, it is necessary to define a specific volume of water to be taken, to draw an initial sample, and to draw the second sample of the day after a specified period of flushing.

The members of the Working Group were of the opinion that no particular analytical technique was superior to the others; thus no single procedure was put forward as a requisite for precision or comparability. Accuracy limits in determining concentrations were proposed and the need for quality control was stressed. This should take place both within and between laboratories in each Member State, and also on an international basis.

As the distribution of levels of lead in water is not known with any degree of certainty in the Member States, it is desirable that national surveys should be carried out and areas with high lead levels defined. In this way, it will be possible to keep a careful watch on situations where aggressive waters are in contact with lead, where the incidence of lead plumbing is high, or where the housing is old, by modifying the routine of water monitoring so that more frequent sampling is undertaken. This would allow early recognition of an increased health risk in these potentially hazardous areas so that appropriate action may be taken to protect the individuals exposed.

Regarding assessment of the degree of severity of exposure to lead, the Working Group did not uphold the view that the measurement of intake from the various sources gave the most useful indication, as many errors might occur in such measurements and these might well be cumulative. The absorption rates would vary depending on the anatomical sites, age, sex and ethnic origin of the individual. The Group therefore preferred to use a measure of lead absorption as an estimate of the non-skeletal (soft-tissue) body burden of lead. The blood lead concentration should be used for this purpose. This is in accord with existing WHO recommendations (*Environmental health criteria 3: lead*, p. 134, 9.5.7.1). Since lead can at present be regarded as a non-essential element in health terms, there is no reason why a zero value should not be put forward as a health objective. In practical terms, a maximum value of

20 μg/100 ml for the blood lead concentration of 50% of the population was accepted as a working hypothesis.[a]

After reviewing existing published work on the subject, the Working Group considered that the contribution of water to the blood lead could be assessed from the increments of the blood lead as observed in certain epidemiological studies. Such studies have shown that the soft-tissue body burden for lead absorption is of the order of 2–4 μ/100 ml blood for each increment of 100 μg/l lead in water. Although it was recognized that the dispersion of blood lead values was large, the association between water lead content and blood lead concentration was statistically significant, but the relationship between the two parameters was not rectilinear.

There is a different pattern of water usage within each household, and the incremental effect on the blood lead may in consequence be greater in certain sections of the population. In fact, three groups were identified as being especially vulnerable, and more stringent standards may be required for these than for the population as a whole:

(a) the foetus,

(b) the young infant,

(c) individuals with certain medical conditions such as increased water intake or those on renal dialysis.

Water obtained from domestic water-softeners and from hot-water systems was considered unsuitable for drinking.

Research

There are many aspects of lead in drinking -water on which insufficient data are available. The Working Group selected a number of areas where data were required and to which they attached a high degree of priority:

(a) the nature of the physical and chemical forms of lead in drinking-water;

(b) the variation of the lead content of water (at the tap) over a period of time;

(c) the consumer's habit of drinking water and their relation to lead content;

[a] This formula is accepted by the EEC as a working hypothesis for countries within its area of jurisdiction.

(d) studies at a national or regional level to identify areas where plumbosolvency exists (the Working Group considered this problem to be of high priority, particularly in rural areas);

(e) the uptake of lead from water by food and drink in the process of preparation;

(f) further epidemiological studies relating blood lead values to the content of lead in water in areas with critical population groups;

(g) epidemiological and biochemical studies of the role of bone as a reservoir for lead in relation to soft tissue and the total body burden of lead.

5. NITRATES, NITRITES AND NITROSAMINES IN DRINKING-WATER

Nitrates are a normal constituent of drinking-water, being derived for the most part from drainage from cultivated and fertiliser-treated land and from sewage effluent. Meteorological conditions affect the levels to a great extent, and while increases occur seasonally (in autumn and winter), the findings have shown a tendency towards an overall increase during the last few years in most European countries.

The sampling of drinking-water for nitrate analysis may be carried out satisfactorily at waterworks or in the distribution system. The sampling frequency should be determined by the proximity of the observed level to the limit set.

In the Group's discussion on the estimation of nitrate concentration, no proposals were made regarding the analytical technique, but a detection level of 10% and an accuracy of 20% were considered to be prerequisites. The need for good analysis control was stressed.

It was agreed that nitrites were not usually present in drinking-water, but where bacterial contamination was present reduction of nitrate could occcur. In the presence of free chlorine this was unlikely, but some participants reported values of up to 1 mg/l in their countries. In the case of nitrites, sampling should be carried out at the consumer's tap. In respect of sampling frequency and analytical procedure, the Working Group made proposals similar to those it made for nitrates (see above).

The participants agreed that preformed nitrosamines were rarely found in drinking-water in significant amounts. The sources and formation of the different types of nitrosamines were discussed, but the health aspects were not considered as water was not considered a significant source.

The health effects of nitrates were discussed. Particular concern was expressed over water supplies in rural areas as nitrate levels tended to show a greater variability there than in urban areas.

Acute effects of increased nitrate concentrations may be seen in infants; hence, babies and pregnant women form the vulnerable groups. There is still a need for work on the significance of subclinical effects. At present the nature of the biochemical changes and, in consequence, their extent, are unknown and it is impossible to relate the nitrate levels in water to body responses. The greatest clinical hazard was considered to be methaemoglobinaemia, especially in bottle-fed babies under six months of age. For this to occur it was necessary to have sufficient nitrate in the water and an appropriate bacterial presence.

The Working Group considered that adults could tolerate higher levels of nitrate in water than children in the long term. The available information on the relationship between nitrates and cancer incidence was examined, but the data were found to be inconclusive and it was not possible to assess the risk with any degree of certainty.

Research

(a) A study on the design of sampling programmes is required. This would include identification of the significant parameters to be measured and of the factors affecting the day-to-day variability of the nitrate levels in a single supply and in the different supply areas.

(b) Further epidemiological and experimental studies are required into the possible association between nitrate levels in drinking-water and carcinogenic effects on certain organs. A study of the incidence of cancer in workers occupationally exposed to nitrates was suggested as being a useful line of enquiry.

(c) Experimental work is needed to examine the transplacental passage of nitrates at various exposure levels.

(d) Research is required to establish the effects of subclinical levels of exposure in man. Biochemical changes need to be identified, and where a dose-effect relationship can be found, it is necessary to know the nature of the dose-effect relationship and its significance.

(e) Environmental impact assessment of changes in land use (including agricultural and forestry practice) which may result in increased levels of nitrate reaching drinking-water supplies should be undertaken. Methods of preventing or limiting such increases should be investigated.

(f) Data on nitrite levels in water are acknowledged to be sparse, and national studies should be established to provide information on nitrite concentrations at the consumer's tap.

6. GENERAL OBSERVATIONS

The Working Group considered the following two subjects on a general basis and recognized that there were wide variations in geographic features and national activities, so that the relevant factors could also be expected to vary widely:

(a) identification of factors or constraints which, together with scientific criteria, must be considered in drafting objectives, norms, standards and regulations;

(b) mode of developing regulations in order to safeguard drinking-water quality from the adverse effects of toxic substances.

The summary report[a] of a WHO Consultation held in May 1977 in Bilthoven, Netherlands, was used as background information. This document covered a number of fields such as economics, social amenities, financial, political, ecological and industrial aspects, which, although relevant to the area under discussion, were not within the areas of expertise of the Working Group's members. It was therefore felt inappropriate for views to be expressed on them.

The meeting was concerned with one aspect of the general environment, namely, drinking-water, yet it was important to view exposure from this source in relation to the total exposure from all sources of the agent in question. It was possible to obtain factual information on the nature of the source and to quantify the intake. If the agent was toxic, the health effects could be demonstrated in the laboratory and elsewhere. The Working Group accepted that the evidence on health effects up to this stage could be verified by scientific techniques. Appraisal of this evidence then enabled a value judgement to be made leading to a decision on safety limits and the setting of standards. The process of standard-setting required to be developed, but it was certain that the national constraints resulting from differences in conditions in various countries would mean that the figures used in the operational techniques would need to be different.

[a] **World Health Organization.** *The application of environmental health criteria:* summary report of a WHO consultation (unpublished WHO document CEP/77.7)

There was general agreement that the logical thought process leading to the setting of standards must take into account both analytical limits and technical feasibility. Furthermore, if a substance was present, the need for a standard should be the first consideration. This would depend on an appreciation of the toxic effects which could be found to be due to the presence of the substance in the concentrations likely to be met in the environment.

7. RECOMMENDATIONS

General

Criteria documents should consist of four parts:

(a) summary of the situation, highlighting the major issues and making recommendations for research;

(b) the main body of the report, including the findings on which the evaluation of the health risk is based;

(c) an evaluation of the health risk to man from exposure to the agent in question;

(d) an appraisal of the significance of the health effect, with an indication of the basis for required safety factors. Short-term or long-term exposure limits should only be proposed if the data are adequate, otherwise tentative guidelines should be suggested.

Lead

(a) After appropriate attention has been given to the details of sampling and analysis, the upper limit for lead in running water should be 0.05 mg/l.

(b) When lead pipes are present, the lead content should not exceed 0.05 mg/l in a sample taken at the tap after flushing. If the sample is taken either directly or after flushing and the lead content, either frequently or to an appreciable extent, exceeds 0.1 mg, suitable measures must be taken to reduce the exposure to lead on the part of the consumer.

(c) When lead is present, the drawing of drinking-water from domestic water-softeners and hot-water systems should be discouraged.

Nitrate

(a) For the general population, a nitrate level in water (as nitrate NO_3) of below 50 mg/l should be considered acceptable, a level of 50--100 mg/l should be considered borderline, and levels in excess of 100 mg/l unacceptable.

(b) For infants below six months of age nitrate levels (as nitrate NO_3) in excess of 50 mg/l should be considered unacceptable.

Annex

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OTHER PUBLICATIONS IN THE FIELD OF WATER POLLUTION CONTROL*

Water pollution control: Report on a Conference. 1967 (EURO 159.4)

Trends and developments in water pollution control in Europe: Report on a Working Group. 1969 (EURO 0415)

Automatic water quality monitoring: Summary Report on a Seminar. 1971 (EURO 3119W)

Accidental pollution of inland waters: Report on a Conference. 1972 (EURO 3105W)

Ecological aspects of pollution in the Rhine: Report on a Working Group. 1975 (ICP/CEP 207(1))

The optimization of water quality monitoring networks: Report on a Workshop. 1977 (ICP/CEP 212)

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