

# Hazards from the kitchen tap

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IT may seem strange that a University Civil Engineering Department is involved in this subject, but as a Municipal Laboratory our terms of reference include investigation into the quality of drinking-water. The following history and evidence will show there is some cause for concern.

In order to commence, reference standards for toxicity were required and these were found in the World Health Organization's (WHO) publications. In principle, their International Standards for Drinking-Water (WHO 1963) have been used together with, later, their European Standards for Drinking-Water (WHO 1970) from which table I has been made.

TABLE I

<i>Toxic Substance</i>	<i>International standards for drinking-water 1963</i>	<i>European standards for drinking-water 1970</i>
	<i>Maximum allowable concentration (MAC) in mg/litre</i>	<i>Upper limit of concentration (ULC) in mg/litre</i>
Lead .. .. .	0.05	0.10
Arsenic .. .. .	0.05	0.05
Selenium .. .. .	0.01	0.01
Chromium-6 .. .. .	0.05	0.05
Cyanide .. .. .	0.20	0.05
Cadmium .. .. .	0.01	0.01
Barium .. .. .	1.00	—
Notes	The presence of any of these substances in excess of the concentrations quoted should constitute grounds for the rejection of the water— as a public supply for domestic use.   for use as a piped supply. It is considered that Barium should not be present at a concentration greater than 1.0 mg/litre.	

WHO also lists in their International Standards components hazardous to health in source waters—

	MAL*		MAL*
	mg/litre		mg/litre
Nitrate as NO <sup>3</sup>	45	Fluoride	1.5

\*MAL—Maximum Allowable Limit

noting these two as—‘Having definite effects upon health’ and toxic substances in source waters—

	MAL* mg/litre		MAL* mg/litre
Phenolic substances	0.002	Cyanide	0.20
Arsenic	0.05	Lead	0.05
Cadmium	0.01	Selenium	0.01
Chromium	0.05		

Radionuclides (gross beta activity)—1000  $\mu\mu\text{c}$ /litre and in this case the attached note reads—

‘Those components that are definitely toxic and whose presence in greater than the limiting amounts would be sufficient grounds for rejecting the water as a source of public supply.’

In their 1970 work, WHO lists Phenolic Compounds, Fluorides and Nitrates as ‘Constituents in water which, if present in excessive amounts, may give rise to trouble’ as shown in table II.

TABLE II

<i>Substance</i>	<i>Nature of trouble which may arise</i>	<i>Approximate level above which trouble may arise</i>
Phenolic compounds (as phenol)	Taste, particularly in chlorinated water	Less than 0.001 mg/litre†
Fluoride (as F)	Fluorosis	Varies between 0.7 and 1.7 mg/litre Temperature dependant
Nitrate (as NO <sup>3</sup> )	Danger of infantile methaemoglobinaemia if the water is consumed by infants	<i>Recommended:</i> less than 50 mg/litre <i>Acceptable:</i> 50 to 100 mg/litre <i>Not recommended:</i> more than 100 mg/litre

† Some phenolic compounds are capable of being toxic when ingested over a long period of time.

Having established these standards which, although few in number, were authoritative, it was felt that as metals were involved a good start could be made by examining the acidity (pH) of United Kingdom drinking-waters. Further, it was decided that as when water is taken for drinking (particularly by children) in the home, very rarely is any amount run to waste beforehand, the long-established and well-learned ritual of flaming the tap and allowing water to run for three or four minutes before taking a sample would not be followed. All specimens taken would be at first running and therefore representative of any water imbibed and possess the virtue of indicating metal solvency properties. Finally, in order to settle sampling points, centres of population greater than 100,000 were selected and the results from 43 towns or county boroughs are given in table III which shows that 15 out of 20 million or 75 per cent of the population surveyed, was being served with an acid water (taking pH 7.0 as neutral) and that the possibility of metal solvency properties was a reasonable line of investigation.

At this time, the late Dr Alan Wilson (1966) was drawing attention in *The Practitioner* to lead in drinking-water and we were grateful to receive his help in our inquiries. Cox (1964) states ‘Lead piping should not be used with waters having pH values less than about 7.8’. Wilson, again, (1965), in his MD thesis stresses this point and draws

attention to the toxic effect of lead when the concentration is more than 0.05 mg/litre, describing gastro-enteritis as an example.

In considering lead in drinking-water we then have the following relevant factors—WHO. International standard maximum allowable concentration of 0.05 mg/litre, which incidentally is the same as in analytical reagent quality water; acid waters; lead piping in old houses and lead-soldered joints in copper piping, not to mention the day-to-day plumbing repairs using lead; Cox's warning and gastro-enteritis. Our comments (a) and (b) in the *Lancet's* correspondence (Reed and Tolley 1967) were, with hindsight, reasonable.

- (a) It seems that 96 per cent of the population surveyed is consuming water which is at times sufficiently acid to dissolve lead.
- (b) It is undoubtedly good practice to run water to waste in the morning before filling the first kettle.

In addition to (b), to clear the pipe to any tank in the loft by flushing the toilet first thing in the morning has its merits.

An argument often advanced in relation to the use of lead piping, is that a coating of calcium carbonate forms inside the pipe which prevents the water dissolving the lead. Acidity is involved here and Cox (1964, figure 14, p. 203) gives two curves of pH versus alkalinity (as calcium carbonate)—'A' representing calcium carbonate solubility equilibrium and 'B', treatment to produce a coating of calcium carbonate. When considering the safety of a piping system in relation to dissolved lead, curve B affords a more logical (and conservative) criterion. However, using the same samples as indicated in table III, the figures given in table IV were obtained.

TABLE III

Minimum pH	Number of Towns or County Boroughs	Approximate population (millions)
≥ 7.8	2	0.7
7.0–7.6	18	4.3
6.0–6.9	21	14.1
–6.0	2	1.3

TABLE IV

No. of county boroughs surveyed	Approximate population (millions)	Minimum values		'Equilibrium' pH (from A)	'Protective coating' pH (from B)
		pH	Alkalinity (as CaCO <sub>3</sub> ) (p.p.m.)		
25	10.21	5.8–7.8	≤ 30	≥ 8.5	≥ 9.5
1	0.17	8.7	30	8.5	9.5
8	1.87	6.6–7.6	31–100	8.5–7.6	9.5–7.8
9	8.14	6.4–7.4	101–250	7.6–7.2	7.8–7.3

These figures show that 94 per cent of the population represented is served with drinking-water of, to say the least, doubtful capacity to form a protective coating of calcium carbonate. Evidently a disturbing proportion of the population is receiving drinking-water acid enough to dissolve through pipes which are inadequately protected internally against the water's solvent action.

By this stage in our investigation we had obtained an atomic absorption unit and all our samples were examined by this method for lead content. Thirteen per cent were found to contain more than the WHO international limit, whilst 30 per cent contained 0.05 mg/litre and over. All our samples were taken personally and we were, in view of

the distance travelled, obliged to take them at all times of the day. Early in the morning at the tap's first drawing would have been preferable.

Regarding strict plumbi-solvency, when all the samples used were each allowed to remain for 10 minutes only in a coil of new and previously flushed-out lead piping the concentration of lead dissolved was greater than 1 mg/litre or greater than 20 times the WHO international limit. The resultant hazard when new lead piping is installed or plumbing carried out in the home or hospital is illustrated here.

Finally, Lord Douglas of Barloch, who, from its inception, had given the benefits of his experience to our work, asked two questions (c) and (d) in the House of Lords (Hansard 1967):

- (c) To ask Her Majesty's Government whether they have given advice, and, if so, what advice, to water undertakers as to the necessity of correcting water supplies which are liable to dissolve lead.
- (d) To ask Her Majesty's Government whether any steps are being taken to limit the lead content of drinking water to the International Standard Limit of the World Health Organization, namely 0.05 milligrams per litre.

As a result, the Ministry of Housing and Local Government asked all public supply undertakings to report on the measures they take to guard against water being contaminated by lying in contact with lead pipes. The reports were followed up in the "relatively few cases" (their words) where it was considered that some improvement of the precautionary measures was desirable. To date we have not seen any figures in support of this bland statement.

Leaving lead we turned our attention to barium and cadmium and, using atomic absorption again, found all samples to contain less than the WHO maximum allowable concentration for barium. With cadmium, however, a higher level was found in one city with 500,000 population. The amount was 10 per cent in excess of WHO, an example which highlights the necessity for continuous and widespread analyses of drinking-water to find the odd toxic levels lurking in the most unsuspected places.

Phenolic substances next engaged our attention. Diazotization, as recommended by the Institution of Water Engineers (1960), being used as the analytical method of choice, a new survey was carried out, samples of drinking-water being obtained from 24 large towns in the UK and representing a population of seven million. In every case more than 32 micrograms per litre were found, or more than 16 times the WHO maximum allowable limit. These figures were reported (Reed and Tolley 1968) together with a query to our medical colleagues as to how realistic was the WHO limit. The contamination was general and at this level of estimation (2 microgrammes per litre) the greatest difficulty was encountered in obtaining consistent blanks.

Work on the two chemical carcinogens, hexavalent chromium and arsenic, was now carried out using the estimation procedures given respectively by the American Public Health Association (1965) and the Fisher Scientific Company (1960). In all 24 samples taken the figures obtained were less than the WHO maximum allowable concentrations, but some were significantly near to the limit and we are concerned to find them there at all. Where carcinogens are involved thresholds at which the normal cell becomes malignant have not been established, and to expect man to tolerate long periods of exposure to known carcinogens is naive. Particularly so in view of the sentence, "These data, with other epidemiological evidence and deductions from laboratory observations, suggested that environmental factors, as opposed to genetic ones, were primarily responsible for perhaps as much as 70-80 per cent of human cancers." (Editorial Article, *Lancet*, June 1970). It is of interest here to consider the average man with his total water content of some 50 litres, contaminated to, say, 50 per cent by drinking-water containing one half the WHO maximum allowable concentrations or limits of

toxic substances, combined with his total complement of  $5 \times 10^{13}$  cells. The minimum toxic insult per cell in number of ions or molecules is as shown in table V. We can only speculate at what threshold the normal cell will, under such attack and in the long term, become malignant.

TABLE V

<i>Arsenic</i>	<i>Barium</i>	<i>Cadmium</i>	<i>Chromium 6</i>	<i>Cyanide</i>	<i>Lead</i>	<i>Phenolic substances</i>	<i>Selenium</i>
100,000	1,100,000	12,500	145,000	1,150,000	36,000	3,200	19,000

Our approach to cyanide was that a substance as potent as this would not be present in drinking-water at all. Chemical analysis (Tintometer 1967) showed that, with one exception, all the samples from the seven-million population survey contained less than 0.05 mg/litre, the exception, from a town of some 120,000, containing 0.10 mg/litre of cyanide. This amount whilst being one half the WHO international standard maximum allowable concentration is twice their European upper limit of concentration, a sufficient cause for concern. Here again, the need for continuous and widespread analyses is illustrated. These single results must be found, they may well be the precursor of more serious contamination to follow.

Regarding selenium, our estimations for this element have yet to be made and it is proposed to use the method indicated by Sherratt and Conchie (1969) for this work.

In addition to the WHO listed toxic substances we should remember those materials taken into solution from geological formations, old mine workings, agricultural and industrial wastes, sewage effluents and accidental spillage, hazards which contaminate our reservoirs and rivers used for the conveyance of water from reservoir to intake. We query the presence in solution of the recognized and suspected chemical carcinogens listed by Hueper and Conway (1964) and the contaminants mentioned by Rachel Carson (1969). Many of these substances are not sought as a matter of routine in drinking-water, consequently significant figures proving their presence or otherwise are not available (Reed and Tolley 1969). Of striking interest here is the comment by the Institution of Water Engineers in their evidence submitted to the Central Advisory Water Committee (1970) as follows:

“Also disturbing is that frequently the first knowledge of pollution has been by visual observation (presumably during the hours of daylight) by the staff of the undertaking, or by others. For any water undertaking to have to rely solely upon chance observation for the protection of a product so vital to the community would be courting disaster. If some of the recorded incidents of pollution, which were visually observed, had occurred during the hours of darkness, or had otherwise been missed, the consequences could have been extremely serious.”

Another aspect, not connected with the kitchen tap, but nevertheless having its supply direct from the drinking-water mains is the water used by the artificial kidney machine for haemodialysis (Reed and Tolley 1970). It is not a happy thought that contaminants as indicated in this paper are present at one side of a semi-permeable membrane with the patient's blood at the other.

Finally, the information given in table VI was compiled from many references in the university library and it is reasonable to ask the question:

If figures show that drinking-water delivered through the consumers' taps contains more than the World Health Organization's maximum allowable concentrations or limits of the toxic substances noted in table VI, how can we be sure that patients presenting with any of the effects shown are not suffering as a result of ingesting contaminated drinking-water?

TABLE VI

TOXIC EFFECTS	SUBSTANCES								TOXIC EFFECTS	SUBSTANCES							
	As	Ba	Cd	CN	Cr-6	Pb	Phenolic	Se		As	Ba	Cd	CN	Cr-6	Pb	Phenolic	Se
Abdominal pain	✓		✓		✓	✓	✓	✓	Lassitude						✓		✓
Abortion						✓			Menstrual disturbances						✓		
Adicosis							✓		Metallic taste	✓		✓			✓		✓
Alkalosis								✓	Muscular aches			✓					
Anaemia	✓					✓		✓	Muscular tightness face and neck muscles		✓						
Anaesthesias of hands & feet	✓								Muscular weakness		✓						
Anorexia				✓	✓	✓	✓	✓	Nausea	✓	✓	✓	✓	✓	✓	✓	✓
Anuria					✓				Nephritis (chronic)	✓							
Anxiety		✓							Nervous irritability								✓
Appetite loss						✓			Oedema of mucosae					✓			
Bradycardia		✓							Oedematous skin	✓							
Carcinogenesis	✓				✓				Oliguria				✓	✓			
Cirrhosis of liver	✓								Pallor					✓	✓	✓	
Constipation						✓			Paraesthesias of hands and feet	✓							
Cumulation	✓		✓			✓			Polyneuritis	✓							
Diarrhoea	✓	✓	✓			✓	✓	✓	Salivation	✓		✓			✓		
Dizziness		✓	✓	✓		✓		✓	Skin bronzed	✓							
Drowsiness				✓					Tachycardia				✓				
Dyspnoea		✓	✓		✓				Thirst					✓		✓	
Easy fatiguability								✓	Tremors		✓						
Extrasystoles		✓							Ulceration of mucosae					✓			
Fatigue						✓	✓		Uraemia					✓			
Foetal damage						✓			Urine brown			✓					
Furred tongue								✓	Vertigo					✓			
Garlic breath	✓							✓	Vomiting	✓	✓	✓		✓	✓	✓	✓
Gastro-intestinal irritation				✓				✓	Weakness (general)						✓		
Hair loss	✓	✓							Weight loss	✓		✓			✓	✓	✓
Headache			✓	✓		✓	✓	✓									
Hyperkeratosis of palms & soles	✓																
Hypertension		✓															
Joint pains						✓											

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**The practice nurse—a new look.** J. WESTON SMITH, M.B., D.R.C.O.G., M.R.C.G.P.; J. B. O'DONOVAN M.B., B.S., M.R.C.G.P. *British Medical Journal*, 1970, **4**, 673-677.

The work of a practice nurse employed by a three-man, semirural practice with 9,000 patients is described. In 12 months the nurse saw 4,296 patients in the surgery, and did 1,360 home visits. 838 of these were primary visits, of which only 87 required follow-up by the doctor. Work done by the nurse included electrocardiography, pregnancy testing, and routine blood-pressure recording, in addition to the more traditional tasks. A questionnaire showed that patients accepted this new concept of the nurse's rôle in practice—"Lay people seem to appreciate our concept of the practice nurse, while the medical and nursing professions tend to be hostile."

**Vocational training for general practice: A preliminary report.** J. H. WALKER, A. SMITH, D. IRVINE. *British Medical Journal*, 1971, **1**, 41-43.

A three-year course in vocational training for general practice has been set up in north-east England, in association with the University of Newcastle upon Tyne. The course starts and ends with six-month periods in general practice, with, in between, hospital posts in subjects related to general practice. The course is now in its second year and running smoothly, but there are certain financial difficulties from the viewpoint of both trainers and trainees. The latter suffer an early financial disadvantage vis-à-vis their contemporaries who enter general practice immediately and vocationally untrained. Several such courses have now been started throughout the country and special efforts are being made by the Department of Health and Social Security to evaluate them.