CIWEM Chartered Institution of Water and Environmental Management

Policy Position Statement

Lead in Drinking Water

Purpose

This Policy Position Statement presents a balanced technical view on the complex subject of Lead in Drinking Water, recognising both the significance of public health implications and the enormity of the potential costs involved with further actions to reduce lead concentrations, and encouraging solutions that are environmentally sustainable. It has been updated in the light of information recently published by the World Health Organization (WHO).

CIWEM's Position on Lead in Drinking Water

1. The European standards for lead in drinking water are fully justified to protect public health. The current interim standard of 25 µg/l will be tightened to 10 µg/l in December 2013, providing a greater level of safety. These standards apply at consumers' cold water taps.
2. A further tightening of the lead standard may be necessary, as health concerns have increased, and it will be essential for a holistic approach to be taken that is achievable in practical terms. The World Health Organization has retained its guideline value of 10 µg/l in the 4th Edition of Drinking Water Quality Guidelines (WHO, 2011), but it has been given provisional status on the basis of achievability.
3. Problems with sampling for determining compliance have been identified in many EU countries (but not the UK) and the specification of a harmonised sampling methodology by the European Commission is long over-due. Recommendations to the European Commission (Hoekstra *et al*, 2008) that are welcomed will:

   (i) incorporate risk assessment and risk management in a revision of the EU Drinking Water Directive, highlighting metal pick-up from domestic pipework systems, particularly lead;

   (ii) encourage operational monitoring additional to compliance monitoring; and

   (iii) adopt random daytime sampling as the harmonised method for assessing compliance with standards for lead (and copper and nickel).
4. Wholesale replacement of lead pipes in the UK would involve great cost and inconvenience and is complicated by lead pipes being partly owned by the water supplier and partly owned by the property owner. Nevertheless, replacement of all lead pipes must be the long-term aim and a strategy for doing this should be developed. In the meantime, the proactive replacement programme (DWI, 2010) for lead pipes in public buildings is welcomed. The partial replacement of lead pipes to a home (such as just removing the lead pipe section owned by the water company) is not recommended

as lead concentrations can be increased as a result of physical disturbance in such circumstances, at least in the short term.

5. Reducing the plumbosolvency of water supplies (how readily they dissolve lead) by dosing with a corrosion inhibitor (most commonly orthophosphate) can, depending on circumstances, offer a rapid, comprehensive and low-cost approach for achieving substantial compliance with EU lead standards.

6. Optimisation of plumbosolvency control by treatment requires:

   (i) correct pH conditions;

   (ii) correct orthophosphate dose;

   (iii) adequate organics removal (particularly colour); and

   (iv) distribution networks to be free of significant iron discolouration problems.

   About 95% of water supplies are now dosed with ortho-phosphate in the UK and following optimisation in England and Wales, 99.8 % of random daytime samples complied in 2010 with the current lead standard of 25 µg/l and 99.0 % complied with the future lead standard of 10 µg/l. Compliance in Scotland and Northern Ireland is fairly similar.

7. Where orthophosphate dosing of water supplies is practised, an objective assessment of its environmental impact in wastewater catchments should be considered, to ensure that any subsequent environmental controls are justified.

8. Corrective action to reduce lead in drinking water will depend on local circumstances and economics, and must be balanced with environmental impact. Whichever corrective action is taken, the intention must be to protect public health, regardless of any complications arising from the split ownership of lead pipes.

9. Across main-land Europe there is scope for a better understanding of the complex inter-related issues relating to lead in drinking water, particularly because some Member States have not historically sampled from consumers' premises and have little relevant data.

10. Small and very small water supply systems are particularly vulnerable as often treatment is either poorly maintained or simply unavailable. Best Practice Guides are now available from the International Water Association that span all sizes of water supply systems (IWA, 2010 a, b).

CIWEM is the leading independent Chartered professional body for water and environmental professionals, promoting excellence within the sector.

Context

Lead is a cumulative poison that affects the nervous system and can retard some aspects of child development (both size and intelligence). The World Health Organization, in its booklet on Childhood Lead Poisoning (WHO, 2010) has drawn attention to:

(i) recent research that indicates that lead is associated with neurobehavioural damage at blood levels of 5 µg/dl and even lower (hitherto, 10 µg/dl has been considered to be the trigger for concern);
(ii) there appears to be no threshold level below which lead causes no injury to the developing human brain;
(iii) an increase in blood lead level from < 1 to 10 µg/dl has been associated with an IQ loss of 6 points; and
(iv) further IQ losses of between 2.5 and 5 have been associated with an increase in blood level over the range 10 to 20 µg/dl.

The potential link with lead in drinking water is considered important (IWA, 2011) and an average concentration of lead in drinking water of 20 µg/l has been associated with a blood lead concentration of between 10 and 15 µg/dl, in generalised terms, although specific impacts from lead in drinking water will depend on individual consumption patterns and age. The Joint FAO/WHO Expert Committee on Food Additives re-evaluated lead in June 2010 and withdrew the provisional tolerable weekly intake guideline value for lead on the grounds that it was inadequate to protect against IQ loss. This guideline value had been used as a basis for determining WHO's guideline value for lead in drinking water of 10 µg/l. It is therefore possible that WHO may lower its guideline value for drinking water in the future. For the time being, WHO (2011) has retained its guideline value of 10 µg/l for lead in drinking water, but as a provisional guideline on the basis of achievability.

Lead pipes were used up to the 1980s both for connecting a property to the water supply main and for internal plumbing, due to lead's strength, malleable nature and resistance to corrosion. In the UK, about 40% of properties are supplied via a lead pipe. Elsewhere in Europe, the estimated percentage of properties supplied by lead pipe-work varies from <5 to 50 per cent.

Although the rate of corrosion of the internal lead pipe wall is very small, lead dissolution into drinking water can very occasionally still reach concentrations of several milligrams per litre (parts per million), way in excess of the concentrations considered to be safe for regular ingestion (parts per billion). Lead pipes are, by far, the commonest source of lead in drinking water. There is no lead in the water suppliers' distribution network, as the materials used for water mains are iron, plastic or asbestos cement. Short-term contributions are possible from some pipe-work fittings (particularly brass) and from the galvanic (electro-chemical) corrosion of lead-containing solders (which are now prohibited for use in drinking water systems) used to join copper pipes. The lead that dissolves mostly remains in solution but contact with iron corrosion deposits from old iron mains can result in the lead being converted to a particulate form. As the extent of the problem of lead in drinking water has become clearer, standards for drinking water have been tightened and much attention is being given to the recently implemented standards that derive from the European Drinking Water Directive of 1998. Such standards do not differentiate between the soluble and particulate forms of lead.

A standard of 25 µg/l has applied since December 2003 at the point of use by the consumer (commonly regarded as the kitchen sink tap). Although this standard is expressed as a weekly average concentration, it has been implemented more stringently in the UK as a maximum concentration because of the way compliance samples are obtained (through random day time samples of the first litre of water that issues from the tap when the sampler visits, taken from randomly selected properties). This standard tightens to 10 µg/l in December 2013 although the UK Government has already required some corrective measures to be taken in an attempt to achieve the tighter standard much sooner, as far as it is practicable to do so.

Key Issues

A Europe-wide problem

The concentration of lead in drinking water varies quite considerably, as a function of how much lead pipe is present, water-pipe contact time and the corrosivity of the water, making it difficult to characterise by sampling. This has made the optimisation of corrective measures much more difficult and many water suppliers have used additional investigational tools, including testing the corrosivity of the water, lead solubility modelling and computer simulation of lead emissions across whole zones (using probabilistic techniques). The UK has a comprehensive understanding of the extent of lead in drinking water problems as a result of widespread sampling at consumers' taps for over twenty years. In contrast, many other European countries have very little knowledge of the extent of the problem because they have not routinely monitored consumers' premises, or have done so only after flushing the pipework. The root cause of these problems is that the EU Member States failed to agree a harmonised monitoring method for copper, lead and nickel at the tap, making the current Drinking Water Directive inoperable for these parameters. On the basis of evidence gained by an international research network (COST Action 637) it appears that problems with lead in drinking water are widespread in Europe. The full extent of the problem will only emerge when monitoring deficiencies have been resolved. For the time being, it has been estimated (IWA, 2010) that up to one in four children in Europe could be at risk from lead in drinking water, but not in the UK because of the comprehensive actions taken.

Pipe replacement

The ultimate solution to the lead in drinking water problem would, very simply, be to replace all the lead pipes (water suppliers and property owners), but this is not without a range of problems:

- In many cases, the ownership of the lead piping is split between the water supplier and the property owner, complicating legal aspects
- Consumers do not perceive lead in drinking water to be a problem (as it cannot be seen, tasted or smelt) so are therefore reluctant to take expensive (and disruptive) action themselves.
- The cost of replacing lead pipes is high – for example, the cost of replacing all lead pipes in the UK has been estimated at between £8 billion and £10 billion.

- The density of properties with lead piping can be as high as 75% in many towns and cities, and any concerted replacement programme would cause considerable disruption to road users and property owners.
- A question also arises: is it acceptable to simply leave old lead pipes in the ground or should they be removed and disposed of properly?

The long-term aim must be to replace all lead pipes. However, it will be necessary to recognise the deep reluctance of many property owners to replace their pipes (due to the inherent cost, disruption and inconvenience). Consideration should be given to new regulations that would require a dwelling to be certified as lead pipe free at the time of its sale or letting; this would take 25 or more years to be fully effective, but costs would be spread (water companies would be required to replace their lead pipes at the same time). It is appropriate that replacement of lead pipes in buildings used by the public (eg. hospitals, schools, offices) should be enforced by regulations, over a shorter, albeit realistic timescale. In appropriate circumstances, grant aid may need to be available.

Consumers can also be encouraged to take other measures themselves to reduce exposure. Flushing standing water from the pipework after a period of non-use has been advocated but recent research suggests that it would be necessary to flush pipework before every period of use, resulting in considerable increases in water consumption. Another option, widely used in the US, is to fit simple point-of-use treatment (filtration/absorption) devices; however, it can be difficult to gauge when such treatment units have become exhausted and therefore ineffective.

Particularly in small and very small water supply systems, lead pipe replacement may be preferred as the strategic means for achieving compliance. However, benefits will be limited if a water supplier replaces its part of the lead connection pipe but the property owner does not replace his/her part of the connection pipe and internal plumbing. Indeed, lead concentrations can increase in such circumstances, at least in the short term. The opportunistic replacement of lead connection pipes by water companies, for example during mains refurbishment programmes, should be considered carefully as part of a routine risk assessment and any perceived risks should be mitigated. Water suppliers should continue to take active steps in their area to prevent the use by plumbers of lead-containing solders in drinking water systems and should actively promote the use of brass fittings that have a lead content no higher than 0.25% in recognition of a recent tightening of the definition of "lead-free" in the US. For small and very small privately owned water supplies, total lead pipe replacement should be pursued by the regulatory agencies. In such cases, any problems with lead in drinking water will be amplified when water quality is poor and inadequately treated.

Orthophosphate dosing

An alternative preventative approach is to reduce the plumbosolvency of the water supplies. For low alkalinity supplies (<50 mg/l as $CaCO_3$) much can be achieved by increasing the pH to above 8.0 but UK experience has shown that the dosing of orthophosphate (a corrosion inhibitor) in the typical range 0.5 to 1.0 mg/l P is also required if the new European standards are to be achieved to a substantial degree. High alkalinity waters do not respond sufficiently to pH elevation and plumbosolvency reductions are achieved by orthophosphate dosing alone, albeit at a higher dose (typically 1.0 to 1.5 mg/l P).

Orthophosphate dosing must be optimised in order to achieve substantial compliance with the tighter standard of 10 µg/l whilst minimising environmental impacts of the additional orthophosphate on receiving waters. Such optimisation is not straightforward because of the limitations inherent in sampling and additional techniques should be considered (such as corrosivity testing, solubility modelling and zonal emission modelling). Optimisation of orthophosphate dosing is largely concerned with establishing the correct concentration, complicated by changing seasonal requirements and by the fact that all water supply areas have their own specific requirements, as determined by how much lead piping is present and by the plumbosolvency of the supplies. Optimisation also requires the correct pH to be maintained, natural organic constituents of the water to be minimised and the distribution network to be kept free from iron discolouration problems.

Optimised orthophosphate dosing will continue to be necessary until such time as all lead pipes have been removed, including those owned by consumers. Particularly in the light of WHO's booklet on Childhood Lead Poisoning and FAO/WHO's withdrawal of the provisional tolerable weekly intake guideline value for lead on the grounds that it was inadequate to protect against IQ loss, there is no scope for water companies in the UK to relax the very high standards of corrosion control that they have achieved in recent years.

The UK approach

In the UK corrective treatment has been promoted, as opposed to the widespread replacement of lead pipes, as an appropriate first stage of achieving the new European standards for lead in drinking water. As a consequence, about 95% of the UK's public water supplies are now dosed with orthophosphate and it has become apparent that very substantial compliance has been achieved with not only the interim standard of 25 µg/l but with the future standard of 10 µg/l in England and Wales, 99.8% of random daytime samples complied in 2010 with the current lead standard of 25 µg/l and 99.0 % complied with the future lead standard of 10 µg/l. The positions in Northern Ireland and Scotland are moving towards these levels of compliance. The DWI (2010) has recently issued further guidance to water companies, based on an integrated package of measures to mitigate lead risks, including responding to regulatory failures, requiring owners of public buildings to take appropriate action, opportunistic removal of lead communication pipes, working with health protection teams to identify vulnerable consumers, and raising awareness in consumers and other stakeholders.

Discussion

The UK's widespread use of orthophosphate is consistent with practice in the USA but contrasts to many other European countries where the dosing of orthophosphate to water supplies is considered to be unacceptable on environmental grounds. The environmental concerns relate to the eutrophication of water bodies and the possible prolific growth of algae, some of which can be toxic. Whilst this linkage is of course possible, the overall perspective relating to the orthophosphate dosing of water supplies appears to be missing. Whereas the concentration added to water supplies for the purpose of reducing plumbosolvency is most commonly about 1 mg/l P, the sewage derived from water use commonly has an orthophosphate concentration of about 10 mg/l P, i.e. ten times as much (this is derived mostly from human waste and to a lesser extent from detergents). Therefore orthophosphate dosing of water supplies is not critical with respect to eutrophication and the European stance poses a number of questions:

- If eutrophication is such an important issue, why has it not been considered necessary to remove phosphate from treated sewage effluent for the great majority of sewage treatment works?
- In cases where nutrients are considered to be a problem (or a potential problem) why does existing European legislation require phosphate removal down to only 1 or 2 mg/l P (depending on size of works) when it is well known that the limiting concentration of phosphate in receiving waters is below 0.01 mg/l P?

It can be concluded that the environmental aspects of dosing phosphate to water supplies need to be properly balanced with the public health consequences of not taking comprehensive action to reduce plumbosolvency, at least in the short to medium term. Whichever corrective actions are taken, the intention must be to protect public health, regardless of any complications arising from the split ownership of lead pipes.

The possibility of WHO tightening its guideline value for lead in drinking water needs to be considered. Whereas compliance with the current guideline value (and future EU standard) of 10 µg/l has been shown to be technically feasible, at least to a level of 99%, compliance with a lower guideline value may not be practicable. It will be essential for water practitioners, health officials, regulators and policy makers to work closely together on any such developments.

July 2011

Note: CIWEM Policy Position Statements (PPS) represents the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review, that previously held views may alter and lead to revised PPS's. PPSs are produced as a consensus report and do not represent the view of individual members of CIWEM.

References

Drinking Water Inspectorate (2010). Guidance on the implementation of the Water Supply (Water Quality) Regulations 2000 (as amended) in England. September 2010.

Hoekstra, E J, Aertgeerts, R, Bonadonna, L, Cortvriend, J, Drury, D, Goossens, R, Jiggins P, Lucentini, L, Mendel, B, Rasmussen, S, Tsvetanova, Z, Versteegh, A and Weil, M, 2008. The advice of the Ad-Hoc Working Group on Sampling and Monitoring to the Standing Committee on Drinking Water concerning sampling and monitoring for the revision of the Council Directive 98/83/EC. European Commission Joint Research Centre, EUR 23374 EN – 2008.

International Water Association (2010a). Best Practice Guide on the Control of Lead in Drinking Water. IWA Publishing. ISBN 9781843393696.

International Water Association (2010b). Guide for Small Community Water Suppliers and Local Health Officials on Lead in Drinking Water. Editor, IWA Publishing. ISBN 13 9781843393801

International Water Association (2011). Comments on the WHO Booklet "Childhood Lead Poisoning". Available to download from the IWA Water Wiki via www.iwahq.org

World Health Organization (2010). Booklet on Childhood Lead Poisoning. ISBN 978 924 150033 3

World Health Organization (2011). Guidelines for Drinking Water Quality. 4th Edition. ISBN 978 924 1548151