Outline of the Significance of Parameters

Introduction

The classification of a water as potable (i.e. fit for drinking) or otherwise is based on the requirements of the European Communities (Drinking Water) (No 2) Regulations 2007 (S.I. No. 278 0f 2007). The Drinking Water Regulations cover a total of 48 bacteriological, chemical and physical parameters for each of which an upper concentration limit or parametric value is specified. There are two further parameters for softened waters which fix Minimum Required Concentrations (MRC).

The relevance of the various standards depends in large part on the local circumstances, which apply to a given water supply. For example, if the source is a boggy surface water, consideration of colour and pH (i.e. acidity or alkalinity) may be important. In a mineral-rich area the presence of iron or manganese may be a major influence on quality.

As a general rule in Ireland, the most important standards are those which relate to contamination by sewage or animal slurries. The relevant standards are those for "Total Coliforms" and "Faecal Coliforms" though others may also be applied in particular circumstance. This section provides details of the extent of compliance (or otherwise) with the Regulations for 16 principal water quality parameters.

1. Aluminium

Aluminium is one of the most abundant elements in the earth's crust. A salt, aluminium sulphate, is very widely used for colour and colloid-removal in the treatment of waters for drinking. The World Health Organisation (WHO) suggests that human exposure to aluminium may occur through a variety of routes, with drinking water probably contribution less than 5% of the total intake.

The WHO Guidelines for Drinking-Water Quality (Draft 3rd Edition) states that "On the whole, the positive relationship between aluminium in drinking water and Alzheimer's Disease, which was demonstrated in several epidemiological studies, cannot be discounted. However, strong reservations about inferring a causal relationship are warranted in view of the failure of these studies to account for demonstrated confounding factors and total aluminium intake from all sources. Taken together, the relative risks of Alzheimer's disease from exposure to aluminium in drinking water above 100 ug/l (i.e. 0.1 mg/l), as demonstrated in these studies, are low". The 2007 Regulations set the parametric value at **200µg/l**.

2. Ammonium

Ammonia is generally present in natural waters, though in very small amounts, as a result of microbiological activity, which caused the reduction of nitrogen-containing compounds. When present in levels above 0.1mg/1 N sewage or industrial contamination may be indicated. The 2007 Regulations set the parametric value at **0.3mg/l**.

3. Total and Faecal Coliforms

Faecal coliforms originate in human and animal waste. Total coliforms include faecal bacteria and also other bacteria with similar properties which originate in soil and are non-faecal. The risk of infection to consumers from drinking contaminated waters will vary depending on the numbers of pathogenic organisms present (i.e. the actual disease-causing organisms). To ensure a high factor of safety when testing for coliform contamination, the practice has been to monitor indicator organisms. To date the universal indicator organisms have been coliforms, specifically Escherichia Coli. These bacteria are of definite faecal origin (human and animal) and are excreted in the vast numbers. Their presence in a water supply is taken as proof that faecal contamination has occurred and it is therefore a definite indication of the risk that pathogens may be present. The absence of these faecal coliforms indicates strongly the probability that pathogens are absent. Some coliform organisms are able to grow in soil and are not of faecal origin thus a second analysis is carried out for the presence of total coliforms, giving an indication of the general level of microbiological contamination of water. The 2007 Regulations set the parametric value for e- coli and enterococci at **0**, but may be quoted as **<1** in drinking water results.

4. Colour

Natural colour reflects the presence of complex organic molecules derived from vegetable (humic) matter such as peat, leaves, branches and so on. The more vegetable matter there is in water the

greater the colour. Objections to high colour are generally made on aesthetic rather than health grounds. Consumers are reluctant to drink water, however safe, which has a strong colour. The 1998 EU Drinking Water Directive, in contrast to its 1980 predecessor, did not set a quantitative standard for colour, effectively leaving the matter to the reactions of consumers.

5. Fluoride

Fluoride arises almost exclusively from fluoridation of public water supplies and from industrial discharges, although it occurs naturally in quite rare instances. Health studies have shown that the addition of fluoride to water supplies at levels above 0.6mg/l F leads to a reduction in tooth decay in growing children and that the optimum beneficial effects were thought to occur around 1.0 mg/1[3]. At levels markedly over 1.5mg/1 an inverse effect occurs and mottling of teeth (or severe

The permissible range of fluoride in drinking water is legally restricted to the range 0.6 – 0.8 mg/l. as set out in the Fluoridation of Water Supplies Regulations 2007 (S.I No. 42 of 2007). In making the European Communities (Drinking Water) (No 2) Regulations 2007 (S.I. No. 278 0f 2007) the Minister for the Environment fixed **0.8mg/1 F** (800ug/1 F) as the maximum parametric value in the case of waters to which fluoride is added. There are no cases of naturally high level of fluoride in this county.

6. Heavy Metals

Heavy metals are a very important category of drinking water parameters and comprise principally antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, tellurium, tin, titanium, uranium, vanadium and zinc. Arsenic, though non-metallic, is included for convenience as it is toxic and is generally referred to as a constituent of this group. Heavy metals specified in the 2007 Regulations include Copper, Arsenic, Cadmium, Chromium, Mercury, Nickel, Lead, Antimony and Selenium. Sources of heavy metals include effluent discharges, distribution piping, or geological formations. Heavy metals are toxic to humans (to a greatly varying degree depending on the metal) and, to a lesser extent, fish. They bio accumulate in fish and other animals tissue and are hence liable to enter the human food chain. The 2007 Regulations set the parametric values as follows:

Metal	Limit	Units
Copper	3.0	mg/l
Arsenic	10	µg/l
Cadmium	5	µg/l
Chromium	50	µg/l
Mercury	1	µg/l
Nickel	20	µg/l
Lead	25	µg/l
Antimony	5	µg/l
Selenium	10	µg/l

7. Iron

Iron is present in significant amounts in soils and rocks, principally in insoluble forms. However, many complex reactions which occur naturally in ground formations can give rise to more soluble forms of iron which will therefore be present in water passing through such formations. Appreciable amount of iron may therefore be present in ground waters. Serious problems can be caused in drinking water supplies by the presence of iron. Problems with iron are primarily aesthetic, as the soluble (reduced)ferrous (Fe++) iron is oxidised in air to the insoluble ferric (Fe++) form, resulting in colour or turbidity (or, in severe cases, precipitate formation). Laundry may become stained if washed in water with excessive iron and vegetables may become discoloured on cooking. Taste problems may also occur. Where iron occurs in the larger, treated public supplies it almost invariable arises from distribution mains made of the metal, and concentrations tend to be not greatly above the parametric value. In smaller supplies – the minor public ones especially the group schemes – its presence is both more frequent and more

pronounced. Such waters are very largely derived from ground waters and the iron is present in the geological composition of the source area. The 2007 Regulations set the parametric value at **0.2mg/l**.

8. Manganese

Manganese is primarily regarded as a "nuisance" parameter, that is, it poses problems of discoloration (both in the water and in laundry or cooking where the water is used) and, if concentrations are very high, it may cause problems with taste and turbidity. It has not been considered a hazard to consumer health but has been considered in detail by the WHO. The body has revised its provisional health-based guideline value to 0.4 mg/l (400 ug/1). It should be noted that a water with an exceedance level anywhere near this provisional WHO value would be most unpalatable. The 2007 Regulations set the parametric value at 50 µg/l.

9. Nitrates

Relatively little of the nitrates found in natural waters are of mineral origin, most coming from organic (waste discharges) and inorganic sources, such as artificial fertiliser. However, bacterial oxidation and fixing of nitrogen by plants can both produce nitrates. Most importantly, high nitrate levels in water to be used for drinking will render them hazardous to infants as they may induce the "blue baby" syndrome (methaemoglobinaemia). The nitrate itself is not a direct toxicant but is a health hazard because of its conversion to nitrite which reacts with blood haemoglobin to cause methaemoglobinaemia. Eutrophication of water bodies due to excess nutrient loading is a major environmental issue in Ireland, as it causes adverse impacts on fish and other biota, on abstraction of waters for industrial or domestic use and on recreational activities. The presence of nitrate in ground waters is a cause for suspicion of sewage pollution or of excess levels of fertilisers or manure slurries spread on land. The 2007 Regulations set the parametric value at **50 mg/l.**

10. Nitrite

Nitrites exist normally in very low concentrations, even in wastewater treatment plant effluent, principally because the nitrogen will tend to exist in the more reduced (ammonia; NH3) forms. Nitrite is an intermediate in the oxidation of ammonia to nitrate, and this process can take place in soil. Sewage is a rich source of ammonia nitrogen, and as such, waters which show an appreciable amount of nitrite are regarded as being of highly questionable quality and contamination with sewage is suspected. Levels in unpolluted waters are normally low, below 0.03 mg/l NO2. Values greater than this may indicate pollution. The role of nitrite in methaemoglobinemia has been discussed in the previous section on nitrate. The 2007 Regulations set the parametric value at **0.5mg/l.**

11. Odour

Related to taste, a strong odour from a water for consumption may cause rejection on the part of the consumer. Its cause is normally dissolved volatile organic compounds, small concentrations of which may have significant organoleptic (i.e. associated with the senses) effects. The majority of odour incidences arise from the presence of excess chlorine in the waters delivered to consumers. Chlorine concentrations in drinking water, even when in excess, are not a direct hazard to the consumer. A water which has toxic chlorine levels would be so totally foul and thus utterly repugnant; it would be rejected out of hand by the consumer. Chlorine in levels above the working target concentration of 0.1 – 0.2 mg/l (there is no statutory level for chlorine in drinking water) would make the odour and taste of the affected waters aesthetically unacceptable. Despite this, the World Health Organisation has issued a guideline value of 5 mg/l for chlorine in drinking water.

12. Taste

As with odour, taste is a parameter which can lead to adverse consumer reaction. While astringent tastes can be caused by the presence of excessive amount of metals or dissolved salts, there are often other more serious problems which arise in such cases. Purely organoleptic (i.e. associated with the senses) taste problems arise most commonly from algae and from phenols after chlorination. Decaying algae masses can release trace organic compounds (including phenol) into the water which produce offensive tastes after chlorination.

13. pH

pH is a measure of whether a liquid is acid or alkaline. The pH scale ranges from 0 (very acid) to 14 (very alkaline). The range of natural pH in fresh water extends from around 4.5 for acid, peaty upland waters, to over 10.0 in water where there is intense photosynthetic activity by algae. However, the most frequently encountered range, where most drinking water supplies fall, is 6.5 -8.0.

14. Trihalomethanes

Chlorine (or appropriate compounds of it) is undoubtedly the most important chemical used in water treatment in Ireland today, as it has been in the past. Chlorine in a very dilute solution is a most effective agent for the disinfection of water. It is very efficient at destroying those bacteria which originate in human or animal waste and which cause wholly undesirable and dangerous contamination of drinking water. As a powerful oxidising agent, chlorine also breaks down complex and inert, organic molecules, (giving rise to colour), forming smaller, reactive entities, which in turn react with chlorine (and with bromine derived from the oxidation by chlorine of bromide naturally present) to form the THM compounds, the most abundant of which is chloroform. There is thus a fairly straightforward relationship between the degree of colour in the water prior to chlorination and the quantities of THMs present following chlorination. If high colour is present at the point of chlorination, THMs are likely being formed. Low colour waters exposed to high Chlorine levels may also result in the formation of THMs. THM compounds are undesirable in drinking water for two reasons. Firstly the actual compounds themselves may pose a hazard to the health of the consumer if present in excessive amounts, as chloroform is a suspected carcinogen. Secondly, the presence of the THM group may be an indicator of the possible presence of other organic by –products of chlorination in trace amounts. The WHO advises that "In controlling trihalomethanes, a multistep treatment system should be used to reduce organic trihalomethane precursors, and primary consideration should be given to ensuring that disinfection is never compromised." Trihalomethanes are required to be monitored under the 2007 Regulations and the parametric value for total trihalomethanes is set at **100ug/l** since 25th December 2008.

15. Turbidity

Turbidity in water arises from the presence of very finely divided solids, called colloids (which are not filterable by routine methods), which may affect its acceptability to consumers and also affect markedly its utility in certain industries. The particles causing the turbidity may also interfere with the treatability of waters having adverse consequences for the disinfection process. As turbidity can be caused by sewage matter in water, there is a risk that pathogenic organisms could be shielded by the particulate matter and hence escape the action of the disinfectant.

16. Cryptosporidium

Cryptosporidium is a small (microscopic) protozoan parasite, which may occur in the intestinal tract of humans and animals. It has pathogenic effects in both children and adults when it enters the gastrointestinal tract and causes an infection termed cryptosporidiosis, which can cause fever, stomach upsets, weight loss and diarrhoea and can be fatal in the young and old and those with weakened immune systems. Cryptosporidium is protected by an outer shell (oocyst) permitting it to survive the long periods outside the body. The oocyst is very resistant to destruction by chlorine and other disinfectants, although it is destroyed by boiling water.

There are no standards in current Irish legislation concerning Cryptosporidium in drinking water. The 2007 Regulations required that water supplied should be monitored for *Clostridium perfringens*, as it was considered to be an indicator for cryptosporidium. Turbidity measurement is now regarded as a more reliable indicator and most modern treatment plants include on-line turbidity meters to help reduce the risk of Cryptosporidium entering the supply network. Risk assessments are carried out on supplies annually, looking at the catchment & treatment process, and, where possible, improvement works are carried out to reduce risk of an occurrence.

(Based on extracts from EPA: The Quality of Drinking Water in Ireland: A Report for the Year 2003. Note: as updated for legislation)