Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

JOINT POSITION PAPER
No.1. Nitrates in Drinking Water
April 2010

This position paper has been developed by the Consultant in Public Health Medicine Environment and Health Group and the Environmental Health Service of the Health Service Executive (HSE) in conjunction with the Environmental Protection Agency (EPA).

Introduction

Nitrate is formed when nitrogenous waste in soil or water is decomposed by microbial action. Vegetable matter, human waste discharge and animal slurries are natural sources of nitrates. A major artificial source of nitrate in the environment is nitrogen-containing fertiliser. Nitrate in the soil is soluble and readily migrates with ground and surface water. Contamination with nitrogen-containing fertilisers and animal or human organic wastes can raise the concentration of nitrate in drinking water above acceptable levels. The toxicity of nitrates to humans is mainly due to its reduction to nitrite, which can occur either in soil or in the human gut. Shallow, rural domestic wells are most likely to be contaminated with nitrates, especially in areas where there are more intensive agricultural practices, or on occasion, poorly functioning on-site wastewater treatment systems nearby. Nitrate exceedances may also occur in public water supplies.

European Communities (Drinking Water) (No.2) Regulations 2007 [1]

The parametric values for nitrate and nitrite in drinking water are summarised below.

Table I: Parametric values for nitrate and nitrite in drinking water

Parameter	Parametric value
Nitrate (NO_3)*	50 mg/l
Nitrite (NO_2)**	0.5 mg/l (at the tap) 0.1 mg/l (ex water treatment works)
Nitrate and Nitrite	the sum of the ratios of the concentrations of each to its guideline value should not exceed 1 (Note 4[1])

* The legal limit in the USA is 10mg nitrate-nitrogen (N)/l, equivalent to 44 mg nitrate (NO_3)/l

** The WHO nitrite guideline value is 3mg/l (short-term exposure), 0.2mg/l (provisional long-term exposure) [2]

Acceptable Daily Intake

The acceptable daily intake (ADI)[3] for nitrate is 0-3.7 mg/kg of body weight. A 60kg individual consuming 2 litres of drinking water per day, at 50 mg of nitrate per litre, would result in a nitrate intake of 1.67 mg/kg of body weight/day from drinking water. Further nitrate will be obtained from food. The ADI for nitrite is 0-0.07 mg/kg of body weight.

Public Health Implications

Nitrates are a natural constituent of a normal mixed diet. The main dietary sources are green vegetables and cured meats but in some areas drinking water may make a major contribution. The drinking water standard of 50 mg/l nitrate, originally set by the WHO in 1958, aims to protect bottle-fed infants from methaemoglobinaemia, a condition first reported by Comly in 1945 [4].

The link between nitrate concentration in drinking water and infantile methaemoglobinaemia (IM) is complex and there are several other causes of IM including genetic causes and exposure to other oxidising agents besides nitrates [5]. However, infants are particularly susceptible to IM and drinking water standards which protect them will protect the rest of the population.

IM occurs when bacteria, either in the soil or in the immature infant gut, convert nitrates to nitrites. Nitrites easily combine with foetal haemoglobin to form methaemoglobin, which cannot carry oxygen around the body. The infant presents with central cyanosis (Blue Baby Syndrome), which fails to respond to oxygen. It is treated by replacing nitrate contaminated water in the preparation of feeds. Severe cases are treated with methylene blue. Breastfeeding protects babies from IM and boiling water does not remove nitrate. Simultaneous exposure to microbial contaminants resulting in gastrointestinal infections may increase the risk of IM [6]. After the age of 4 months the gut flora changes, foetal haemoglobin is replaced by adult haemoglobin and reducing enzymes, which convert methaemoglobin back to normal haemoglobin, become more active. As a result infants gradually become less susceptible to IM.

Associations between nitrates and other adverse health effects such as pregnancy complications and cancer have been studied in the scientific literature. While pregnant women are more susceptible to methaemoglobinaemia, epidemiological evidence does not support a causal relationship between nitrates in drinking water and adverse reproductive effects [7]. Also, the ADI for pregnant women is the same as for an adult male. With regard to cancer, nitrate is a precursor in the formation of N-nitroso compounds which are probable carcinogens [8]. However, results of epidemiological studies examining associations between cancer and nitrates in drinking water are inconclusive [9,10].

Scope of the Problem

There is no reliable estimate of the incidence of methaemoglobinaemia associated with drinking water worldwide. It is now rare in most industrialised countries, although occasional cases continue to be reported from rural areas. The Irish Hospital In-Patient Enquiry (HIPE) data indicate that two patients under four years of age were discharged with a diagnosis of methaemoglobinaemia between 1997 and 2006 [11]. The HIPE database does not differentiate between cases caused by nitrates in drinking water and cases which occur as a result of genetic defects or toxicity from other substances. A report in the literature in 1998 describes methaemoglobinaemia in three Irish siblings which occurred as a result of accidental poisoning with sodium nitrate - commonly known as saltpetre and used for curing meat [12].

Nitrate Monitoring in Ireland

Table II shows the number of water supplies with a nitrate exceedance and the number of people on these supplies. Both increased in 2007 in comparison to 2006. In 2007, approximately 16,337 people were on water supplies with a nitrate exceedance. More public water supplies reported an exceedance in 2007 in comparison to 2006. These data do not reflect the magnitude of the exceedance or any potential health impact.

Table II. Summary of Water Supply Zones (WSZs) Non-Compliant with the Nitrate Parametric Value in 2007 and 2006 (EPA, 2009) [13]

	No. of WSZs with Exceedances in 2007	Population Affected in 2007	No.of WSZs with Exceedances in 2006	Population Affected in 2006
Public Water Supply	18	13,886	16	10,209
Public Group Water Schemes	1	42	2	1,904
Private Group Water Schemes	8	2,409	17	3,204
Small Private Supplies	22	N/A	12	N/A
Total	49	16,337	47	15,317

Nitrite Monitoring in Ireland

There are two parametric values for nitrite; one is the concentration at which the water leaves the water treatment works (0.1 mg/l) and the other is at the tap (0.5 mg/l) (Table I). Compliance with the nitrite parametric values in water supplies in Ireland in 2007 was very high – 99.9% at water treatment works and 99.9% at the tap [13].

Legislative Framework

Water Services Authorities (WSAs), 34 City and County Councils throughout Ireland, are responsible for the production, distribution and monitoring of public water supplies. The European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. No. 278 of 2007)[1] set down the drinking water requirements and enforcement procedures. The EPA is the supervisory authority in relation to public water supplies and the Local Authority is the supervisory authority in relation to private water supplies. Both the EPA and the Local Authority have enforcement powers under the regulations. The EPA publishes an annual report on drinking water quality and provides guidance to Water Services Authorities.

The 2007 drinking water regulations require each Sanitary Authority (WSA) to immediately investigate any failure to meet a parametric value specified in the water regulations in order to identify the cause of such failure. Furthermore the Sanitary Authority (WSA) is required to ensure that the remedial action necessary to restore the quality of the water is taken as soon as possible. Also, the 2007 regulations explicitly refer to the role of the HSE in relation to both the water supplier and the supervisory authority. Consultation with and the agreement of the HSE is required if there are any implications for public health.

The Nitrates Directive (91/676/EEC) [14] concerns the protection of waters against pollution caused by nitrates from agricultural sources and was adopted in 1991. The Nitrates Directive requires Member States to identify and monitor susceptible waters and to establish a code of good agricultural practice to protect them. Ireland's national Nitrates Action Programme, a requirement of the Directive, was given statutory effect by the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 [15]. These regulations have been updated [16] and it is the responsibility of the Local Authority to ensure that they are enforced.

Interventions

Protecting the drinking water supply is paramount. This may require Local Authority inspection and enforcement of compliance with the Nitrates Directive and proper management and treatment of sewage and waste water discharges. Where trends show an increasing concentration of nitrate in raw water, action may be necessary. Where nitrate levels repeatedly exceed recommended values in drinking water, intervention is required. In the short term, an alternative supply or blending/diluting with another supply may be needed.

It is possible to remove nitrate from water but treatment is difficult and expensive. There are generally three methods of removing or reducing nitrate in water; reverse osmosis, ion exchange or blending. Reverse osmosis forces water under pressure through a membrane to filter out contaminants. Ion exchange involves replacing nitrate with chloride ions as it passes through an ion exchange resin. Simple household treatment procedures such as boiling, filtration, disinfection, and water softening do not remove nitrate from water. Boiling may increase the nitrate concentration of the remaining water.

Where the nitrate level in a water supply persistently exceeds the parametric value of 50 mg/litre, an advisory notice may be issued by the Water Services Authority (in consultation with the HSE) stating that children under 6 months of age should not consume the water and that nobody should consume the water if levels persistently exceed 100 mg/litre, as this will exceed the ADI. For non-breastfed infants an alternative water supply or bottled water should be used to prepare infant feeds. The legal limit for sodium (Na) in drinking water is 200 mg per litre. Most bottled water is well below this level but the label should be checked. Commercial bottled water is not sterile and should be boiled once and cooled. Ready-to-use formula that does not require re-constitution with water can also be used.

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