



Nitrate in drinking water and other position papers

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What I am going to say

- Brief background on position papers
- Nitrogen, Nitrates and Nitrites
- Legislative Framework
- Public Health Implications
- Magnitude of problem in Ireland
- Interventions
- Conclusions



Background

- In Oct 2006, HSE (Pop Health) and EPA
- ‘memorandum of understanding’
- Joint commitment to health and environment
 - Develop effective working relationships
 - Share expertise and knowledge
 - Collaborate with regard to training
 - Develop joint work and research programmes
 - Establish advisory and consultative committees



Position Papers

- Agreed development of joint position papers
 - Nitrates in drinking water
 - Trihalomethanes in drinking water
 - Radon
 - Aluminium in drinking water
 - Co-incineration of waste
 - Mechanical and biological treatment of waste
 - Arsenic and Chromium



Protocol

- One to one and a half pages in length
- Facts but also proposals for resolutions
- History of problem / how it effects Ireland
- The cause and scope of the problem
- Irelands policies and justification for them
- Evidence to back up Ireland position
- Actions taken by Irish Government
- Conventions and resolutions that Ireland has signed and ratified
- EU actions that Ireland has supported /opposed



Nitrates in Drinking Water

- Nitrates (NO_3^-) are a by-product of Nitrogen
- Sources of Nitrogen include:
 - vegetable matter, human waste and animal slurries
 - nitrogen-containing artificial fertilisers
- Nitrogen decomposed by bacteria to form Nitrates
- Rainfall washes nitrates into ground and surface water – contaminating drinking water
- Toxicity to humans due to reduction to Nitrite (NO_2^-)
- This can occur in either soil or the human gut



Nitrates in Drinking Water

- Shallow rural domestic wells most likely contaminated with Nitrates
- Especially if chemical fertilisers in widespread use
- Exceedances can occur in public water supplies



Broader Legislative Framework

- European Communities (Drinking Water) (No.2) Regulations 2007 (S.I. No. 278 of 2007)
- Nitrates Directive (91/676/EEC)
 - Nitrates Action Programme was given statutory effect by
 - the European Communities (Good Agricultural Practice for Protection of Waters) Regulation 2006
 - Local Authority are the enforcement agency for these regulations



EU Drinking Water Regulations 2007

- 3 Tables
 - Table A – microbiological parameters
 - Ecoli, enterococci
 - Table B – chemical parameters
 - Health based
 - Table C – indicator table
 - Evidence for health effect is weaker
 - Acceptability to consumer (taste and colour)



EU Drinking Water Regulations 2007

- Exceedance
 - Water services authority inform EPA
 - Notify under regulation (complete Appendix A)
 - 10(2) remedial action
 - 9(1) a ‘potential danger to human health’
 - restrict, prohibit or take other action
 - ensure the consumer is informed
 - Collaborate with Environmental Health
 - We are involved in determining ‘potential danger to human health’
 - Not always easy / communicate uncertainty



EU Drinking Water Regulations Nitrate Parametric Values 2007

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

*The WHO nitrite guideline value is 3mg/l (short-term exposure), 0.2mg/l (provisional long term expos)
(ATSDR, US EPA, - Guidelines = 10mg/ l of Nitrate-nitrogen.

50 mg /l of nitrate = 11.3mg/ nitrate nitrogen)



Public Health Implications

- Nitrates are part of a normal diet
 - green vegetables, cured meats, drinking water
 - no apparent adverse effect in adults or children
- DW standard of 50mg/l, set by WHO in 1958 aims to protect bottle-fed infants from infantile methaemoglobinaemia (IM)
- Original hypothesis Comly 1945 'Cyanosis in infants caused by nitrates in well water' JAMA 1987



Methaemoglobinaemia

- Haemoglobin can be oxidised to methaemoglobin – can't carry oxygen - central cyanosis
- Acquired:
 - Exposure to oxidising agents
 - benzocaine, amyl nitrate, aniline dyes, butchers saltpeter
 - nitrates / nitrites in drinking water
 - Babies under 6 months of age particularly susceptible
 - reduced cytochrome B₅ reductase activity
 - high stomach pH
 - foetal Hb easily oxidised
- Inherited
 - Autosomal recessive
 - methaemoglobin reductase deficiency



Fugate Family Troublesome Creek, Kentucky





Babies : predisposing factors to IM

- 1) Infant gut flora has a high pH (not very acidic)
 - bacteria in gut convert Nitrates (NO_3^-) to Nitrite (NO_2^-) more readily
- 2) Foetal Hb is more easily oxidised than adult Hb
 - Nitrite is an oxidising agent
- 3) Young infants have reduced activity of enzyme
 - Less Meth Hb is converted back to normal Hb

Foetal haemoglobin Hb (Fe^{+2}) → Methaemoglobin Hb (Fe^{+3})
Ferrous state → Ferric state



Babies : predisposing factors to IM

From ~ 4 mths babies become less susceptible to IM

- Gut pH reduces (more acidic) and flora change, ↓ nitrates to nitrites
- cytochrome B reductase becomes more active
- Infant starts replacing foetal Hb with adult Hb which is not oxidised as readily



More about IM

- Replace nitrate contaminated water for infant feeds
- Severe cases treated with methylene blue
- Breastfeeding protects babies from IM
- Boiling does not remove nitrate, concentrates it
- Gastrointestinal infection increase the risk of IM
 - Original evidence based on a few cases
 - Guideline value established on based on a case series
 - Adopted since, re-examined and re-endorsed
 - Minority opinion that GI infections cause IM and nitrate is a co-factor
 - Evidence may not support the hypothesis completely but there is no evidence showing that raising the levels in DW is safe for infants



Drinking water versus diet

- Some vegetables are high in nitrogen
- Vegetables contain nitrosamination inhibitors so oxidation of haemoglobin to methaemoglobin is not common
- Cases of methaemoglobinaemia from vegetables have been reported – usually excessive consumption



Other effects of Nitrates

- Adverse effects on pregnancy
 - Pregnant women are more susceptible to MethHb. No evidence of a causal association between Nitrate in drinking water and miscarriage, IUGR and congenital malformations
 - Many reviews, biological plausibility, poor evidence
- Cancer
 - Strong biological plausibility as nitrate is a precursor of N-nitroso compounds a known carcinogen
 - Again, no strong epidemiological evidence of an effect
- Confounding by social class



Nitrate Monitoring in Ireland

Type and number of water supplies not compliant with Nitrate / parametric values in 2006 and 2007

Provision and Quality of Drinking Water in Ireland. A report for the years 2007 and 2008. EPA

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



Incidence of IM

- No reliable estimate worldwide
- Not a notifiable disease
- Rare in developed countries
- Cases continue to be reported
- 1997 and 2006 Irish HIPE data
- Two patients <4 years of age discharged with a diagnosis of methaemoglobinaemia (ICD 9: 289.7, ICD 10: D748)
- Can't determine cause from the database



Nitrate Monitoring in Ireland

- It would be useful if we had continuous nitrate data over time
- Trends in mean levels could then be described
- This could be by source or just pooled nationally
- There is evidence from some Water Services Authorities that the mean level of nitrates is increasing, even though it is well below the EU parametric value
- Some WSAs take action at a level above 25mg/ l in anticipation of a deteriorating situation

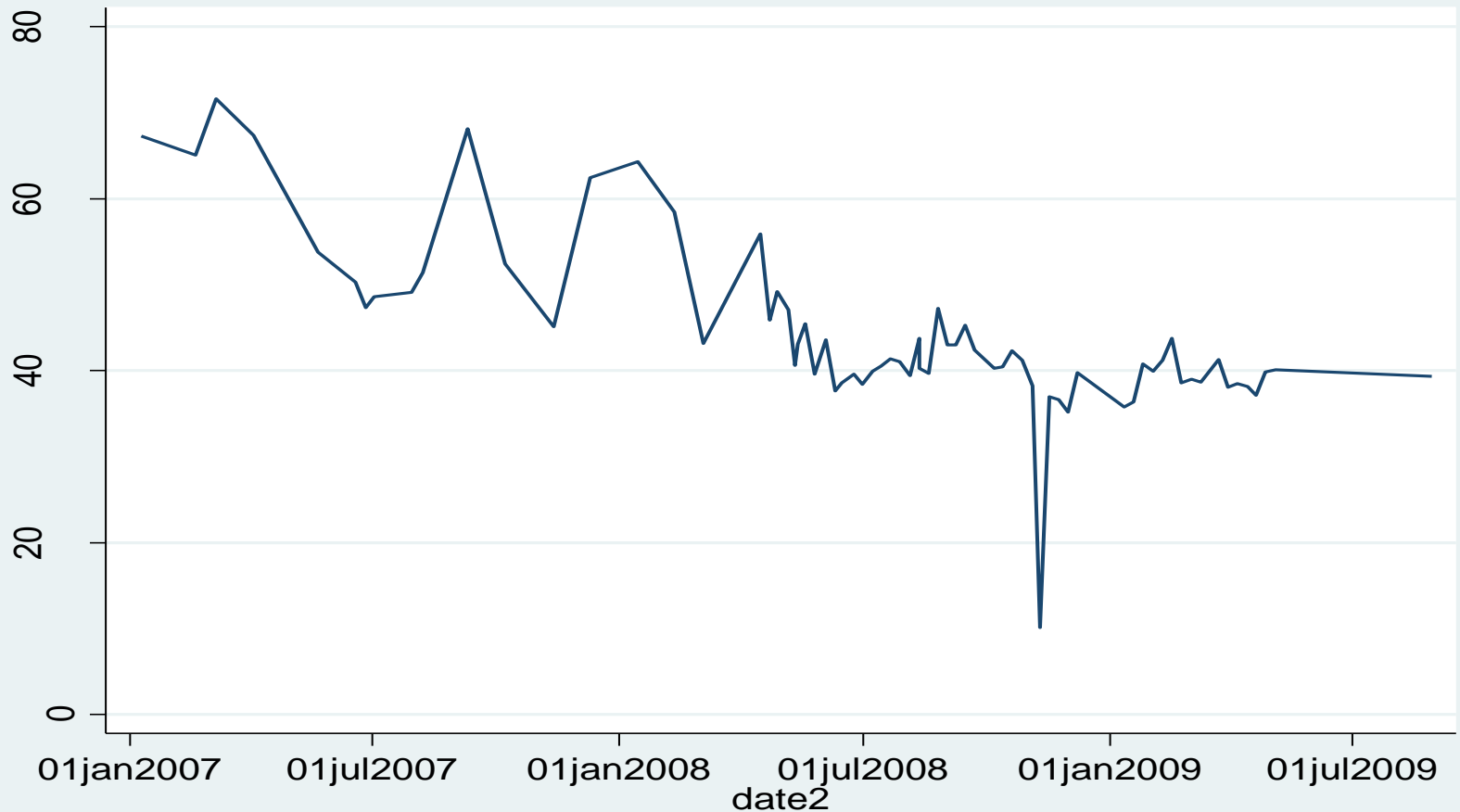


Summary of Nitrate levels (milligrams /l) in a water supply

Year	Mean	95% confidence interval	Range	No. of observations
2007	57.13	(38.9 to 75.33)	(45.14 to 71.6)	14
2008	42.01	(26.6 to 57.37)	(10.1 to 64.31)	39
2009	39.20	(35.3 to 43.05)	(35.7 to 43.72)	17
All	44.35	(25.35 to 63.32)	(10.1 to 71.6)	70



Nitrate levels (milligrams /l) in a water supply from 2007 to May 2009





Interventions

- Protecting the water supply is paramount
 - Requires inspection by LA and enforcement of the regs
- Find an alternative supply
- Removal of nitrates
 - Distillation
 - Reverse osmosis
 - Ion exchange
- Exceedance of 50 micrograms/l
 - Advisory notice not to use for babies under 6 months
- Exceedance of 100 micrograms/l
 - Nobody should use the water (will exceed ADI for adults)



Interventions

- For non-breast fed babies
 - alternative safe water supply
 - ready-to-use formula
 - bottled water should be used
- Bottled water should be boiled
- Bottled water should not exceed EU legal parameters for drinking water
 - Sodium < (less than) 200mg/l
 - Nitrate < (less than) 50mg/l
 - Nitrite < (less than) 0.5mg/l
 - Sulphate < (less than) 250mg/l



Conclusions

- Public health implications
 - IM seems to be rare, but we don't know
 - Effects on cancer and reproduction are uncertain
- Magnitude of problem in Ireland
 - not huge / may be getting worse / ? mean increase
- Wider benefit to protecting supplies
- Interventions
 - new supply
 - nitrate notice
 - treatment



Questions?