THE GSI GROUNDWATER NEWSLETTER

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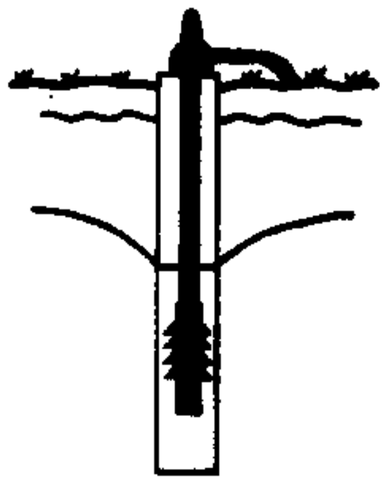

NUACHTÁN SCREAMHUISCE SGÉ

- *Taiscéalaíocht*
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Edited by: Donal Daly.

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IN THIS ISSUE

Rising **nitrates** in groundwater, and to a lesser degree in surface water, has become a major issue in the last 15 years for water engineers and scientists in Britain and in most of mainland Europe. Undoubtedly the main reason for this increase in nitrates in water has been **agricultural practices,** particularly the use of **inorganic fertilizers** and to some degree spreading of organic wastes and ploughing of grassland. Concern about this issue has resulted in a proposed European **Community directive,** which is outlined by Richard Thorn on page 4. **But what is the situation in Ireland? Have we a significant nitrate problem or will we have in the future?** It is not possible to answer these questions with certainty as little research on nitrates has been carried out in Ireland and we do not have a nationwide groundwater quality monitoring programme. A **review** of much of the available data and studies in Ireland is given on page 7 and on page 6 Congella McGuire reports on a **survey on nitrates in groundwater near Fermoy.** Based on this information it is concluded that high nitrates in wells - approaching or greater than the E.C. maximum admissible concentration (M.A.C.) - are usually caused by **point pollution sources** - mainly **farmyards** - although the background levels in some areas have been raised considerably by diffuse sources - spreading of organic and inorganic fertilizers.

Editor

TOXIC WASTES IN EUROPE - PARLIAMENT, PEOPLE, POLITICS, PROBLEMS AND POTENTIAL

3 - People

In the first article in this series I posed the question 'What can public opinion and changes in public opinion tell us about the nature of the problems that we as environmental scientists are going to have to solve?'. Public opinion and concern over environmental matters in the European Community may be gauged in two ways:

1. The response of the public in environmental awareness surveys.
2. The voting patterns at European parliament elections.

The second of these is the subject of the next article in the newsletter.

As part of the activities of the European Year of the Environment in 1986 the European Commission commissioned a major survey of Europeans' attitudes to environmental matters[1]. From the many questions asked during the survey, which dealt with all Member States, I have selected the responses to two for brief examination:

i) The forms of environmental damage considered serious;
ii) The attitude of Europeans with regard to development versus the environment.

In order to elicit information on the forms of environmental damage considered serious the question 'When we talk about possible damage to the environment, what do you think of above all?' was posed. The interviewee was asked to choose three things from a list that included toxic discharges from factories, acid rain, vehicular pollution, litter, noise, unauthorised building, overuse of biocides and fertilisers, waste of raw materials and oil pollution. The response to the question showed clearly that Europeans considered that industrial discharges of toxic materials posed the greatest threat - almost six out of ten mentioned it. Also rated highly were industrial waste and the use of weedkillers and fertilisers. Three distinct groups of countries could be identified on the basis of the seriousness which they attached to the different forms of pollution mentioned in the question:

1. Countries concerned primarily about chemical and industrial pollution, i.e. Germany, Denmark, the Netherlands and, to a lesser extent, Luxembourg and Belgium.
2. Countries where concern about chemical and industrial pollution is high, but still below Community average, and where pollution by consumers, as opposed to production processes, is highly placed. For example, many of the Portugese, Italian, Irish, Greek and Spanish interviewees put the emphasis on litter problems.
3. In France and the United Kingdom the order of importance for the various forms of pollution matched the order for the Community as a whole.

Interestingly, when the survey was repeated in 1988[2], to examine the effect that the European Year of the Environment had had on public opinion, a similar grouping emerged; between Ireland and the southern European countries and their concern for consumer pollution and the remaining countries with their concern for toxic discharges.

Perhaps the most significant aspect of both the 1986 survey and its follow-up in 1988 was the response to questioning on the issue of development versus the environment. To elicit this information the interviewees were asked to note with which of a series of opinions did they agree most. The opinions and the responses to them for Ireland and the Community averages are given in the Table below. Note that the figures in brackets are the responses in the 1988 survey.

	Ireland	Community Average.
Economic development should take priority over environmental issues	23 [21]	9 [7]
It is sometimes necessary to choose between economic development and the protection of the environment	26 [26]	32 [31]
Protecting the environment and preserving natural resources are essential to economic development	40 [42]	50 [55]

The results of this part of the survey show clearly that most Europeans have learnt how important it is to protect the environment. At a European Community level only 7% in 1988 felt that development of the economy should take precedence over environmental questions while 55% of those surveyed felt that protection of the environment was essential to economic development. What is notable about the results in the Table is, with the exception of Ireland, the low proportion of people who felt that development of the economy should take priority over environmental considerations.

The picture that emerges from the survey is one of a population that is, in general, starting to embrace post-materialist values and thus beginning to show a greater degree of concern for the environment. From the professional point of view this indicates that the services of environmental scientists will be called upon with increasing regularity. However, as far as Ireland is concerned, the results of the survey suggest to me that:

i) Although hazardous waste legislation is (or stronger legislation will be) in place, because we consider consumer pollution to be more important than production pollution, it may be difficult to get full public support for actions to reduce or remove pollution caused by toxic industrial discharges, particularly where there appears to be a conflict between jobs and the environment.
ii) The 'jobs versus the environment' debate has not yet been adequately dealt with and at least part of the responsibility to show that it is possible, in most cases, to have economic development with minimum disruption to the environment rests with us, the professional environmental scientists.

1 Commission of the European Communities (1986) The European and their Environment in 1986. Commission of the European Communities. 102pp.
2 Commission of the European Communities (1988) The European and their Environment in 1988. Commission of the European Communities. 14pp. (This is an English summary of a much larger survey, the results of which were published in French).

Richard Thorn, Sligo RTC.

The Proposed 'Nitrate Directive'*

The full title of the proposed Directive is "Council Directive concerning the protection of fresh, coastal and marine waters against pollution caused by nitrates from diffuse sources". The full text of the proposed Directive may be found in OJ No. C 54/4-9, 1989. A number of amendments have been proposed and accepted by the European Commission and these may be obtained from the European Commission offices in Molesworth Street, Dublin.

The Directive consists of 12 Articles and 5 Annexes. Articles 1 and 2 deal with the objectives of the Directive (which are essentially to control nitrate in drinking water and to prevent it from causing eutrophication problems in surface waters) and definitions used within the Directive. Articles 6 to 12 inclusive are administrative and deal with the operation of the Directive. The substance of the Directive is to be found within Articles 3, 4 and 5.

Article 3 concerns the designation of zones vulnerable to water pollution from nitrogen compounds. Article 4 deals with the establishment of criteria governing the maximum number of livestock ha^{-1} and the maximum amount of chemical fertiliser allowable within the designated zones. The article also deals with the establishment of rules governing such activities as the time of spreading of fertiliser and the construction of storage vessels for farmyard wastes. The article further requires the keeping of records of total quantities of nitrogen applied, the number and type of livestock and, if a proposed amendment is incorporated into the Directive, crop yields. Article 5 deals with monitoring of water bodies and with analytical reference methods.

Rising nitrate levels in groundwater and increasing eutrophication of inland, esturarial and coastal waters provide the background to this proposed Directive. Of the many 'environmental' Directives issued by the European Commission and relevant to Ireland this proposed Directive, if it were implemented, could give us the greatest difficulty vis a vis its implementation, at least as far as groundwater is concerned. This is not because we have a problem from diffuse sources (land spreading of animal wastes and chemical fertilisers) but, ironically, because it appears that we do not. This apparent contradiction may be explained by the fact that while we do have problems with high nitrate levels in a number of areas they appear to be derived from point sources of pollution (i.e. septic tanks and farmyards) and are thus, theoretically, outside the scope of the proposed Directive. (See Donal Daly's review of studies dealing with nitrates in Ireland on page 7 of this issue of the newsletter). Since the European Commission has indicated that this is not to be an 'a la carte' Directive with each Member State taking from it what it fancies and leaving what it doesn't, it appears likely that the onus will be on us to prove that it doesn't affect us. The studies carried out to date are not definitive as to the origin of our high nitrate levels. We will therefore have to design and carry out a monitoring programme that definitively identifies the source of high nitrates in groundwater.

Further questions arise concerning the implementation of the Directive.
Who will designate the vulnerable zones?
Who will keep livestock, fertiliser use and crop yield records.

* This item was presented at an I.A.H. Technical Discussion Meeting on "Nitrates in Groundwater" in October 1990.

Richard Thorn, Sligo RTC.

Nitrates: Situation in European Community Groundwaters

Belgium: In the Ardennes area levels in groundwater range from 10-15mg/l; around Brussels levels remain within the range of 20 to 50mg/l, but are steadily increasing; and in north Belgium, where there is intensive agriculture together with cattle and pig rearing, the average nitrate content of small rivers can reach 100mg/l during winter periods and values of 800mg/l have been observed. In order to reduce the problem, the use of nitrogenous fertilizers is limited to 400 kgN/ha and animal production is limited to 4 adult cattle equivalents/ha. Permission is required for storage of slurry in silos within a radius of 2km of public supply wells. Also the spreading of nitrogenous fertilizers (including slurry) is banned from 1st September to 31st January in this area. Newly built animal housing is required to contain 6 months manure storage capacity.

Denmark: 8% of public water supplies exceeded 50mg/l either temporarily or permanently and 18% exceeded 25mg/l. Mean levels in groundwater have tripled in thirty years from 4mg/l to a current value of 13mg/l.

Britain: The highest concentrations occur in Central and Southern Britain where rainfall is lower and agricultural activity is more intense. Levels in some areas exceed 50mg/l and may eventually exceed 100mg/l. It has been predicted that the 50mg/l limit will be exceeded in 39% of the land area of England and Wales in the future.

France: Over a million people are drinking water with a nitrate content of between 40 and 50mg/l. Levels are rising. It is anticipated that between 1990 and 1995 they could exceed 50mg/l in enough supplies to affect 10 million people or almost 20% of the population, compared with 2% at present.

Federal Republic of Germany: Problems arise in areas (i) of light and permeable soils, (ii) regions of intensive agriculture, (iii) where there is intensified ploughing of grassland and (iv) wine growing areas. Streams in the lowland plains average 20mg/l. In 1980 5% of groundwater used for public supply exceeded 50mg/l. Data for 1982/83 showed that 20% of groundwater supplies exceeded 25 mg/l. Levels continue to rise, although attempts are now being made to change agricultural practices so that less leaching would occur.

Luxembourg: Nitrates in the main aquifer ranges between 10-40mg/l.

The Netherlands: Surface water, which supplies 35% of water supplies, has nitrate levels of 15mg/l. Levels in groundwater are rising due mainly to slurry originating from intensive cattle breeding. Water from some private wells contain very high concentrations, up to 400mg/l.

Portugal: No problems.

Spain: Nitrate levels in groundwater in some of the heavily irrigated areas exceed 100mg/l.

Main Source: Commission of the European Communities. Explanatory memorandum to proposed nitrate directive. 1988.

Donal Daly, Geological Survey of Ireland.

Survey of Nitrates in Groundwater near Fermoy Co. Cork.

A survey of groundwater quality in 17 wells and springs was carried out in a 5km^2 area near Fermoy, Co. Cork. This survey is part of a joint study of nitrates in groundwater, being conducted by Teagasc and the Geological Survey of Ireland. It is an intensive dairy farming area, with a relatively high usage of nitrogen fertilizer being applied to grassland (The second highest in the country).

The locality is favoured by a good climate and free draining soils. The geology is dominated by Carboniferous limestone, underlain by Devonian Old Red Sandstone.

In the second week of July 1990, 12 private farm water supplies, 4 group schemes and one public groundwater supply were sampled. The results for which are given in Table 1.

Table I Statistical Summary of the Principle Water Quality Parameters of the 17 Wells and Springs in the Survey (mgl^{-1})

Parameters	Min	Max	Median	Mean	SD	A	EC Limit
Nitrate as N	0.4	10.0	4.5	4.36	2.3	53	11.3
Potassium (K)	1.2	10.7	1.9	2.60	2.2	29	12.0
Potassium/Sodium Ratio (K/Na)	0.1	0.99	0.17	0.23	0.21	18	-
Chloride (Cl)	13.7	25.2	18.2	18.46	3.2	47	-
Sulphate (SO_4)	5.0	17.7	8.8	9.80	3.7	47	-

Note (1) SD = Standard deviation
(2) A = Percentage of samples in which the parameter determined is in excess of the mean.

Two of the sites sampled had water quality close to that expected from natural uncontaminated water, with 0.4 and 1.6 mg/l NO_3-N. These sites are located on a sandstone ridge in an isolated and partially forested area. This water quality may illustrate the role agricultural activities play in nitrate concentration in groundwater as compared to forestry. Only two sites have relatively high nitrate levels of 10 and 8 mg/l NO_3-N. Both of these sites are located on limestone and in the vicinity of farm yards, where there are inadequate storage facilities and poor waste disposal systems in operation.

One site showed a high K/Na ratio of 0.99, so this contamination may be explained by a nearby farmyard. Another site had a high ammonia level of 0.4 mg/l, indicating nearby organic matter point source contamination, probably a septic tank.

Data is available for the public water supply in the survey area since 1983, from Teagasc and County Council sources, and it appears that the nitrate levels have risen from an average of 2-3 mg/l in 1983 to 7-8mg/l in 1990.

Overall the water quality is good, save for the few randomly distributed incidences of contamination, for which there is evidence of pollution from point sources.

Congella McGuire, Environmental Sciences Unit, TCD.

Nitrates in Groundwater in Ireland: A Review*

Assessment of the situation in Ireland is difficult as (i) little research on this topic has been carried out and (ii) there is no nationwide groundwater quality monitoring. There has been a tendency to take research findings in Britain and to apply them directly to Ireland. It is undoubtedly true that inorganic fertilizers are the main source of high nitrates in groundwater in parts of Britain, Czechoslovakia, Denmark and other developed countries. Two questions arise: (a) Is there a problem with nitrates in groundwater in Ireland: and (b) what are the main sources of nitrates in groundwater in Ireland. In order to draw some conclusions, I have reviewed below some of the available data and previous studies.

Groundwater Quality Study in Co. Offaly by GSI (see Groundwater Newsletter No. 13 1989).
Sampled 14 private wells in 1988 along a stretch of road 2km long.
Geology: gravels overlying limestone aquifer; free-draining soils.
Farming: mainly grassland, some tillage.
Results: nitrates ranged from 13-190; high levels randomly scattered, but associated with high potassium levels.
Conclusion: farmyard wastes seeping into groundwater beneath farms were cause of high nitrates and not inorganic fertilizers.

Ballywater Catchment, Co. Louth by Audrey Mooney (see Groundwater Newsletter No. 15 1989).
Sampled 34 private wells in 1989.
Geology: till overlying Silurian grits and slates.
Farming: mainly grassland.
Results: 23 wells (67%) less than guide level (25mg/l), 10(30%) ranged from 25-50mg/l and 1 well had greater than 50mg/l.
Conclusion: Point source pollution (mainly farmyards) was probable cause of high nitrates and not inorganic fertilizers.

Nitrates in the Barrow Valley by Catherine Coxon (see Groundwater Newsletter No. 5. 1987).
Sampled 20 private wells and 1 group scheme well in 1987.
Geology: free-draining glacial deposits over limestone.
Farming: higher proportion of tillage than normal in Ireland.
Results: Levels varied from 5-101mg/l, mean 47mg/l. Eight wells had high K/Na ratios, suggesting organic source of pollution.

Nitrate Leaching in the Unsaturated Zone by Richard Thorn (see Groundwater Newsletter No. 9 1988). This was a Ph.D research project.
Conclusions: 1. Where application of fertilizer nitrogen is less than 200kg/ha, the amount leached is small.
2. Where greater than 200kg/ha is applied, the leaching was more variable, but significant leaching likely.
3. Beneath sugar beet and spring barley the amount of fertilizer leached is proportionately much greater than for grassland, with in most cases 20-40% of the applied nitrogen leached.
4. Leaching of fertilizer nitrogen alone is unlikely to be responsible for the high levels encountered by Catherine Coxon in the Barrow Valley, but it may assist in raising background levels.

Water Quality of the Major Springs in 1985/86 by Eugene Daly (see Groundwater Newsletter No. 13 1989).
195 large springs in 24 counties sampled in 1985/86.

* This review was presented at an I.A.H. Technical Discussion Meeting on "Nitrates in Groundwater" in October 1990.

Results: 85% with nitrate levels less than 25mg/1, 14% 25-50mg/1 and 1% greater than 50mg/1.

Nitrate Concentrations in River Waters in the South-East of Ireland and their Relationship with Agricultural Practice by Michael Neill, Regional Water Laboratory, Kilkenny.
Sampled 7 rivers (Shannon, Suir, Nore, Blackwater, Barrow, Slaney and Burren) monthly or bimonthly between 1979 and 1987.
Results: i) considerable variation between rivers;
ii) large increase in nitrate levels in 1986 with a drop-off in 1987.
Assessment: Although a number of factors were examined to account for the rise in nitrate levels in 1986, the main factors considered were
a) the inorganic fertilizers applied, and
b) the percentage of ploughed land in each catchment.
Conclusions: i) climatic factors caused the rise in levels in 1986.
ii) the ploughing of agricultural land is presently the principal factor effecting the concentrations of nitrates and the application of nitrogen fertilizer alone is not responsible for the high river nitrate concentrations.

1989 Annual Report of the Dublin Region Public Analyst.
1328 samples were analysed from the Midland and eastern counties; if Dublin is excluded, as little groundwater is used here, the number is 986.
Results: 915 (92.8%) had levels less than 25mg/1; 64(6.5%) 25-50mg/1; and 7 (0.7%) greater than 50mg/1. About 50% of the samples were from wells and springs and if it is assumed that all the high nitrate levels came from these, the percentages are 85.6% less than 25mg.1, 13% with 25-50 and 1.4% greater than 50mg/1 (MAC). In contrast 16% of all samples analysed had aluminium levels greater than the European Community MAC!

Overall Conclusions
1. A nationwide programme of regular chemical monitoring of groundwater in representative sources if required.
2. The increased use of fertilizers in Ireland has led to an increase in the background levels of nitrate in groundwater in areas of intensive agriculture - perhaps up to 20-25mg/1 in places.
3. Inorganic fertilizers should not cause the same degree of problems in Ireland as in other developed countries because:
   a) Leaching of nitrate from grassland is less than from tillage crops. Grassland-based agriculture is dominant in Ireland whereas in the problem areas in other countries tillage is dominant.
   b) Our higher effective rainfall in Ireland has a diluting effect. However one factor that is acting against this is the rapid throughflow of groundwater here compared to the major aquifers in other countries.
4. Point pollution sources, particularly farmyards, are the main cause of high nitrates in wells in Ireland, in my view. In areas of free-draining subsoils, soiled water from farmyards either leaks underground readily or is sprayed on adjoining land. The spraying on adjoining land is used as a means of disposal and so the sprinklers/rain guns are not shifted regularly, allowing infiltration of large volumes of soiled water with high nitrogen content.
5. Further research is required. Using data from private wells, which are frequently located near potential point pollution sources, and from which only a small quantity of water is abstracted, is a poor basis for drawing conclusions on nitrates in groundwater in Ireland.

Donal Daly, Geological Survey of Ireland.

Septic Tank Effluent Disposal and Groundwater Pollution

The Newsletter has not contained any items on septic tank systems in recent issues. In case you may have thought that I have forgotten about this topic (and many may wish that I would!) I give below the abstract of a paper presented in Cork last November at a conference "Sewage Disposal: Where do we stand?" organised by the Sherkin Island Marine Research Station.

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Never in the history of humanity has environmental concern and awareness been so great. Much of the concern and debate has been about issues in which individual people can have little discernible impact or influence. However there is one major environmental problem that has received little publicity to date and which we can solve - that is the pollution of water by septic tank effluent. Consider the following points:

i) Septic tank effluent is highly polluting - for instance, containing 9-120 million faecal bacteria per gallon of effluent.
ii) There are over 300,000 septic tank systems in Ireland, producing over 40 million gallons of effluent daily, most of which ultimately enters groundwater.
iii) Groundwater from wells and springs supplies 20-25% of our drinking water overall, but a considerably higher proportion in rural areas.
iv) There are parts of Ireland where a substantial proportion - over 50% in places - of wells are polluted at some time during their use. Many people using these supplies are unaware of this pollution.
v) Septic tank systems and farmyards are the two main sources of pollution.
vi) Drinking water polluted by septic tank effluent is a health hazard.
vii) Up to 40% of the land surface of Ireland does not have "good" subsoil conditions for septic tank systems.

These statements highlight the problem. But, are there solutions? The answer is, undoubtedly, yes! Householders, local authority engineers and planners, environmental health officers and county councillors all have a role to play. The "bottom line" is that:

i) People with septic tanks must become aware and face up to the potential of these systems to pollute water and cause a health hazard;
ii) The Eolas recommendations on septic tank system location must be followed;
iii) Septic tank system location must be given a higher priority by local authorities;
iv) It must be accepted that there are many areas in Ireland which have geological conditions that make them unsuitable for septic tank effluent disposal. Consequently, permission for septic tank systems in these areas should not be given or alternatively the applicants should be required to take remedial measures.

These points are developed further in the paper.

Donal Daly, Geological Survey of Ireland.

IAH NEWS

I.A.H. Technical Meetings

These are informal discussion meetings held at the GSI on the 1st Tuesday of every month (apart from the summer months) at 5.30 p.m. The future topics, dates and speakers are as follows:

7th May "European Community Directives and Groundwater"
Introduced by Kevin Cullen.

4th June "The application of remote sensing to hydrogeology in Ireland".
Introduced by David Ball, E.R.A. (This meeting was arranged on 8th January but was cancelled due to bad weather).

There will be no meetings in April, July or August.

For further information contact either Kevin Cullen (Tel. No. (01) 697082) or Donal Daly (Tel. No. (01) 609511).

Editor

NEWS FROM ABROAD

California

Californians have been ordered to cut water use by a half. A fifth year of drought has prompted the creation of a "water bank" which will transfer water to the neediest areas.
Source: Worldwater and Environmental Engineer. March 1991.

Malaysia: Mineral Water Fraud

Twenty one producers of local brands of mineral water have been ordered to cease operations immediately and withdraw products already on the market by the Health Ministry in Kuala Lumpar. Ministry checks revealed that only one local producer sold genuine products. The others were found to be either tap or well water or a mixture of both.
Source: Worldwater and Environmental Engineer. March 1991.

CONTRIBUTIONS FOR THE NEXT ISUE OF THE NEWSLETTER

The **GSI Groundwater Newsletter** aims to improve communication among the many scientists and engineers involved with groundwater. It includes news, developments, reviews and opinions on all aspects of groundwater - exploration, development, management, water quality, pollution and energy. It is published at three-monthly intervals.

Your contribution to the dialogue would be welcome. These should reach the Geological Survey before **31st May 1991.**