THE GSI GROUNDWATER NEWSLETTER

NUACHTÁN SCREAMHUISCE SGÉ

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Published by the Geological Survey of Ireland. Beggars Bush, Haddington Rd., Dublin 4. ☎ (01) 609511

Foilsithe ag an Suirbhéireachta Gheolaíochta Éireann. Tor an Bhacaigh, Bóthar Hadington, Baile Átha Cliath 4. ☎ (01) 609511

Edited by: Donal Daly.

No. 6. December, 1987

IN THIS ISSUE

Was 1987 an exceptionally bad year for **groundwater pollution incidents?** Hearsay evidence would suggest that this is the case and David Drew provides confirmation on page 2. But was **silage effluent** the only or main source of pollution? The article on page 3 recommends caution in blaming all pollution on silage. Tom Spillane (page 4) outlines a practical, cost-effective means of dealing with **silage effluent** which has the advantage, from a groundwater viewpoint, that only a small effluent collection tank is necessary thus minimising the depth of excavations needed. An excellent booklet **Structures for Silage** is reviewed on page 13. **Synthetic organic chemicals** are the latest pollutants worrying groundwater scientists and engineers in developed countries. Bruce Misstear reviews a British report on the problem on page 5 and suggests that the conclusions may apply to Ireland. Kevin Barton continues with his series on **Applied Geophysics** on page 7 describing the use of geophysics in assessing the geological controls on a spring in Co. Limerick. One of the joys for any hydrogeologist is to tap **artesian water** in boreholes. Eugene Daly succeeded admirably in Co. Kilkenny (see page 9) where the artesian flow from one bore was 1300m^3/d (12,000gph). An interesting and important **court case on the right to abstract groundwater** is described by Geoff Wright on page 10. He follows this up with a description of a recent **conference** at T.C.D. on **Groundwater Effects in Geotechnical Engineering.** A stimulating paper on **waste disposal** is reviewed by Steve Bennett on page 12.

One former contributor, whose contributions will not be accepted in future, suggested irreverently that I should liven up the **Newsletter** by including a "Spot-the-Ball" competition! If anyone has more positive suggestions, let me know.

Donal Daly, Geological Survey of Ireland.

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GROUNDWATER POLLUTION

Groundwater Pollution - Summer 1987

The well publicised pollution of surface waters that occurred this past summer seems to have been matched by severe, localised groundwater contamination, at least in the limestone aquifers of Counties Clare, Galway and Mayo. In the cases investigated by the author there seem to be some common characteristics concerning the pollution:

(i) The pollution this summer was on a scale appreciably greater than noted in previous years.

(ii) Pollution began in mid-June to mid-July and ended mid-August to mid-October.

(iii) Often the pollution occurred in several pulses rather than as chronic low quality water (graph 1).

(iv) Where analyses are available it seems that bacterial pollution was widespread, and that the pulses of such pollution did not necessarily coincide with the chemical contamination presumed to be due to silage effluent (graph 1).

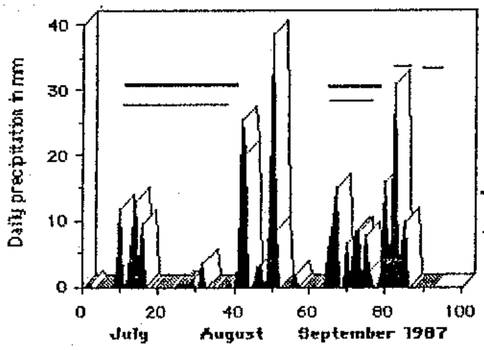
(v) At two sites bacterial contamination was directly proportional to rainfall discharge from springs (see graph 2). Is this remarkable? Would a dilution effect not be expected?

(vi) Pollution episodes were usually associated with heavy antecedent rainfall.

(vii) Extreme localisation of pollution was common even where there was no apparent local pollutant source.

(viii) By no means all of the chemical contamination was clearly derived from silage.

(ix) In addition to the increase in silage making, the pollution was intensified by the warm, humid weather, interrupted periodically by very heavy rainfall events in the late June to early September period.



GRAPH 1

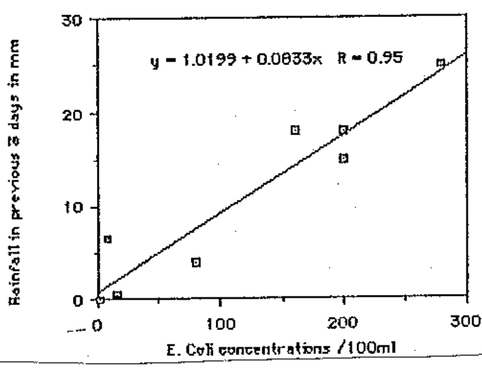
Precipitation & Pollution at a Co. Mayo Spring

Precipitation

Chemical pollution

Bacterial "

Relationship between recent rain and E Coli concentrations



GRAPH 2

David Drew, Department of Geography, T.C.D.

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Silage Effluent - Is it the only source of summer pollution?

There is general awareness of the potential of silage effluent to pollute water. Wells polluted during the summer months are usually blamed on silage. Is this justified? How good is the evidence? The article by David Drew, in this issue, suggests that definite conclusions are difficult to make.

The indicators of groundwater pollution are usually E. coli, manganese (Mn) and sometimes fatty acids. Yet E. coli is not present in silage and it seems likely that silage effluent with its high acidity would kill E. coli. So the presence of E. coli in the polluted well could indicate that silage effluent is **not** the cause. The only situation where silage effluent could mix with E. coli during the summer is on dairy farms where the effluent and wash water are contained together. But the volume of dirty water would be even greater in winter, so why does the pollution only occur in summer?

Manganese can not only indicate pollution from silage effluent, but also from septic tanks, dirty water, slurry or tip site leachate - any pollutant that causes reducing conditions in the ground. Admittedly, silage effluent has a higher B.O.D. than the other sources and would probably result in higher levels of Mn than the others, however, care must be taken in making simplified conclusions.

Fatty acids are regarded as a good indicator of silage effluent. As yet I am not convinced that they cannot be obtained from other sources - perhaps someone would respond to this article with conclusive comments.

If silage isn't the only or main source of pollution, why then does it occur mainly in the summer and what are the other likely sources? Perhaps it is because the pollutants build up in the unsaturated and saturated zones during non-recharge periods and are then washed through rapidly in pulses after heavy rainfall events. The main alternative sources are septic tanks, dairy wash water and in parts of the west of Ireland, the spreading of manure and slurry.

In conclusion, although I believe that silage effluent is a major source of pollution, I suggest that if E. coli is present in the water, an open mind should be maintained when assessing the source of pollution.

Donal Daly, Geological Survey of Ireland.

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Pollution of Water Resources by Silage Effluent

Over a protracted period, investigations by the Dunsinea Research Centre of A.F.T. indicated that a large proportion of surface water and groundwater pollution had periodically emanated from silage effluent. Some surface waters such as rivers and streams may to a certain extent be self-cleansing, but many farm well supplies posed more serious and lasting problems. The reasons for this have already been highlighted in the Geological Survey booklet "Protection of Wells and Springs from Agricultural Pollution" but it may also be added that where, as is the usual practice, ensilage takes place in the same area over many years the soil in that area can no longer act as a biological filter. In extreme cases well waters have become black and foul-smelling due to the production of hydrogen sulphide and new wells have had to be sought. Even in the average mild pollution the family health is unnecessarily put at risk. In addition, other water sources further afield become a hazard to friend, neighbour and fish life.

With the ever increasing production of silage the risk to health continues to escalate and that this should be the case is a grave reflection on our national committment to combatting pollution. The solution to the problem is not difficult for this reason: freshly-cut pasture, i.e. after the previous cut has been ensiled, is an ideal biological filter, particularly where the effluent is spread over a wide area. This objective of land-spreading away from water resources may be achieved by fulfilling the following simple requirements:

i) Direct the effluent by channels to a holding tank of about 100 gallon capacity ($0.46m^3$). A larger tank is unnecessary and expensive.

ii) Screen the ingress to the tank in order to remove straw and other solid matter.

iii) Use a $^1/_4$HP - $^1/_2$ HP centrifugal pump controlled by a floatswitch, to spread the effluent some 100 metres from the silage pit. Such a pump is capable of spreading effluent at the rate of 600 gallons/hour and thus capable of coping with effluent from 2,000-3,000 tonnes of silage.

iv) Neutralisation of effluent is achieved by contact with limestone chips in the collection tank.

Results: (1) Pollution prevention; (2) Irrigation of pasture during relatively dry weather; (3) Useful fertiliser value to pasture; (4) Economy and efficiency.

Tom Spillane and Joe O'Shea*, formerly of An Foras Talúntais
*Deceased

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Synthetic Organic Chemicals - A Major Pollution Hazard

Synthetic organic chemicals pose a major threat to groundwater supplies in Britain, according to a report* just published by the British Geological Survey. Many such chemicals are believed to be toxic at very low concentrations (a few parts per billion or less), yet little is known about their behaviour in groundwater once pollution has occurred. Much more research is needed, say BGS.

The report deals with two specific groups of organic pollutants: pesticides and industrial organic solvents. It shows that concentrations of pesticides in groundwater can exceed EEC guide levels for drinking water even when leaching rates from the soil zone are very low. Soluble herbicides, which are widely used in cereal production, are identified as a particular threat.

The use of industrial organic solvents, such as tetrachloroethylene and trichloroethylene, has increased dramatically since 1945, notably in dry cleaning businesses, leather factories, machine workshops, computer industries etc. However, their pollution hazard has only been recognised recently. Potential sources of pollution are numerous, and include leaky tanks, pipes and sewers, spillages, waste tips etc. These chemicals are often more dense than water and therefore tend to penetrate deeply into an aquifer, where they form persistent pollutants which are difficult to trace and remove. A large spillage can amount to an environmental disaster, say BGS.

In line with this growing concern about organic pollution in Britain, our firm has been involved in a number of assignments recently in East Anglia, both to investigate the extent of such pollution and also to design treatment plants to remedy the problems. Treatment of water contaminated with volatile chlorinated hydrocarbons is normally by aeration and by sorption onto activated carbon filters. The latter process, to bring about almost complete removal of the contaminants, is particularly expensive.

What are the implications of this recent British experience - and similar experiences in the USA and several other developed countries - for Ireland? With less industrial and agricultural development, and a lower population density, the numbers of pollution sources would be expected to be fewer in Ireland. On the other hand, Irish aquifers consist mainly of fissured rocks which would be particularly susceptible to contamination. Therefore, the conclusions of the BGS report about the need for more research and monitoring could also apply to Ireland.

* 'The pollution threat from agricultural pesticides and industrial solvents', by A.R. Lawrence and S.S.D. Foster, BGS Hydrogeological Report 87/2.

Bruce Misstear, Groundwater Development Consultants Ltd.

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Groundwater Quality Monitoring. Conference at the British Geological Survey, Nottingham on 6 October, 1987

This conference dealt mainly with pollution of groundwater by trace organics. Two of the papers were particularly relevant to the Irish situation and the main points are given below.

Groundwater Sampling Techniques for Organic Micropollutants by Lewis Clark and Keith Baxter (Water Research Centre, U.K.)

Contamination of samples during sampling is a major problem. Lewis Clarke showed showed results from a borehole in an aquifer confined by 200m impermeable rock and with water thousands of years old. Yet the sample contained very low concentration of human generated trace organics indicating corss contamination during sampling. He suggests nylon and PVC tubes should not be used as they can contaminate the sample, and advocates the use of stainless steel, teflon and glass. Equipment must be kept clean.

It is difficult to obtain representative samples. Lewis showed one case where the concentrations varied considerably during 24 hours pumping.He suggests three methods of sampling in 6"+ boreholes:

a. Use a 4" pump to extract four well volumes and then sample with a small second pump which uses a teflon rising main.
b. Use a packer system to abstract water at different depths.
c. Use *in situ* steel samplers with teflon pipes.

All have advantages and disadvantages and pre-planning is essential.

Obtaining sufficient numbers of samples for statistical analysis is seldom feasible.

Sampling and analysing for trace organics is very expensive.

Sampling of Groundwater in Fractured Rocks by Dr. John Cherry, University of Waterloo, Canada.

Sampling in fractured rock is usually difficult and complex. In Canada, monitoring boreholes are usually cored to enable the fissures to be located and the sample points are normally set opposite the fissures. The University of Waterloo have developed a sampling system which enables multi level sampling and measurements of hydraulic head and hydraulic conductivity in 75mm diameter boreholes to depths of 150-200m. The sampling levels are separated hydraulically by packers that inflate during installation. Water samples can be drawn from the sample points or a sampler can be dropped down to the sampling area. This is a sophisticated and expensive sampling system, yet according to John Cherry it is a cost-effective method of sampling properly for trace organics in fractured rocks.

sampling properly for trace organics in fractured rocks.

Other points that arose from the meeting were as follows:

i The EEC limits for trace organics were considered by several speakers as too low and not based on toxicological evidence, whereas the WHO and US EPA recommendations are scientifically based.

ii Dry cleaning and degreasing establishments are major potential sources of pollution.

iii The cost of chemical analyses for inorganic constituents is likely to decrease due to automation. John Cherry mentioned one firm in the US who are charging £20.00 Stg for analysing a suite of 21 constituents.

iv John Cherry implied that pollution of groundwater by trace organics is a major issue and that at present only "the tip of the iceberg" is seen.

Donal Daly, Geological Survey of Ireland.

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GROUNDWATER DEVELOPMENT

Applied Geophysics in Groundwater Exploration

2. Resistivity - Vertical Electric Sounding (VES)

The VES technique was used by Gerry Sheehan in the Kilmallock area, Co. Limerick. The objective of the survey was to investigate the geological controls which give rise to a series of springs in an area with little outcrop and extensive drift cover.

VES data can be transformed using graphical and/or computer-based techniques to provide a layered resistivity model. This layered model, which extends vertically downwards at the centre of the sounding, can be interpreted in terms of possible geological strata, or layers which may give rise to it. The interpretation technique makes the sometimes large assumption that geological strata penetrated by the VES are homogenous and exhibit horizontal bedding or layering within the survey area. The Barker Cable, which utilises the Offset Wenner array (Barker, 1981)*, (used in this survey) offers a means of reducing the effects of near surface lateral resistivity variations which often occur within the area of a VES.

In this survey a series of soundings were conducted to find the depth to, and nature of, the bedrock in the vicinity of springs which rose at a break in slope. To the south of the spring line one sounding (Fig. 1a) found thick drift and did not penetrate bedrock. A second sounding (Fig. 1b) to the south of, but closer to, the spring line revealed thinner overburden underlain by higher resistivity, possibly weathered bedrock. A series of soundings (Fig. 1c) north of the spring line showed thin overburden overlying bedrock which had relatively high resitivities. The resistivity data were interpreted in conjunction with other geophysical' survey results (see Article 3 in the next issue of the Newsletter) and available geological data to propose that the spring line occurred along a geological fault or fracture zone.

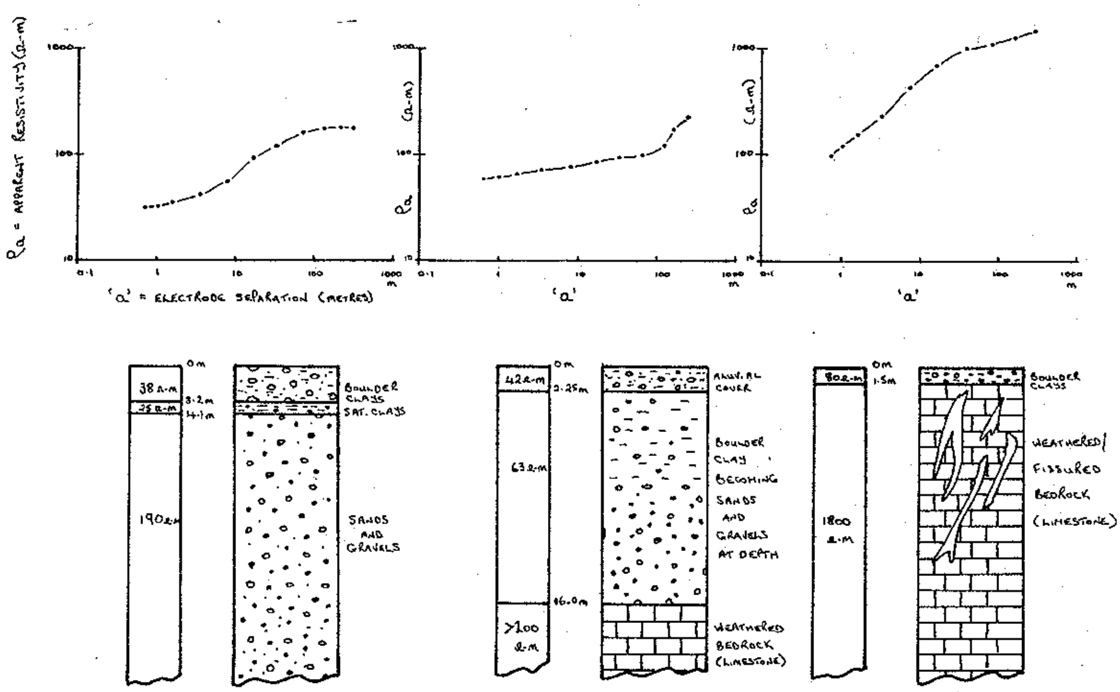

Fig 1a Fig 1b Fig 1c

Simplified sketches showing VES curves, layered resisitivity models and interpreted sections based on the geophysical results and available geological data.

* BARKER, R.D. 1981. The Offset system of electrical resistivity sounding and its use with a multicore cable. Geophysical Prospecting, 29, pp 128-148, 1981.

Kevin Barton, Applied Geophysics Unit, U.C.G.

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ARTESIAN WELLS IN SOUTH KILKENNY

In the south eastern part of the Central Plain the Kiltorcan Sandstone Aquifer has been defined as consisting of the Porter's Gate ("shale") Formation and the underlying Kiltorcan ("sandstone") Formation. A comprehensive report on this aquifer in the Nore River Basin, by the Geological Survey in 1985, contains a detailed account of its geology, hydrogeology, hydrochemistry and development. This report showed that the upper part of the sandstone formation is the most productive and that when it is tapped at certain favourable hydrogeological locations reasonably large artesian supplies can be expected.

One of the problems encountered in working with the Kiltorcan Formation is that there is very little drill core available for detailed hydrogeological examination. What information is available comes from the observations of geologists mapping these strata, the core from a number of mineral exploration boreholes which only penetrate a short distance into the formation, well drillers' borehole logs and geophysical well logs run in numerous water wells. Hence it was decided to drill one or two boreholes in the aquifer with the Geological Survey's Mobile B53 drilling rig.

Two boreholes were drilled, about two kilometres apart, in the Windgap area, just east of the "Nose" of Callan, in South Kilkenny. The two boreholes (Kny 30/41 and Kny30/49) were drilled by the water flush rotary method to bedrock (20m and 15m) and then by the wireline coring (NQ - 76mm borehole diameter) technique to total depths of 107m and 116m, respectively.

Glacial till overlies the bedrock at both well sites. The first borehole (Kny 30/41) started some distance down into the sandstone formation whereas the second collared into the base of the shale formation. The upper part of the sandstone formation consists mainly of sandstones and thin mudstones. The proportion of mudstone increases with depth. The sandstones were found to be extensively weathered to depths of over 70m. The core recovered from Kny 30/41 is very broken and shattered in places.

Both boreholes hit artesian water at several levels. Borehole Kny30/41 overflowed at around 1,300m^3/d and has a specific capacity of 74m^3/d/m. A piezometric head of 25p.s.i. (17.6m) was recorded in October, 1987. The high yield at this particular location is probably due to the presence of a large fault for which there is some evidence at the surface. Borehole Kny 31/49 overflowed at 350m^3/d and has a specific capacity of 35m^3/d/m.

Eugene Daly, Geological Survey of Ireland.

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English Court of Appeal Confirms Right to Abstract Groundwater

A recent decision of the English Court of Appeal in London (Stephens vs Anglian Water Authority, as reported in "The Times", 24 August 1987) should be of interest to everyone involved in groundwater development in this country.

In this case, the plaintiff had claimed that subsidence and consequent damage to her property had been caused by abstraction of groundwater beneath adjacent land, and that this abstraction had persisted despite warnings that it was likely to cause subsidence. The claim had failed in the lower courts.

For the purposes of the appeal, it was assumed that the facts of the case were as presented, i.e. that the abstraction had caused the subsidence and that warnings had been given that subsidence was likely to occur. It was also accepted that the underground water was flowing in undefined channels and that there was no question of the removal of any sediment with the water.

The Court found that "As the law now stood, the right of the landowner to abstract subterranean water flowing in undefined channels beneath his land ...... appeared to their Lordships to be exerciseable regardless of the consequences, whether physical or pecuniary to his neighbours. Whether or not that state of law was satisfactory was not for their Lordships to say".

The Court found that the defendant did not owe the plaintiff a duty of care and therefore "could not have committed the tort of negligence in doing what it had". The Court therefore dismissed the appeal.

The decision may be surprising to many people. However, it would not surprise those who have read the excellent short summary of "The Law relating to groundwater in the United Kingdom", in Chapter 16 of the recently published Water Practice Manual No. 5, from the Institution of Water Engineers and Scientists, in London. This manual, entitled "<u>Groundwater: Occurrence, Development and Protection</u>", is edited by T.W. Brandon, published 1986 (ISBN 0 901427 14 4).

The book has over 600 pages, arranged in sixteen chapters contributed by a distinguished array of leading practioners. Several chapters deal with topics which are not well covered in other textbooks, such as "Downhole Geophysics", "Water Tracers", "Contract Specifications", and the chapter on legal aspects. In short this book is a "must" for anyone in groundwater in Ireland and at Stg£39.50 (29.50 for IWES members) it is good value. It can be viewed in the Geological Survey of Ireland Library.

Geoff Wright, Geological Survey of Ireland.

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Groundwater Effects in Geotechnical Engineering

This was the theme for the 9th European Conference on Soil Mechanisms and Foundation Engineering, held at Trinity College Dublin, on 31st August - 3rd September. About 500 delegates attended, mostly from Europe but including many from further afield, and about 200 papers were submitted. Irish contributions to the technical sessions were small in number but very significant.

Within the main theme, the main discussion sessions centred on nine topics:

1. Field and laboratory testing
2. Groundwater control
3. Environmental effects and seepage
4. Groundwater problems in embankments, dams and natural slopes
5. Special problem soils
6. Dynamic effects
7. Groundwater in foundations and excavations
8. Groundwater modelling
9. Filters

In addition to the discussion sessions, there were general reports on all the topics, three special lectures by invited speakers including Professor Hanrahan of U.C.D., two poster sessions, and field excursions to Tara Mines tailings dam, Derrygreenagh Bog (Bord na Mona) and ESB's Turlough Hill power station. On the social side, there were receptions hosted respectively by the Lord Mayor of Dublin in the Mansion House and by the Minister for the Environment in the Royal Hospital, Kilmainham. An interesting technical exhibition was also mounted in TCD.

The discussion sessions were held in parallel, three at a time, and inevitably there were clashes of interest. For me it was infuriating to have to chose between topics 1, 2 and 3.

Summarising such a large conference is virtually impossible. The emphasis was very much on engineering rather than hydrogeology, and as far as I was aware, there were very few hydrogeologists there. At times there were definite indications that there needs to be much more inter-communication between the disciplines, particularly on subject such as waste disposal.

The exhibition was particularly interesting in the area of geotextiles. I believe that the various types of geotextile filters, in combination with flexible impermeable membranes, have a considerable potential in controlling pollution, both on the large scale (landfills) and on the small scale (farm waste).

To host such a conference is both an honour and a heavy responsibility. In hosting and organising this conference, the Irish Geotechnical Society acquitted itself with distinction, and can be proud of the way it rose to the challenge.

Geoff Wright, Geological Survey of Ireland.

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REVIEWS

Paper: Editorial: A new approach to the disposal of solid waste on land.

Authors: R.C. Heath and J.H. Lehr

Journal: Ground Water, Vol. 25, No. 3, 1987.

This thought provoking article starts by highlighting the dismal dimensions of the groundwater pollution problem caused in past decades in the United States. However, hydrogeologists are making "impressive" (my emphasis) progress on various impacts resulting from salting activities, septic tanks, chemical storage, the use of organochemicals and waste disposal. This progress follows from a massive increase in public awareness and more effective legislation and is being paralleled by dramatic lessening of waste stream volumes - a reduction to 10% of present contaminant loadings is predicted by the turn of the century.

I trust that we hydrogeologists along the western seaboard of Europe reflect a similar view, but I cannot agree with the authors that hydrogeologists may tend to be less concerned than the general public about groundwater pollution because we have an awareness of slow rates of movement and about attenuation mechanisms. The public are not aware of our professional optimism: does our greater awareness of problems make us optimistic?

The article states that hydrogeologists are intensely concerned with identifying areas of least adverse environmental impact for disposal operations, by evaluating the pollution potential of different physical environments, and that engineers strive to achieve no-failure designs or leak proof secure disposal sites.

However, US experience shows that:

1. even double liner systems can fail and result in groundwater contamination;
2. low permeability coverings may become increasingly permeable with time;
3. monitoring wells may not show pollution due to improper location, sampling, or analytical techniques.

Therfore, to achieve the twin goals of minimising surface water and groundwater pollution, the authors recommend 'dilute and disperse' sites providing that:

1. there is an adequate unsaturated zone high in clay or silt;
2. groundwater movement is horizontal or upward;
3. much dilution is available in nearby streams;
4. sites are elevated above the 1 in 100 year flood level.

The authors obviously do not like barriers that may fail and are drawn towards mechanisms which delay leachate migration, whilst emphasising the importance of high quality, low permeability caps that will significantly reduce rainwater input for 30 years or more. Fine, so the Americans consider that 'dilute and disperse' has advantages over 'concentrate and contaminate' for waste disposal in some instances. Agreed, but have we the self confidence to infer, as the authors do, that if an attenuation site is well located it will result in some groundwater pollution so why monitor groundwater extensively when one can rely on surface water monitoring?

Steve Bennett, Aspinwall and Company Ltd.

Publication: Structures for Silage
Authors: A.J. Kavanagh and O.G. Daly
Publishers: An Foras Talúntais. 18 pages. Price £2.50 (incl. postage)

The only solution to prevention of water pollution by silage effluent is collection and safe disposal. Like a lot of pollution problems, generalised solutions are easy to describe but are far more difficult to carry out in practice. This is particularly true of silage effluent which is so corrosive that collection is difficult to achieve due to leakages through the silo floors and holding tank walls. Good construction is essential and this booklet "Structures for Silage" gives details on the correct type of concrete and steel reinforcing, with practical advice on the layout of silo walls, channels and collection tanks. There are chapters on silo construction, building materials, effluent drainage, silage effluent management, and structural defects and remedies, all simply and concisely written and accompanied by clear diagrams.

The booklet describes how groundwater can be polluted. However, there are a number of areas where the booklet could be improved from a groundwater viewpoint. I would recommend that in gravel areas or where the rock is close to the surface (i.e. where the groundwater is most vulnerable) excavations should be minimised and as much of the soil and overburden as possible should be retained beneath the silo system. This material acts as a protecting filtering layer above the groundwater. In particular, digging a pit to install an effluent holding tank can remove the protecting layer.

Consequently, the depth of the tanks (and perhaps size?) should be minimised or preferably, where practicable, they should be constructed above ground level. Careful backfilling with clayey material around the outside of the tank is advisable, otherwise any overspilling effluent is offered an easy passage into the groundwater.

I would welcome more emphasis on the sealing of joints in the concrete silo floor. Also the compacted hardcore beneath the floor usually consists of permeable gravel, stones or crushed rock which can act as a conduit for the flow of any leaking effluent under and away from the collection channels and perhaps into water. Is there a practical solution to this?

Drawings of the silo in Figure 6 are inadequate, in my opinion, as they only show one effluent collection channel, at the lower end. Surely a channel is also required at the top end as the slope of the floor is not always sufficient to prevent effluent flowing in both directions?

These comments should in no way take away from the importance and usefullness of this booklet. I strongly recommend it to everyone dealing with water pollution problems from farming.

Donal Daly, Geological Survey of Ireland.

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GSI DIRECTOR RETIRES

On the evening of 5th October, the IAH joined with five other Irish earth science societies in a presentation to Dr. Cyril Williams to mark his retirement in November from his post as Director of the Geological Survey.

Before joining the Survey in 1967 to oversee its reorganisation and expansion, Dr. Williams had spent most of his earlier career in the Geological Survey of Uganda, eventually becoming its Director. He developed a keen interest in groundwater work, which he retained when he moved to this country. His interest was reflected in a continuing encouragement for hydrogeology, through the creation of the Groundwater Section in the Survey, facilitating the involvement of GSI staff in the IAH, and not least, the Groundwater Newsletter.

We wish him well in his retirement.

Geoff Wright, Geological Survey of Ireland.

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CONTRIBUTIONS FOR THE NEXT ISSUE OF THE NEWSLETTER

For the next issue your contribution should reach the Geological Survey before 1st February, 1988.