THE GSI GROUNDWATER NEWSLETTER

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GROUNDWATER QUALITY AND POLLUTION

Disinfection of Small Water Supplies.

The article in issue No. 2 of the Newsletter on disinfection of water supplies using ultra violet radiation (UV) prompted a response. The article did not refer adequately to the shortcomings of UV or to the advantages of chlorination.

In water supply treatment, chlorination is the most common form of disinfection. In small systems chlorination is usually effected either by using hypochlorite solution or use is made of chlorine tablets. There are other chemical methods such as the use of potassium permanganate or iodine. UV is a new tool that is now available and is well proven already.

The selection of the method of disinfection for a water supply source would be dependent on certain factors, most of which will stem from the site, and the type of water involved. Effectiveness of the method to be adopted should be the prime consideration in the logic of choice. UV is a nice convenient method but when circumstances such as variable electricity supply voltage or the existence of significant pollution in the water exists, then effectiveness of UV is called into question. Where there are long distribution pipelines or potential contamination sources downstream of disinfection, again UV will be ineffective. For successful disinfection, the UV unit must be sized correctly, must have adequate monitoring and control devices incorporated into the installation, and must be regularly maintained. It is seen as being suitable for single consumer use with clean water.

Chlorination has a distinct advantage in that it provides for a residual chlorine presence, as it were, in the water subsequent to the dosing of the chlorine. Thus chlorination has the advantage of continuity of disinfection throughout the system and the capability of dealing with any downstream contamination. It is particularly suitable for systems to supply two or more consumers.

UV is deemed to be an automatic system, but unless regular attention is applied to the quartz lens and to monitoring the strength of radiation, the method becomes inefficient. Chlorine is not fully automatic, in that regular inspection is required to renew supply of the source material. Hence, there is not much difference between the two systems in relation to the amount of attention required.

UV should be seen as another tool available for disinfection purposes to be used where and when appropriate. Its advantage is that it is a compact method with no taste and odour problems and has a short contact time. However, from a contamination point of view, chlorination is the better method, if only that it allows the operator to sleep at night secure in the knowledge that the water is well protected - if it is properly maintained. And that is another day's discussion!

John Walsh, E.G. Pettit & Co.

Emergency Planning to Protect Groundwater Resources

This topic is particularly relevant at present following the recent IEI conference 'The Protection of Water Supply Sources' at Carysfort College and the issuing of the 'Guidelines for Emergency Planning to Protect Water Resources' by the Department of the Environment in May 1986. The protection of groundwater sources differs somewhat from protection of surface water sources.

Groundwater could play an important role in providing emergency water supplies, particularly in areas where surface sources are used at present. Groundwater is less vulnerable to airborne pollution, such as fallout from nuclear or chemical accidents. The need to take account of this type of accident has increased significantly since the Chernobyl accident.

If it is intended to utilise groundwater as an emergency supply, standby boreholes are needed. Existing unused high yielding boreholes could be purchased and maintained for emergency use. Alternatively information on where to drill at short notice could be obtained as wells can be drilled in less than one day in favourable areas.

In borehole schemes, provision of additional capacity should be made for emergency use. The additional capacity in existing schemes should be quantified properly. In particular, the additional capacity that would be available for a 'short' period should be quantified (Groundwater sources can often provide high yields for short periods which would not be sustainable for long periods).

In preparing the plan and the hazard analysis guide that will accompany each plan, some local authorities will have difficulties, because they are not sufficiently aware of their groundwaters and aquifers and/or have little information on them. As the plan is intended to cover groundwater, local authorities would need information on the following parameters, as well as those already listed in the guidelines:

(i) Location and classification of aquifers.

(ii) Vulnerability or aquifer protection maps which take account of the geology, hydrogeology, depth to bedrock, borehole yields, etc. These should show the varying degrees of aquifer vulnerability, the best protected aquifers (obviously these are the most suitable for emergency supplies), the catchments of springs and boreholes which are used for major water supplies or those which might be used in emergencies.

These would require a detailed desk study with a field survey as is required by the guidelines for surface sources.

These maps and associated studies would indicate whether groundwater needs to be taken into account in an emergency, for instance, whether a spillage is likely to cause problems, whether on-land containment is safe, etc.

Some of these aspects will be dealt with in detail at the IAH meeting in Portlaoise in April. (See page 10).

Donal Daly, Geological Survey.

Septic Tanks and Groundwater: The Septic Tank System.

A septic tank is a buried, watertight container designed and constructed to (1) receive waste-water from a house, (2) separate solids from liquids, (3) provide limited digestion of organic matter, (4) store solids and (5) allow the effluent to discharge for disposal in a soil absorption system.

Septic tank effluent is highly polluting if it directly enters water because it contains bacteria and viruses, nitrogen (40-80mg/l) and phosphorus (10-30mg/l) while the B.O.D. ranges from 20-450mg/l. Estimates of the number of faecal coliforms in the effluent vary from 0.2 million/100ml to 2.8 million/100ml.

There is a popular misconception that a septic tank itself adequately treats domestic sewage. This is of course incorrect. The main treatment of the sewage effluent occurs only after it has left the tank and been discharged into the ground. It is the soil and surficial deposits (overburden) which are relied upon to treat the effluent and render it harmless.

As the effluent moves through the granular material of the surficial deposits, various physical, chemical and biological processes take place which remove many of the chemicals and break them down to simpler, usually less harmful substances. Filtration is also important, removing most particulate matter and pathogenic organisms like bacteria and viruses. All these processes are encouraged if the surficial deposits are relatively thick, unsaturated and have a low, but significant, permeability.

Two types of problem arise with septic tank systems which are due to the geology of the site - insufficient soakage, which causes the effluent to pond at the surface, and excessive soakage which allows the effluent to move rapidly away and pollute a nearby well (usually on the same property). These two problems are usually mutually exclusive - if there is inadequate soakage due to a low permeability soil and overburden the effluent cannot percolate downwards to contaminate the groundwater. Insufficient soakage causes problems of surface water contamination, odour nuisance and possibly public health risks. Most people are aware of the problems caused by insufficient soakage but few appreciate the problems caused by excessive soakage where the effluent moves rapidly through the ground into groundwater with minimal purification thus polluting it and perhaps nearby wells. Consequently, the main groundwater problems occur in areas of <u>freely draining</u> soils, where there is no surface evidence of pollution.!

(This contribution is the second in a series on septic tanks. If you have points to make, write in to the Newsletter).

Donal Daly, Geological Survey.

Attenuation of Inorganic Nutrients Derived From Septic Tank Effluent.

Septic tank systems rely mainly on the attenuating ability of the soil to remove the inorganic nutrients from the effluent. If the soil is sandy and has a low cation exchange capacity (C.E.C.) the possibility of groundwater contamination is increased.

As part of an ongoing study of septic tank systems and groundwater quality in the Sligo area, deep soil sampling and effluent analyses were carried out in the vicinity of a septic tank to try and determine the mechanisms and amount of nutrient attenuation. The septic tank system incorporated a soakaway for the disposal of the effluent and was located in an area with sandy soil (82% sand and gravel) and a low C.E.C. (10 meq/100g). A borehole 5m downgradient of the soakaway had a standing water level at the time of the investigation (late winter) of 9.8m below ground level.

The soil analysis showed that about 96% of the phosphorus (P) in the effluent had been removed within 7m of the soakaway. The attenuation of the sodium (Na) was much less marked with about 65% removal within 9m of the soakaway. The failure of the soil to maximise attenuation of the sodium was shown by a Na concentration of 61mg/l in an unpumped sample from the borehole. (A pumped sample would have been preferable but this was not possible). High background concentrations of potassium (K) in the soil caused difficulties in interpreting the results for this nutrient but a high concentration (138mg/l) in the borehole indicated that attenuation was incomplete. Although ammonia (NH_4^+) levels decreased rapidly with distance from the soakaway the decrease appeared to be due to oxidation to nitrate (NO_3) rather than to adsorption. A concentration of 45mg/l NO_3 as N in the borehole suggested that the nitrate was largely lost by leaching. These high levels of Na, K and NO_3 in the polluted borehole water contrast markedly with the general groundwater background concentrations of 7-12mg/l, 1-4mg/l and 1-3mg/l respectively.

A significant point about the septic tank system investigated was that while the groundwater beneath the site was grossly contaminated there were no problems associated with the working of the system i.e. backing up, smells etc. It would appear therefore that an outward appearance of normality does not indicate that the system is working properly.

Microbiological analyses of the effluent, soil and water samples were also carried out and the results of these will be presented in a later issue of the Newsletter.

Marie Doyle and Richard Thorn, Sligo R.T.C.

Treating Supplementary Groundwater Sources

Regional water supplies are often supplemented by boreholes distant from the main source. Unless specificaly planned for, chlorine and fluorine dosing and monitoring can cause problems. Initially, these may not be necessary. However, due to pollution and the extension of fluoridation by Health Boards, they may be required at a later date.

Usually recommended residuals of fluorine (F) (0.8 - 1.0 ppm) and chlorine (Cl) (0.2 ppm) are achieved at the main waterworks and additional dosing at the supplementary borehole is ruled out on financial grounds.

This can cause public health problems:-

1. It produces water of unacceptable microbiological standard in the mains suplemented by the groundwater, if a pollution incident occurs.
2. Fluorine addition to water is designed to aid teeth development in children up to 12 to 14 years but below 0.8 ppm it has no effect and is a waste of money.
3. If problems 1 or 2 arise, increases in chemical doses at the main waterworks can cause the following:
   (a) Water with chlorine residuals greater than 0.2 ppm occurring near the main waterworks giving rise to complaints from the general public about taste and odour. Furthermore, the practice of maintaining residuals above recommended levels cannot be condoned on health grounds. Indeed the use of chlorine residuals is under critical review in the Netherlands with regard to their carcinogenicity (O'Reilly, 1983)*.
   (b) Water with fluorine residuals above 1 ppm.
   Excessive fluorine levels cause fluorosis, including mottling of the teeth.

Recommended standards have safety limits built in, in line with current knowledge. However, carelessness with chemicals can have long term effects and therefore provision should always be made so that supplementary groundwater sources can be properly dosed if the need arises.

* O'Reilly, J.P. (1983) A study of water supplies in the Netherlands and Federal Republic of Germany 1983. Environmental Health Association Year Book 1983.

Anne Deacon, South Eastern Health Board, Wexford.

GROUNDWATER EXPLORATION AND DEVELOPMENT

Groundwater from Poor Aquifers.

Finding a good source of groundwater is always a problem in areas where the underlying bedrock is a poor aquifer. Much of Ireland, especially along the west coast, is underlain by hard rocks such as granites, schists, slates and sandstones, which normally yield little water to boreholes - averaging 200-300gph, and rarely over 500gph. Such areas are often hilly and streams are short and flashy. Although annual rainfall is plentiful, a dry spell reduces streams to a trickle, making them unsuitable for water supply. Moreover, summer visitors create seasonally heavy water demands which are difficult to meet, especially in dry summers (remember them?).

The hydrogeologist's approach to this problem usually sets out two possible options:

- Look for a small gravel aquifer, as have been developed in such places as Fanad Head, Co. Donegal (raised beach deposit), the Mullet peninsular, Co. Mayo (spring issuing from dune sands), and Minane Bridge, Co. Cork (buried river gravels). Aerial photographs can help in locating such aquifers.
- Try to identify a local zone of intensely fractured or fissured bedrock, where a borehole can produce an above-average yield. Such zones may be identifiable by using aerial photographs, satellite imagery and ground geophysical methods. This approach, which has been used in other countries has achieved some limited success in Co. Kerry, with two boreholes drilled for the County Council at Ballyferriter (about 4000gph) and Ballinloghig. Near Dingle, two boreholes which were sited without benefit of any such techniques, and yielding several thousand gph, appear (with hindsight) to lie along a major fracture zone. It is likely that other high-yielding wells, so far unreported, can be similarly attributed to fracture zones. We would be interested to hear from engineers or drillers who have tested wells over 1000gph in areas of generally unproductive rocks, to see what pattern can be established. In this way we hope to improve our approach to one of Irish hydrogeology's main problems.

Geoff Wright, Geological Survey.

Turloughs

Turloughs are seasonal lakes, found particularly on the Central Lowlands west of the Shannon in counties Galway, Mayo, Roscommon and Clare. They occur in areas of pure, well-bedded limestone, where the glacial drift cover is patchy, or thin and permeable. Approximately 60 turloughs with areas of at least 10 hectares, and many more smaller turloughs, flood at the present day, although a substantial number have been drained.

Turloughs generally fill in October, in a matter of hours or days, and empty more slowly in early summer. A few have surface water inputs, but the vast majority fill from groundwater, often filling and emptying via the same holes, commonly situated near the edge of the turlough floor (which often contains peat and marl deposits). A white precipitate of calcium carbonate can often be seen coating the floor vegetation when the turlough empties; this annual natural liming ensures that the turloughs provide good summer grazing.

No exact equivalent of these features has been found outside of Ireland, so they are of great interest to scientists. They are of considerable ecological importance; they have an unusual vegetation; and in winter they are important wildfowl sites. The turlough water body also includes some interesting invertebrates.

The water level in turloughs is related to groundwater levels, but they are not simply hollows which flood as the water table rises. They appear to be associated with zones of higher permeability in the aquifer, and the underground flow velocities from turloughs to springs are similiar to that in karstic areas, and may exceed 100 m/hr. Obviously filtration and purification of water along such flow routes is virtually non-existent, so the need for groundwater protection in such areas is very great, and the disposal of waste in swallow holes must be prevented.

Catherine Coxon, Environmental Sciences, T.C.D.

Use of the Thermometer in Hydrogeology - Geohydrothermometry.

The careful use of the mercury thermometer can yield valuable data when investigating groundwater. This somewhat neglected mode of investigation gives cheap, simple, direct and quick results. The mercury-in-glass therometer is to be preferred where it can be used. Thermistors and thermo-couples should be used with great care; they can drift in an irregular manner.

The following eight items outline some of the places where accurate temperature determinations (say to 0.05°C) can be of much value.

1. Temperature of Precipitation and Infiltration. Temperature of precipitation is available from the Met. Office. Infiltration is low-nil in June, July, August due to high evapotranspiration. Infiltration in January is low due to rejected recharge by full aquifers. Temperature of infiltration to aquifers is around 8.50°C, excluding June, July, August and January.
2. Solar and Geothermal Heat Contribution. Normal groundwater temperature in Ireland is about 10.5°C. The 8.50°C heat of infiltration is all of solar origin, much reduced by radiation and evaporation. The balance of say 2.0°C is a residual of geothermal origin; primary geothermal heat raises the groundwater temperature by some 11.5°C, of which 9.5°C is radiated off, since earth temperatures are kept in balance.
3. Location of Recharge Areas. Temperatures of groundwater arising from recharge on high ground will be lower than that from low ground infiltration. Infiltration from bodies of surface water will vary seasonally, with summer infiltration being warm and winter infiltration being cold. Slow infiltration may also result in small temperature changes.
4. Time of Flows. Where spring temperatures are very regular, a long distance of underground flow may be assumed. Where spring temperatures vary sharply, infiltration from a body of standing water and short underground flow may be inferred. In some cases, as in karst terrain, the identity of the recharging surface water may be determined.
5. Depth of Circulation. In Ireland, the temperature of groundwater should rise by 2.5°C for every hundred metres of depth to/from which it flows. Ignoring the first 100 metres (where mixing, radiation etc. cause complications) groundwater of say 15.5°C may be considered as having flowed for some time at a depth of around 300 metres.
6. Effects of Earth Tides. Recent studies of Irish groundwaters show that many are affected by earth tides. Do these affect confined,

semi-confined and unconfined groundwaters? Pressure changes are transmitted almost instantaneously. Physical movement of the groundwater is much slower; in some cases the warm groundwater reaches surface (as Kilbrook), in others only pressure and not the physical hot groundwater reach surface (as Cloyne).

7. Borehole Temperature Logging. Here, thermistors have to be used. Inflows of groundwater of different temperatures at different horizons may be determined. Mixing of two groundwaters of different temperatures may produce an overall temperature indicating the amount of flow from the two aquifers.

8. Temperature Effects of Pumping. A considerable amount of energy is used effectively and non-effectively in pumping from a borehole. Loss of energy occurs by turbulent flow through screens and gravel-packs, through pump bowls, in rising mains, and at bends in rising mains. These energy losses are converted into heat. Is such heat sufficient to give a measurable rise in temperature to the pumped groundwater? Do groundwater temperatures in the aquifer and at the outflow of the pump differ considerably? Do large heat differences there indicate an inefficient groundwater production unit?

David Burdon, Minerex Limited.

I.A.H. NEWS

The seventh annual groundwater seminar is scheduled for the 7th and 8th April in the Killeshin Hotel, Portlaoise. Topics will include both groundwater resource development and groundwater pollution and protection. Our guest speaker will be Dr. Andrew Skinner of Severn-Trent Water Authority, who will speak on Aquifer Protection.

We hope for the usual good attendance at this popular meeting which has become established as the highlight of the I.A.H. calendar. Details will be circulated in February.

Geoff Wright, Geological Survey.

Report on 19th Congress of IAH held at Karlovy Vary, Czechoslovakia, September, 1986.

There was an attendance of about 300, of whom about half were from Czechoslovakia with about 50 participants from Western Europe.

The Congress consisted of two symposia:

1. Integrated land use planning and groundwater protection management in rural areas.
2. Groundwater protection areas.

The following summary lists some of the many interesting points raised.

Symposium 1

Good communications between hydrogeologists and those in other disciplines particularly engineers, planners and politicians are vital. Until quite recently surface water was the chief source of supply in many countries. Today, although there is a worldwide trend towards adapting to the increased usage of groundwater, as yet most legal and institutional systems do not adequately provide for groundwater.

Water resources face the twin pressures of depletion and pollution. In rural areas the problem often is particularly complex as the means of increased agricultural production may be the cause of serious water pollution.

The design of monitoring systems to protect groundwater should take into account the nature of the pollution and the degree of aquifer vulnerability. Knowledge gained by monitoring must be provided in a form usable by the relevant decision makers.

Symposium 2

Groundwater protection today in many countries can no longer be confined to abstraction points, but should be of a whole system, even of a whole aquifer. Certainly more attention must be given to protecting recharge areas.

Proper regional planning requires maps showing the varying sensitivity of groundwater to pollution. The eventual aim should be an accurate model of each major aquifer.

The scientific basis for protection zones is the transport time of the most common types of pollutants. Countries using these zones usually have groundwater movement rates much slower than is the case in many Irish aquifers.

Bob Aldwell, Geological Survey.

NEW PUBLICATIONS

Groundwater Resources of the Republic of Ireland

In 1978 the European Community instigated a study aimed at quantifying the Community's groundwater resources. The 'Groundwater Resources in the European Community' has been published recently. This includes seperately published 'National Surveys' and maps for each country. 'Groundwater Resources of the Republic of Ireland' is a 140 page compilation of the available information, prepared by the Geological Survey, for each of the seven water resource regions. It is accompanied by a set of 3 maps at the scale of 1:500,000. The report costs DM43 and the map set costs DM80. They can be purchased from:

Verlag Th. Schafer,
Tivolistrasse 4,
D-3000 Hannover 1.
Federal Republic of Germany.

One copy of the report and maps is available for inspection at the Commission of European Communities office, 39 Molesworth St., Dublin 2. A copy of the report can also be examined at the Geological Survey - a copy of the maps will be available in the near future.

Donal Daly, Geological Survey
