SEWAGE SLUDGE DISPOSAL

CONSTRAINTS AND OPPORTUNITIES

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by

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VOLUME I

ABSTRACT

The problems of disposing of sewage sludge, possibly by re-use on agricultural land are considered in the context of the interaction of traditional pollution control philosophies, policies and strategies of EEC member states.

After briefly reviewing the evolution of the 'pragmatic' policies controlling the discharge of trade effluents to rivers or sewers, in England and Wales, investigations focus on problems caused by heavy metal contamination of sludge.

Literature reviews are used to examine:-

How sludges become contaminated;

The extent of that contamination;

How sludges have been disposed in the past;

Some indication of future constraints on disposal by those means.

A contribution of the study is in an analysis of the evolution of the DOE/NWC 1981 Guidelines on the disposal of sludge to land. Guideline constraints are compared to those specified in proposals for an EC Directive.

A further contribution is in carrying out a case study in which the implications for trade effluent controls in an inner city catchment/treatment works area are considered, if sewage sludge at present disposed to sea, is disposed by use on agricultural land.

A simple model makes use of 1980/81 computer file data. Important features of the use of the model are in simulating the effects of reducing metal inputs from a few known key sources, and of the elimination of high sludge metal concentration cases on the achievement of simple and 95% probability of compliance with proposed EC constraints. Results are discussed in relation to the findings of literature reviews.

The effectiveness of the current politico-economic framework is assessed.
The use of traders' perceptions of the 'rules of the game' in evaluating current controls is explored.

Technological and policy implications are deduced, conclusions reached and a basic premise questioned.

Key terms:

Control

Policy

Sewage sludge

Metals

Trade effluent.

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LIST OF ABBREVIATIONS USED IN THE TEXT

ADAS	Agricultural Development and Advisory Service.
ARC	Agricultural Research Council.
CBI	Confederation of British Industry.
COI	Central Office of Information.
CDEP	Central Directorate for Environmental Pollution.
COPA	Control of Pollution Act.
CUEP	Central Unit on Environmental Pollution.
DAS	Department of Agriculture for Scotland.
DHSS	Department of Health and Social Security.
DOE	Department of the Environment.
DOI	Department of Industry.
DS	Dry solids.
EC	The Council of the European Communities.
EEC	The European Economic Community.
EDTA	Ethylene diaminetetracetate.
EQO	Environmental quality objective.
HLSC	House of Lords Select Committee.
MAFF	Ministry of Agriculture, Fisheries and Food.
MHLG	Ministry of Housing and Local Government.
MPH	Metropolitan Public Health.
NFU	National Farmers' Union.
NWC	National Water Council.
OECD	Organisation for Economic Co-operation and Development.
OM	Organic matter.
PCO	Pollution Control Officer.
RCEP	Royal Commission on Environmental Pollution.
RCSD	Royal Commission on Sewage Disposal.
RWA or WA	Regional Water Authority.
also	AWA Anglian W.A.
	NWWA North West W.A.
	STWA Severn Trent W.A.
	SWWA South West W.A.
	TWA Thames W.A.
	YWA Yorkshire W.A.
SCDSS	Standing Committee on the Disposal of Sewage Sludge.
SI	Statutory Instrument.
STC	Standing Technical Committee.
TS	Total solids.
WO	Welsh Office.
WPC	Water pollution control.
WRC	Water Research Centre.
WSL	Warren Springs Laboratory.
Zn≡	Zinc equivalent.

LIST OF THE MAIN SYMBOLS AND CODING USED IN THE MODEL

A - J	Code letters of known trade sources of metal loads greater than 100 $kg.y^{-1}$ input to sewers.
K	Source of dual input 'a' and 'b' to sewers.
L_1-L_4	Code letters of known trade sources in the very low 'agreed' flows.
M	Mandatory constraints.
O	Metal concentrations, in $mg.kg.^{-1}$, in sewage sludge output.
P	Partition ratio. (see also S7.2).
r	Stabilisation concentration factor (see S7.3).
R	Recommended constraint.
S	Metal concentration, in $mg.1^{-1}$, in sewage input to WPC works.
T	Known trade total metal load.
WPC works	Water Pollution Control Works.
X	Production of mixed sewage sludge, in 10^6kg., leaving the WPC works.
Y	Flow of sewage, in $10^6$1, entering the WPC works.

For symbols A - L_4 see also S7.1

For other symbols see S7.4.

1. CONSTRAINTS AND OPPORTUNITY

1.0. The evolving scene

For many hundreds of years control of environmental pollution in the UK has evolved independently, philosophy, policy, common law, statute law and codes of practice being built up largely on the basis of precedent.[1a] The industrial revolution and requirements for public health led to strains and changes which took place as matters of great urgency. Because of geographical insularity pollution problems and the determination of necessary remedies and controls could be dealt with as national, regional or local affairs.[1b]

The second half of the twentieth century has been marked by the growing awareness of the need for international cooperation in dealing with many pollution problems.[2] The 1970s and now the 1980s are noticeable for the increased involvement of the UK in international agreements on measures to be taken to control pollution. Some measures require the use of new national legislation to implement them.[3]

In reaching and maintaining international agreements on aspects of pollution control UK philosophies, assumptions, policies and practices have been questioned and challenged and forced to evolve as UK representatives interact with those of other states with different heritages and policies. Some of those states are more used to dealing with problems of transfrontier pollution than the UK.[4]

The scale and intensity of involvement and interaction increased dramatically on November 22nd 1973, when the UK in its first year as an EEC member state, became party to the first 'Programme of action of the European Communities on the Environment.'[5]

It is in the context of ongoing transactional change and adaptation that the present study considers the problems of disposal and/or utilisation of an organic waste. Unlike many organic wastes such as straw left by combine harvesting, the use of which incurs considerable expenditure on collection, the organic waste studied is already collected together and there is a predictable supply of the raw materials that make up the waste, sewage sludge.

In the late nineteenth century early developers of biological treatment of sewage found they could produce a flammable gas, a source of light and power as a by-product of the new treatment processes.[6] Further, "The developers of the contact bed and septic tank processes both anticipated that all the organic matter would be destroyed and that no sludge would be produced, but this was not to be the case."[7] Not only was the aim of total destruction never realised but in 1970 the Working Party on Sewage Disposal reported, "...the treatment and disposal of sludge would appear from observations and discussions during our visits and from the evidence submitted to us, to be the greatest problem at treatment works to-day."[8]

In an earlier study Mess considered the potential for using primary and/or secondary sewage sludges as animal feed ingredients. Discussing the results of a review of the literature, two feeding trials and three computer studies, he concluded that:

a) there were four main limiting factors of which "The second limiting factor, or group of factors, would appear to be the presence of toxic contaminants in sewage."[9]

b) "It is in large sewage works often situated in towns, cities and industrial areas that the real problems of sewage treatment and disposal are most acute."[10]

A Government Green Paper, 'War on Waste' published in 1974 had pointed out that sewage sludge can be used as an agricultural fertilizer or soil conditioner, but adds, "Precautions have of course to be taken to avoid health hazards, such as swine versicular disease, or the take-up and concentration of undesirable constituents such as heavy metals."[11] But Mess was of the opinion that sewage is a product which has not been designed with the use of the discarded product in mind. He suggests, "... the design could be improved and recycling may be feasible and desirable,"[12] and suggests "The question of how long the present contamination levels of sewage can be tolerated is itself a highly relevant issue," pointing out that "From an historical point of view present policy of allowing certain trade wastes to be discharged to sewers can be seen to have arisen at the turn of the century when evidence, expectations and many trade wastes themselves were very different to those of today."[13] Indeed evidence given to the Royal Commission on Sewage Disposal, when enquiring into the relations between local authorities and manufacturers in regard to the disposal of manufacturing effluents, is analysed and indexed in the 1903 Third Report. No names of metals or groups of metals appear as terms in that index.[14]

1.1. The contemporary scene

But in the 1980s the problems of the level of contamination of sewage final effluents and of sewage sludges by the so-called 'heavy' metals is important as is shown by their inclusion as listed toxic substances in the following European Council directives designed to protect the quality of aquatic environments from harmful organisms and substances.

Decision No.:

76/464/EEC	a) On pollution caused by certain dangerous substances discharged into the aquatic environment of the community.
78/659/EEC	b) On the quality of fresh waters needing protection or improvement in order to support fish life.
75/440/EEC (see also 79/869/EEC)	c) Concerning the quality required of surface water intended for the abstraction of drinking water in the Member States.

79/923/EEC d) Directive on the quality required of shellfish waters.

76/160/EEC e) Concerning the quality of bathing water.

75/437/EEC f) Concluding the convention for the prevention of marine pollution from land-based sources.[15]

'Heavy' metal content of WPC works final effluent or sewage sludge output presumably enter the works through the sewer system or in a very small amounts as a result of wastes tankered in. Heavy metals having entered the sewer system become mixed and complexed with sewage from other sources. Some of the insoluble metals and metal compounds are then removed in primary sludge.[16] Heavy metals remaining in the settled sewage may affect, sometimes seriously, subsequent biological treatment processes.[17] Although primarily concerned with stabilising the sewage and reducing the mass of organic matter, biological treatment of sewage is regarded as an efficient way of 'removing' heavy metals.[18] Treatment involves the binding, mainly by adsorption, of metals to organic sludge,[19] any increase in efficiency of primary settlement or of biological removal of heavy metals from the effluent flow resulting in a corresponding increase of metal load in the sewage sludge output.[20]

It may therefore be seen that the EC directives constraining the disposal of metals to the aquatic environment may affect the quality of sewage sludge output as follows:-

a) If because of the standards required by the directives total metal load entering sewers is reduced then quality of effluent and sludge output may be improved.

b) If total metal load entering sewers remains the same but the efficiency of 'removal' of metals from the effluent to the sludge output is increased sludge output quality will deteriorate.

c) Similarly if compliance of trade effluents entering aquatic environments is 'improved' by diverting metalliferous wastes, and increasing total load of metals entering sewers again total load of metals in sludge produced will also increase.

d) If minimally or partially treated sewage formerly allowed to enter the aquatic environment is now required to have full sewage treatment, loads of metals formerly discharged to the aquatic environment will now in the main be diverted into sewage sludge output.

From the above it is seen that although in some areas the effect of the EC Directives will lead to improved quality of sludges, in others sludge quality may deteriorate and overall sludge production may increase.

With growing concern over possible long-term effects of atmospheric and marine pollution and continued international pressure to reduce dumping of wastes at sea.[21,22] Political and economic reasons are likely to be invoked to constrain quality and quantity of sludge disposed by these means.[23]

Any reduction in quantity of sewage sludge dumped at sea will therefore increase the burden on other disposal options. While the reduction of sewage sludge mass by incineration remains a high cost option the main alternatives are in disposal to land. In view of national concern and the existence of an EEC Council Directive Decision No. 80/68/EEC on the protection of groundwater caused by certain dangerous substances,[24] the number of sites classified as suitable for sludge disposal by tipping, may be reduced considerably.

In a Water Research Centre (WRC) study carried out in 1977 for Yorkshire Water Authority (YWA) it was found that out of 35 possible disposal routes ranked in order of cost, "The 6 most economical routes for all populations were found to rely on ultimate disposal to farmland."[25] Thus if sludge quality is suitable disposal to farm land may in many areas still provide an acceptable disposal route.

1.2. Purposes

In view of the concerns, constraints and possible consequences discussed above, and of the existence of a discussion document and draft of "a proposal for a Directive on the use of sewage sludge in agriculture"[26] it is the purpose of this study, in focussing on the problems caused by inputs of heavy metals to the sewer-treatment works system, to seek answers to the following questions.

1. Can sewage sludge be designed for disposal? The study will look particularly at disposal by use on agricultural land.

Marquand states, "We are often presented with a false choice between an expensive and possible ineffective control policy, and a negative policy of allowing an unknown proportion of the damage to continue unabated."

2. To try to avert such a false choice, data from a YWA urban catchment treatment system is used to calculate, for that location, using stated constraints.

2a. Which metal outputs need to be reduced?

2b. How large is the required reduction of input?

2c. How many input sources need be affected?

2d. What strategies are available to bring about the required reductions?

The question is then posed -

3. Why have the level of inputs to sewers not been reduced already?

The study is seen as a sequel to the earlier study by Mess.

1.3. Method

In order to seek answers to the basic questions the research is carried out in three parts

1. By reviews of the literature, subdivided into Part 1A and Part 1B.

2. By the design and use of a simple model.

3. By reference to the outcomes of 1 and 2 and other appropriate data.

Each part is divided into sections and arranged as follows:-

Part 1A is concerned with pollution control policy, and includes this introduction;

Section 2 uses an historical perspective to consider how present day methods of controlling inputs of trade effluents disposed to sewers came to be developed;

Section 3 examines the rational and some effects of allowing wide local discretion in determining the extent to which trade effluent loads are allowed to enter sewers.

Part 1B is concerned with the control of sewage sludge disposal and includes:

Section 4. Assesses for England and Wales the scale of sewage sludge disposal and of present and likely future constraints on disposal, particular attention being given to metals as a constraining factor;

Section 5. Is a study of the evolution of Voluntary Guidelines controlling disposal of sewage sludge to agricultural land;

Section 6. Compares the Voluntary Guidelines with constraints contained in the proposal for a directive on the use of sewage sludge in agriculture.

Part 2. The development and use of a model

Section 7. Analyses data of inputs and outputs of an urban sewer catchment-treatment system. Results are used to develop a simple model;

Section 8. Applies the Model using available data and specified constraints.

Part 3 Effective control?

Section 9 seeks answers to the question 'Why have the level of inputs to sewers not been reduced already?'.

Section 10. Attempts to draw the results of the previous enquiries together and to reach conclusions.

Except when otherwise stated it has been expedient to concentrate on controls and sewage sludge disposal in or from England and Wales.

1.4. Pollution: a definition

It is tempting to proceed with this thesis without defining the term 'pollution'. When used by others it remains open to inference, and this may make rigid adherence to one definition difficult.

However, Marquand provides a definition of pollution, "A pollutant is defined as a substance or substances which is in an undesirable condition (in terms of state or location) because it causes more damage or has the potential to cause more damage to a target or targets than it would in some other attainable condition." The word target arouses queries but is qualified as "a target may be anything to which we attach a value: present or future human beings, animals, crops, forests, whole ecosystems, certain landscapes, artefacts." Further, "a target has been damaged when the action of the pollutant, ceteris paribus, has caused it to perform the present and/or future services for which we value it less well than it did before."

It is suggested that the thesis should be read with this definition of pollution in mind.

2. THE BEST PRACTICAL MEANS?

A HISTORICAL PERSPECTIVE OF WATER POLLUTION CONTROLS

2.0.

When examining reports of Inspectors appointed subsequent to the Public Health Act of 1848, the reader is left in little doubt that something had to be done to relieve the sanitary conditions in which many families were forced to live. Overflowing cess pits, washed in dunghills and contaminated well water, drunk because wholesome water was dear to buy, were not uncommon features of some townships.[1]

The expedient of draining houses into sewers was made compulsory in the Town Improvement Clauses Act of 1847.[2] The resultant outflow from sewers added to the pollution of rivers by the fast expanding industrial enterprises of the mid nineteenth century. The massive increase in pollution of watercourses led to public outcry and demands for government action.

Night soil had been disposed to land for centuries so it is not surprising to find that as early as 1864 a House of Commons select committee, urgently seeking a way of relieving the pollution of the waterways of the Metropolis, suggesting land disposal of sewage might provide a means of reducing this nuisance.[3]

This thesis is concerned with the expediency and problems of disposal of sewage sludge, particularly to agricultural land 120 years later, particular attention being paid to problems of controlling metal contamination.

2.1. Purposes and Method

It is the purpose of this brief historical study to consider for England and Wales:

1. How present day water pollution control policy came to be developed;

2. To examine how within that policy trade effluents discharged to sewers came to be controlled by important implicit as well as explicit criteria applied at a local level;

3. To examine briefly the statutory basis for charges made by the local authority for receipt, transport, treatment and disposal of those effluents;

4. To establish how the disposal of sewage sludge came to be an inferior part of a Water policy;

5. To discuss the use made by central and local control agencies of some voluntary agreements.

By examining acts and reports an attempt is made to build up a perspective of the control system extant in 1976.

2.2. <u>The Pragmatic Approach</u>

As a result of the Public Health Act 1875 local authorities became responsible for sewers, sewerage and sewage disposal. The Act also gave the owner or occupier of 'any premises' the right to 'cause his drains to empty' into the sewers of the local authority subject to two conditions,

a) Of giving 'such notice as is required by the authority', and

b) complying with regulations in respect of 'mode of communication' between drains and sewers.[4]

The Act does not make any provisos as to the quality or quantity of industrial effluents discharged to sewers or of any charges to be levied for treatment, it does make the local authority responsible for treating the contents of sewers.[5]

To carry out this task the local authority are given certain powers such as to construct works, to contract to supply persons with sewage, to deal with land application of sewage - as they deem most profitable, to lease and farm land to which sewage is to be applied "...disposing of the produce there from;" subject to not creating a nuisance.[6]

It is clear that a determined effort was being made to protect all watercourses and areas of still water from the direct effects of pollution by sewage. But in allowing the right of discharge to sewers the Act did not proscribe quality or quantity of trade effluents so discharged or discharged direct to water courses.

The Rivers Pollution Prevention Commission appointed in 1868, in reports published between 1870 and 1874, proposed maximum concentrations above which effluents from mines or 'manufactures' should be deemed polluting and inadmissible to any stream.

Two of the ten standards concerned metals, being "Any liquid which contains in solution in 100,000 parts by weight more than two parts by weight of any metal except calcium, magnesium, potassium and sodium," and "Any liquid which in 100,000 parts by weight, contains whether in solution or suspension, in chemical combination or otherwise, more than 0.5 parts by weight of metallic arsenic."[7]

Subsequently the standards were written into a) the Bill for the Public Health Act 1872 but withdrawn during its passage through parliament, and b) the Pollution of Rivers Prevention Bill of 1873 but failed to become law.[8]

It is perhaps symptomatic of the UK environmental statute making process, at least for England and Wales, that the Rivers Pollution Prevention Act 1876 a) "... represented a compromise with powerful manufacturing interests", b) "...even the original proposals in the 1876 Bill were modified to make them acceptable to the manufacturers", and c) "In the end the President of the Local Government Board argued that it was better to have the Bill than nothing at all."[9]

No standards are stipulated in the 1876 Act. While still requiring sanitary or other local authorities to allow manufacturers in their district to connect drains to sewers, there is now the proviso that this does not now compel sanitary authorities to accept into sewers "... any liquid which would prejudicially affect such sewers or the disposal by sale, application to land, or otherwise of the sewage matter conveyed along such sewers..."[10]

Of the 'manufacturing' effluents still discharged to river the 1876 Act is prohibitive in that "Every person who causes to fall or flow ... or to be carried into any stream any poisonous, noxious or polluting liquid from any factory or manufacturing process shall ...be deemed to have committed an offence."[11] But is deemed not to have committed an offence if he can show to the satisfaction of a court "that he is using the best practicable and reasonably available means to render harmless the ... liquid so falling or flowing or carried into the stream."[12]

Proceedings could only be taken by a sanitary authority, who were themselves subject to similar clauses prohibiting entry of solid or liquid sewage matter.[13] The 'gamekeeper' being a potential 'poacher' the sanitary authority could not take proceedings without the consent of the Local Government Board. "The said Board in giving or withholding their consent shall have regard to the industrial interests involved in the case and to the circumstances and requirements locally." The Board were also to be satisfied "... that no material injury would be caused to the industry by such proceedings."[14]

A certificate from an inspector of the Board to the effect that the means used were the best or only practicable and available means was also a defence.[15]

So here in the 1876 Act we have a) a form of words incorporating 'best practicable means' taking the place of specification of standards; b) Defences for the manufacturer which require local and arbitrary judgement in which individual or local circumstances are involved, and c) Unlike the

Alkali inspectorate,control is by a local rather than a central body, local inspectors themselves being subject to local influence.

In February 1888, A. E. Fletcher, Inspector for Scotland under the 1876 Act, complained to the Secretary of State for Scotland that although under the Act pollution of streams and water courses was prohibited "... none, however, but a sanitary authority can enforce these provisions or take proceedings against the offender. In certain cases the central authority may order such proceedings to be taken (clause 6), but the local authority may then exercise its discretion as to whether it shall obey such an order or not." He then comments "Cases often occur where the local authority or those that have influence with it are themselves the offender."[16]

In addition to this problem of local influence Fletcher also complains that under section 12 of the Act the local inspector may grant to a manufacturer a certificate that he has employed "... the best or only practicable and available means for rendering harmless the polluting solid or liquid matter falling or flowing into any stream," which remained in force as a legal defence for two years. "Yet he has no power of ascertaining whether those best and practicable means for which he has certified are continuously practiced or whether on granting the certificate they are allowed to lapse into disuse."[17]

Fletcher's complaints are followed by his suggestion that sections 6 and 12 should be removed from the 1876 Act and "... provision should be given for the appointment of a Chief Inspector and district inspector as under the Alkali Act."[18]

Ironically it is to Fletcher, when Deputy Alkali Inspector, that credit has been given for promoting the 'best practical means' formula incorporated into the Alkali Act 1874.[19]

In spite of the demonstrable weakness the 'Best practicable means' strategy used by the centrally controlled and specialised Alkali Inspectorate is still used to justify the inclusion of a similar strategy with implicit defences used in the still locally controlled water pollution controls extant a hundred years later.[20]

The requirement of S.7 of the 1876 Act may also be seen as giving rise to the three main point sources of pollution of rivers today, industrial wastes discharged to sewers, sewage and industrial wastes discharged, with or without treatment, to rivers.[21]

The Royal Commission on Sewage Disposal having examined the provisions of the 1876 Act conclude "On the one hand they provide facilities for escaping the consequences of the commission of an offence; and, on the other hand, they do little to assist manufacturers who are anxious to avoid the offence itself."[22]

To control the polluting effect of sewage entering non-tidal water-courses the RCSD were committed to the constitution of a Central Authority and River Boards and to the use of standards. But as their terms of reference required them to have regard to 'economical and efficient' discharge of duties by Local Authorities, the Commissioners considered that such factors as relative volume of sewage input and receiving stream, speed of flow and depth might be taken into account.

Having discussed how discharges of sewage effluent might be controlled by means of a general standard or where justified a special standard, the RCSD also recommended general standards for particular classes of trade effluents discharged to rivers. The standards are based on neutralisation and like the general standard for sewage on suspended solids and 5 day BOD tests. The Commissioners acknowledge that information given is incomplete and that additional 'special' standards may have to be imposed "e.g. .., a standard for arsenic or other poisonous metal for trades in which those substances are used or mined...", but suggest that special standards should be "applicable only to certain rivers or reaches of rivers where local circumstances call for them."[23] The Commissioners were in favour of standards determined by "... the character of the particular trade waste to be treated and by the means available for treating the particular waste ..." rather than by the local conditions in which it was to be discharged.[24]

Of the trader they state "... he is not compelled to discharge into the stream but only uses it as a convenient method of getting rid of his waste liquids;"[25] and express the opinion, "We think it generally desirable to aim at securing uniformity of treatment for those engaged in any given industry rather than providing for preferential treatment in those cases where merely local conditions would seem to warrant a relaxation of ordinary requirements."[26] But immediately preceding this egalitarian sentiment they had expressed a wish, or possibly a hesitant opinion, in stating "We hope, however, that in future the difficulty will be solved in the majority of these cases by the reception of the effluents into the sewers of the local authority."[27]

Quite clearly the Commissioners are seeking some parity when trade effluents are discharged to water courses, but their first objective is to protect the receiving waters. They do not challenge the assumptions underlying the requirement laid on the Sanitary Authority to receive those effluents into their sewers. They do, however, suggest that those effluents should be controlled and suggest a) the local authority should frame regulations; b) in most cases these regulations should be in the form of definite standards for 'different manufactures'; and c) that it appeared from their evidence "that manufacturers would much prefer to have standards to work to."[28]

The commissioners were of the opinion that in allowing trade effluents into sewers "... that very few effluents in which the organic matter has been well oxidised would contain poisons in quantities to do harm to fish life, and that the heavy metals would be brought down in the sludge." They give an example "When the Leeds sewage was known to contain a considerable quantity of arsenic, the effluents from its biological filtration showed only minute traces of it..."[29] As Mess comments, "The implications of this type of heavy metal for the subsequent utilisation of the sludge does not appear in the report."[30]

As will be seen later in this study there is still difficulty in disposing of sludge from a Leeds WPC works today. Control of trade effluents entering sewers remains problematic.

Neither Fletcher's proposals nor the firm recommendations of the Royal Commission were implemented in law.

In giving all owners or occupiers the right to discharge effluents into local authority sewers, the opportunity of keeping trade and domestic sewage separate was foregone. In failing to include standards below which effluents were deemed not polluting, subsequent control of sewage and trade effluents discharged to rivers and of trade effluents discharged to sewers was committed to a pragmatic tradition depending on a form of words open to interpretation, negotiation and judgement, variably enforced at local level. The so-called pragmatic approach, but whose pragmatism?

Harvey commenting retrospectively from a legal point of view observes, "The Rivers Pollution Prevention Act 1876, intended to be the means of a comprehensive attack on pollution was an utter failure as a result mainly of its inept enforcement agencies: numerous small local authorities were not sufficiently motivated to curb pollution, being offenders themselves."[31] Administratively the roles of gamekeeper and poacher were not separated until the 1876 Act was superseded by the Rivers Board Act 1948.

Consents and Charges

The Public Health Act 1936 again requires local authorities to allow liquids from manufacturing processes to be discharged into sewers.[32] But are not required to admit "... any liquid which would prejudicially affect the sewers, or the treatment or disposal of the content of the sewers, or would from its temperature or otherwise be prejudicial to health." With the exception of the last clause these requirements are similar to those of the 1876 Act.[33]

The following year this section of the 1936 Act was repealed by the Public Health (Drainage of Trade Premises) Act 1937, which then stipulates the procedures by which Trade Effluents may be allowed to discharge into sewers. The effluent may be subject to consent, the consent may be unconditional or may specify a) the sewer to which discharge is made, b) the nature or composition of the effluent to be discharged, c) the maximum quantity in any one day, d) the highest rate of discharge, and e) any other matter with respect to which by-laws may be made under the Act.[34] Discharge of any trade effluent contravening the consent is an offence.[35]

Provision is also made for effluents to be controlled by by-laws, by agreements and by direction.

By-laws could also specify charges to be made for the reception of the trade effluent and subsequent 'disposal thereof', "...regard being had to the composition and volume of the trade effluents so discharged."[36]

The 1937 Act may be seen to use concepts developed by the RCSD in the early years of the century to provide a legislative base for control of trade effluents discharged to sewers today.[37]

The right to make by-laws was repealed by the Public Health Act 1961. The right to make charges for trade effluents discharged to sewers being now contained in S 59e of that act. The Act is also notable for its confidentiality clauses and the severe penalties stipulated for their breech, effectively cloaking the consent making and an important part of the enforcement procedure in a cloak of secrecy.[38]

The control of river pollution remained open to a great deal of criticism. Some local improvements resulted from the use by individual and collective riparian owners of the common law, but this was an expensive process. Administrative improvements were made under the Rivers (Prevention of Pollution) Acts 1951 and 1961, the Clean Rivers (Estuaries and Tidal Waters) Act 1960 and by the Water Resources Act 1963 which set up a Water Resources Board and replaced River Boards by River Authorities. From a legal point of view Harvey comments, "Of the four methods of pollution control contained in the acts, most reliance was placed on the consent procedure, especially after 1963 when all discharges into non-tidal rivers came under control". He considered the main defects were that "....the standards imposed by river authorities were too low," and that "...the consent procedure was not enforced," concluding "The system worked well against those prepared to submit voluntarily."[39]

Categorisation

As the economic climate worsened in the sixties the efforts of River and local authorities were further limited by Government circulars such as that of December 4th 1968 which emphasises the importance attached to the cooperation of river and sewage disposal authorities with industrial dischargers,".. and to the need for river authorities to be prepared to justify all standards laid down for industrial effluents, whether the standards are unusually stringent or not." With the exception of improvement needed to secure water for "foreseeable use for public water supply or other urgent purposes. Otherwise even in present economic circumstances river authorities should continue to aim at preventing deterioration."

Suggesting that the critical requirement by law, that the rivers should not become materially less wholesome.[40] Thus poor quality rivers remain poor and the 'wholesomeness' of a river without a fish population allowing relaxation of controls on effluents discharged to both river and sewers. The underlying principles of categorisation are still in use in 1984.

Returning to the problem of controlling trade effluents discharged to sewers. Any attempt to assess the success of the 1937 Act, subsequent legislation and circulars,[41] in providing a more efficient administrative structure and control procedure must be tempered by the findings of the Working Party on Sewage Disposal. In 1970 they report, "We have been surprised to learn of the comparatively large number of cases where the provision of the Public Health (Drainage of Trade Premises) legislation have either been ignored altogether by local authorities or discharges permitted for which available treatment facilities were or had become inadequate," and conclude, "We consider it imperative for local authorities to exercise effective trade effluent control."[42] Fletcher had identified similar problems 82 years before. Local discretion, influence and pragmatism continued to prevail.

The Working Party recommended that all discharges of industrial effluent should become subject to control and liability for charges, that charges throughout the country should be based on a common formula,[43] and that "One firm should not be required to subsidise another (which would be the effect of equalisation)."[44]

2.3. A strategic approach

The Water Act 1973 and Control of Pollution Act 1974

Further to the formation of a Department of Environment in 1970, it was claimed that "a total strategic approach to environmental planning and protection is replacing the fragmented approach which previously handicapped effort and sometimes wasted resources of the multitude of agencies involved."[45] The provision of the Water Act 1973 may be seen to be in keeping with this claim.

The Act requires the Secretary of State for the Environment and the Minister of Agriculture, Fisheries and Food to "... promote jointly a national policy for water in England and Wales..."[46]

The Act specifically makes the Secretary of State responsible for the 'effective execution' of "Sewerage and the treatment and disposal of sewage and other effluents."[47]

This is a logical allocation of responsibility but does not take account of the situation when sewage sludge is disposed/utilised on agricultural land, where DOE policy may conflict with the responsibilities of the Minister to the agricultural industry.

Much of the joint policy is to be executed by 9 English and the Welsh Water Authority. A National Water Council is also set up. The potential for much more coherent and uniformly applied policies is apparent but at a price, once again 'gamekeeper' and 'poacher' are part of the same authority.

But in spite of the strategic approach, the administration of which is facilitated in the 1973 Act, the Control of Pollution Act which emerged from the statute making process in 1974 continues the pragmatic tradition.

Of particular importance in this study are the provision within the Act for staggering implementation of the act by requiring 'the appointed day' to be specified, and in allowing liberal use of statutory instruments to interpret, over an apparently unlimited period, the content and application of sections and clauses. In practice the Act is unique, providing little guidance to those applying it, or subject to it, as to the exact requirements or the date of implementation of unimplemented sections and clauses.

Two examples are of considerable concern to this study. First SI

1976 No.732 exempts a 'waste', sewage sludge when disposed to agricultural land from control by Part 1 of the Act. See sections 4, 5 and 6 of this study.[48] Second, the delayed implementation of Section 41 allowing public access to registers of consents and analyses of effluent samples for public inspection, a major innovative feature of the act important for the following main reasons.

First because the cloak of secrecy is still maintained round the consent making process; secondly, unlike the Alkali and Clean Air Inspectorate, the act still does not empower Water Authority Officers to specify or control the uses of treatment plants prior to discharge of effluents. Thirdly once again the Authority is also a polluter. Fourthly, in the absence of strong pressure from the centre, pressure exerted through potential of public access to registers is important in providing urgency and priority in the consent making, consent keeping and enforcing processes.[49]

COPA '74 like its predecessors is also of note in stating little about the consent making process itself. Having briefly reviewed pollution control in England and Wales, Bennett concludes, "... control over individual discharges is exercised by various means according to the particular pollutant and receiving environment. But although procedures vary, the responsible authorities have generally adopted a common basis for control, namely the concept of 'best practical means'. It may be explicit or implicit, but the principle of exercising control with reference to currently available technology, economic considerations and local circumstances has been favoured over the uniform standards approach for its pragmatism and flexibility."[50]

Defending the policy of delegating pollution control to local level a DOE publication states, "Authorities may in many areas exercise a considerable degree of discretion as to the limit they impose on the release of local pollutants, so that account may be taken of local resources and social priorities, the uses to which surrounding areas are put and the capacity of the environment to absorb pollutants."[51]

But Bennett points out that those wide powers of discretion are open to abuse, "Moreover, in Britain discretion is associated with a high degree of confidentiality."[52] The provisions of the COPA 74 Act are no exception to that generalisation.

Trade Effluent Charges

The Water Act 1973 makes provision for Water Authorities to fix and make charges for services performed, facilities provided and rights made available by them, S.30.5 requiring them to ensure that "as from a date not later than 1st April 1981 their charges are such as not to show undue preference to, or discriminate unduly against, any class of persons."[53]

As Water Authorities came into being on 1st April 1974 a long lead time was available to fulfil this requirement.

COPA 74 specifically states that provision of S30 and 31 shall apply to Trade and Sewage Effluents "... made by virtue of consents given in pursuance of this Act or the Public Health (Drainage of Trade Premises) Act 1937..." and therefore includes trade effluents discharged to sewers.[54]

But ten years later in 1984 this apparently egalitarian provision has not been brought into force.[55] Preference and discrimination through trade effluent charges are further discussed in Section 9 of this study.

Voluntary controls

Extra statutory controls, particularly in the use of the RCSD general "30:20" standard, have become an important feature of pollution control.

Perhaps because of the sparcity of quantitative norms to be found in statutes, the general standards proposed by RCSD at the beginning of the century, provided norms for consultants, planners, managers, pollution prevention officers and other local or central government officials to work to.

Voluntary product control schemes have also been an important feature of Government pollution control policy. The most visually apparent success being achieved by the voluntary cooperation of manufacturers with government in replacing 'hard' anionic with 'soft' biodegradable detergents. An important feature of the 1964 scheme being in the self 'policing' exerted by the manufacturers themselves.[56] Also of importance to water pollution control policy has been the Pesticides Safety Precaution Scheme. Perhaps it is symptomatic of the advantages and potential weaknesses of this scheme that it has become the subject of sustained public concern. In May 1970 the Government announced that it would be replaced by statutory controls.[57] In 1971 the Royal Commission on Environmental Pollution recommend it should be replaced by statutory controls,[58] but in their Fourth Report (December 1974) are of the opinion that this step is not justified at present.[59] In their 7th Report (September 1979) recommend the amalgamation of PSPS with the also voluntary Agricultural Chemicals Approval Scheme.[60]

Common features of these schemes are a) the small number of product manufacturers; b) they control product formulation; c) they have a considerable degree of self policing by the interested parties; d) although they may provide some control over distribution of products they do not in themselves control final use.

2.4. Conclusions

1. The pragmatic water pollution control policies extant in England and Wales today are a direct result of pressure brought to bear by manufacturers in the 19th and 20th centuries to prevent trade effluent standards being stipulated in statute laws, most notably in the Rivers Prevention of Pollution Act 1876.

Having failed to achieve stipulation of central standards the problems of standard setting were passed down to local authorities themselves subject to local control, pressures and expedients. Control by by-laws was found to be generally ineffective. Although effluents controlled by means of consents, following the process laid down in the Public Health (Drainage of trade premises) Act 1937, control was not mandatory, and pre-March 1973 discharges were conditionally exempted.

Control was such that in 1970, i.e. three years prior to the UK becoming party to the first EEC environmental programme, the Working Party on Sewage Disposal were surprised by evidence of large numbers of trade effluents not controlled or inadequately controlled by the consent system. They also heard "...that some councils make no charges in order to encourage industries to settle in their area."[61]

In passing responsibility for standard or consent making and charging to local authorities, central authorities allowed the right to pollute to be manipulated as a financial incentive. With weak enforcement agencies and with local authorities themselves often major polluters, effectiveness of consents often depending on the willingness to cooperate of the traders themselves.

2. Control of discharges is today mainly by individualised consents.

In spite of the RCSD proposal that standards should be according to the character of the trade waste, trade effluents discharged to sewers are subject to legal clauses, but in addition 'best practical means' criteria underlying defences stipulated in the 1876 Act have become implicit in the consent making process. Unlike the Alkali and Clean Air Inspectorate whose use of best practical means is explicit in law, Consent officers do not have control over the processes to be used or the maintenance and ongoing use of effluent treatment plants used by the traders. Is it not fair then, in this context, to ask best practical means for what - or whom?

Unfortunately the answers to these questions although vital may again be individualised and hidden behind confidentiality clauses.

3. Provision for allowing the Water Authority to charge for receipt, treatment and disposal of trade effluents is written into COPA 74 and the Water Act 1973. Section 3 of the latter requiring that by 1st April 1981 charges should not show '...undue preference to, or discriminate unduly against, any class of persons.'

4. Perhaps because of preoccupation with water pollution control and particularly with suspended solids and oxygen demand as the main criteria for determining quality, the RCSD and subsequently local authorities have paid less attention to the effects of potentially toxic substances entering sewers on the quality of sewage sludge produced.

5. The 1973 Act in making the Secretary of State for the Environment responsible for sewage sludge disposal, even when disposed to agricultural land, may in some circumstances, conflict with responsibilities of the Minister for Agriculture to the agricultural industry.

6. In the past considerable use has been made of extra statutory norms. Considerable success has been claimed for voluntary product control schemes where the number of participants is small. It is noticed however that these schemes do not control final use of products.

General

7. Acknowledging that the laws controlling pollution have grown up in a piecemeal fashion, the 1970 White Paper subtitled 'The Fight Against Pollution' restates the general approach "The British system of law in this, as in related fields, does not traditionally rely on the very heavy penalty as the main deterrent. It relies on persuasion and the belief that, especially to industrial firms, it is the disgrace that counts and not the fine." To some ears this statement is in danger of sounding like a

pious hope rather than control policy. It pays little regard to the pressures on individuals to contravene or the range of perceptions that traders, industrialists or managers have of 'good business'. The White Paper adds "The weapon of prosecution has been sparingly used."[62]

8. The ongoing interpretation of COPA 74 by means of statutory instruments and delays in implementation of Part II make strategic planning difficult, weakening the consent making, keeping and enforcement processes.

3. POLLUTION CONTROL

REDUCTION OR TRANSFER?

3.0 Introduction

Structural changes taking place in the late 1960s and particularly in the first five years of the 1970s may be seen as reflecting a growing public awareness in pollution issues.

Events such as the first National Wildlife Exhibition in 1963 followed by Countryside in 1970 Conferences in 1963 and 1967 providing foci of attention, media coverage and follow up activity which in turn led to wide participation in the 1970 European Conservation Year.

Perhaps the publication of the categorising circular 64/68 on 4th December 1968 was itself instrumental in creating a crisis. The working party on sewage disposal was appointed in February of the following year "to consider and report on the public health, amenity and economic aspects of the various methods of sewage disposal."[1] A further action was to reconstitute the Central Advisory Water Council to advise the Minister for Housing and Local Government on the reorganisation of the 'water and sewage industry'.[2]

Indirectly the wreck of the Torrey Canyon in 1967 and subsequent oil pollution, but more directly the publication of the Select Committee on Science and Technology "Report on coastal pollution" and subsequent acrimonious debate may be seen as leading to machinery of Government changes:

a. Setting up the precursor to the Department of the Environment;

b. The creation of a Central Scientific Unit on Pollution within the office of the Secretary of State;

c. The establishment of a Standing Royal Commission on Environmental Pollution with wide terms of reference;[3]

d. The withdrawal of the categorising circular 64/68;[4]

and e. In May 1970 the publication of a White Paper subtitled 'The Fight against Pollution'.

Following the change of Government in June 1970 the administrative changes continued in the amalgamation of ministries to form the Department of Environment.

In addition to a preoccupation with administrative changes, one of the most marked features of the period was the increased involvement in international agreements controlling pollution.

With regard to controlling pollution in Britain both the White Paper and the RCEP emphasised the importance of an informed public opinion. The latter stating, "What we have to achieve is a combined operation between public opinion, economic incentive and legislation."[5]

3.1. Purpose and Method

In the improved circumstances of 1970-72 the effects of the trebling of world oil prices could not be foreseen. But it is against that background and of the administrative and legal framework already outlined that it is now the purpose of this section to examine again a statement of policy made in DOE Pollution Paper 9, and to consider the effects of that policy as shown by the results and implications of the clean rivers policy anticipated in May 1970.[6]

In explaining how pollution control in Britain works the general statement is made: "Thus central Government lays down the statutory framework for pollution control, but implementation is delegated to a large extent to local level. Authorities may in many areas exercise a considerable degree of discretion as to the limit they impose on the release of local pollutants, so that account may be taken of local resources and social priorities, the uses to which surrounding areas are put and the capacity of the environment to absorb pollutants."[7]

Setting aside the historical reasons for why this local pragmatism should prevail, it is now necessary to examine this apparently rational parochial situation in which there is 'a considerable degree of discretion as to the limit they impose on local pollutants' and in which account is taken of 'the capacity of the environment to absorb pollutants.' The word 'absorb' itself could be the subject of a whole study. But are we here having described the rationality of local control of pollutants which are contained within the confines of the administrative area? Or does the rationality of this statement breakdown when the realities typical of many localities and completely omitted from the statement are taken into account? The results of river pollution surveys are now used to gauge the effectiveness of these local controls.

The river survey results must be set against the report in 1970 that in England and Wales there were 'some 5000' municipal sewage treatment works 20% of which served populations greater than 10,000 persons. Sewerage and hence control over trade effluents entering sewers, sewage treatment and sewage disposal were then administered by 1,400 Local Authorities.[8] But much of the pressure for improvement of the rivers was focussed on 29 River Authorities. Responsibilities of the Local Authorities and River Authorities were assumed by the 10 Regional Water Authorities in April 1974.[9]

Unfortunately results of successive surveys are not neatly compatible; it is therefore necessary to look at results in some detail.

3.2. River Pollution Surveys

Comparative results of river pollution surveys carried out in 1958, 70, 75 and 80 and up dates for 1971 and 72 are shown in tables 3.1-3.4. The surveys applied to nontidal and tidal rivers with a summer flow greater than 0.5 $m^3 sec^{-1}$.[10] The data shown is based, in the Royal Commission tradition, mainly on BOD and suspended solids, and to a lesser extent the presence or absence of 'toxic materials'.[11] Class 4 includes 'all rivers' known to be 'incapable of supporting fish life'.[12] Criteria of classification are included in Appendix 3.1.

Information from the 1958 survey is officially regarded as "significantly less comprehensive and more subjective than subsequently."[13]

Results

As shown in table 3.1-4 total lengths of rivers are different in each survey. 1975 and 1980 data is based on Water Authority assessments, data is claimed to be more accurate with each successive survey.[14] A further complication is due to the inclusion of revised 1975 data as shown in tables 3.2 and 3.4.

Non tidal rivers

On the basis of percentages calculated, the greatest increase in length of Class 1 rivers appears to be 3.3% in the 12 years from 1958-70 with an overall decrease of 0.17% in the period 1970-80. See table 3.1. Part of this change is due to changes of measurement. On the basis of 'quality' 1980 class 1 rivers are equivalent to 76.2%, when using the 1975 surveyed lengths as a basis. This figure is identical to the percent length given for 1970 and within the limitations of the data would suggest no overall change. See table 3.2.

However much of class 1 mileage is made up of relatively small rural and upland rivers, as shown in the maps accompanying the surveys.

Comparing combined lengths of Class 1 and 2 rivers table 3.1 indicates a 3.7% improvement, from 87.2 to 90.9 percent in the period 1958-1970 and a small but steady improvement of 2.22%, from 90.9 to 93.12 percent between 1970 and 1980. When 1980 data is corrected for measurement changes equivalent 'quality' change is 2.19%, from 90.9 to 93.09 percent during the

1970-1980 period. See tables 3.1 and 3.2. Comparing revised 1975 with 1980 data there appears to have been an increase of length of 202 km in Class 1 or 2 due to quality changes. See table 3.2.

Although improvement is slow net increases in lengths of Class 1 and 2 rivers due to quality changes appear to be taking place.

There has also been a steady reduction in Class 4 rivers, as shown in table 3.1, lengths reduced from 6.4 to 4.3 per cent of total between 1958 and 1970 and from 4.3 to 2.05 percent between 1970-80. A net reduction 442 km of Class 4 rivers in 5 years is shown when revised 1975 data is compared with that for 1980. See table 3.2.

Although Class 3 rivers appear to have reduced in length from 6.4 to 4.8 percent between 1958 and 1970 and reductions made from 4.8 to 4.0 percent in the period 1970-75 the trend has been reversed and lengths of Class 3 rivers increased by .83% in the period 1975-80. See table 3.1. Or if data shown in table 3.2 is accepted, on the basis of 'quality' Class 3 rivers increased by .66% i.e. 240 km when revised 1975 data is compared with 1980 data. See table 3.2.

1975-80 results, particularly as shown in table 3.2, appear to reflect the River Water Quality policy of the National Water Council, which in 1978 recommended, amongst other things, that:

> "a. River quality objectives should be determined by water authorities, as far as practicable for rivers, canals and major streams in their regions ..."
>
> "b. Objectives should have regard to uses of those waters and environmental considerations, ..."
>
> "c. Long term objectives should be identified where the water involved is of adequate quality and short term objectives pending upgrading as and when possible to adequate quality..."

In order to facilitate the implementation of the Control of Pollution Act 1974 the strategy of river categorisation is reintroduced.

The policy also recommended that objectives should be "...based on values of quality parameters which are expected to be achieved by 95 per cent of samples taken."[15]

Tidal Rivers

Class 1 tidal rivers are a lower percentage of total lengths than nontidal. In part, a reflection of their use both past and present as low cost waste disposal channels often supported by conveniently regarding them "... as capable of taking virtually unlimited polluting loads."[16]

Results

Increases in length of Class 1 rivers, between 1958-70 and 1970-80 are 7.4 and 2.24 percent respectively suggesting a slowing down in improvement. When revised 1975 is compared with 1980 data increase in Class 1 rivers due to quality change is 57 km. or 2.01%. See tables 3.3 and 3.4 during that period.

When Class 1 and 2 lengths of rivers are taken together change between 1958-70 and between 1970-80 appears to be a reduction of 2% and a steady improvement of 12.71% respectively. See table 3.3. Comparing revised 1975 data with 1980 data there appears to be an improvement of 7.81% by length from 75.32 to 83.13 percent due to quality change. See table 3.4.

Although there appears to have been a deterioration between 1958-70 of 2% when Class 3 and 4 rivers are taken together, between 1970-80 there appears to have been a considerable improvement of both Class 3 and Class 4 rivers from 16.8 to 7.93 and from 11.7 to 7.86 percent respectively. See table 3.3.

Comparing revised 1975 with 1980 data there appears to have been a reduction in length of Class 3 and Class 4 rivers of 174 and 48 km. equivalent to 6.12 and 1.69 percent respectively due to quality changes over the 5 year period. See table 3.4.

As tidal rivers tend to have a much greater volume per length than non tidal rivers increases in length of Class 1 and 2 and decreases in Classes 3 and 4 tidal rivers appear to represent a considerable improvement.

3.3. Discussion

Among the reasons given for upgrading river quality are:

a. Industrial decline;

b. New and extended sewage treatment works and trunk sewers.

If viewed from the content of potentially toxic metals, trunk sewers may be seen as means of transferring the problem rather than eliminating it. Improvements were also due to:

c. New or improved waste water treatment plants; and

d. The connection of polluting trade effluents to sewers.[17]

Of this last practice the 1975 Rivers Survey Report, published in 1978, concludes,

> "Latterly the tendency has been to discharge industrial effluents to sewers rather than directly to watercourses. This has resulted in decreasing numbers of industrial effluents which are not satisfactory but has increased the problems of obtaining satisfactory effluents from sewage treatment works."[18]

The Report found that whereas 68.3% of sewage effluent discharges to non-tidal rivers were judged 'satisfactory' in 1972 the percentage in 1975 was lower 64.3%. In the same period industrial effluents improved from 49.9 to 54.3 percent 'satisfactory'.

Numbers of sewage effluents slightly increased by 0.37%, and reported industrial effluents decreasing by 8.2% in the same period.[19]

The effects of connecting trade effluents to sewers on the resulting sewage sludge output of the treatment works is not discussed in either the 1978 or 1980 River Survey Reports.

Reasons given for downgrading of rivers were:

a) Agricultural inputs of pollutant particularly in relation to downgrading of Class 1 rivers;

b) "Trade effluents have tended to become more complex in their chemical composition over the years and have caused problems at some sewage works."[20]

Again the effects of b) on sewage sludge produced and the implications for its disposal are not considered.

The deterioration of the RWAs own effluents may also have a 'knock on' effect in that as 'Gamekeeper' and 'Poacher' they are expected to show an even handedness in allocating environmental quality objectives and subsequently consents between their own discharges and those of others. The CBI and NFU being particularly concerned that this principle should be upheld. Thus ironically deterioration of the RWAs own sewage effluents as a result of receiving into sewers industrial effluents formerly polluting rivers, may be used as a bargaining position to now allow laxer consents or greater tolerance of effluents still discharged to rivers.[21]

Of future river quality the NWC predicted that while there might be some reduction in gross pollution, "...deterioration in some areas seemed inevitable." The general prospect being of "little overall change in the next five years."[22]

3.4. Conclusions

1. On the basis of the criteria used there has been some improvement in river quality. When percent of total length is used as a basis, improvement appears to have been greater in tidal rather than non-tidal rivers.

2. Much of the improvement in river quality appears to be due to transfer of pollutants rather than reduction of pollutants per se.

3. Whatever the reasons for the slow down in improvement of river quality in many cases the use, ortolerance by use, of local discretion in

allowing local potential pollutants to be discharged to sewers or streams is in many cases far higher than the 'local' environment can 'absorb' and has become a massive and expensive operation in the transfer of potential pollutants to areas outside, sometimes far outside, the localities in which they are emitted.

3. Increasing the size of the control agency does not in itself make the use of local discretion more rational particularly when the agency is itself a major polluter.

5. The strategy of transferring trade effluents to sewers, whatever it might achieve in terms of BOD and suspended solids reduction, will often contaminate local sludges making them less fit, or unfit, for local disposal.

6. As disposal may still be perceived as a competition for diluting capacity any deterioration in the Authority's own effluents whatever the cause, and however expedient the strategy, may be used to weaken the controlling power of the authority over trade effluents still discharged to rivers;

7. Which suggests that a key point in this process must be in achieving and maintaining effective control of trade effluent inputs to sewers.

But policies involving transfer of pollutants must now also take account of attempts being made to control the use of international 'commons' by international agreements to which the UK is now party.

As since 1973 the UK has become an EEC member state, a signatory to the Treaty of Rome, pressure to comply with some of those agreements involves the use of economic as well as environmental criteria.

TABLE 3.1. Total lengths of Non-Tidal rivers in various quality classes in 6 river pollution surveys

Year	1958a		1970 ab		1971b		1972b		1975 bc		1980d	
Units	km	%	km	%	km	%	km	%	km	%	km	%
Chemical Class												
Class 1 (unpolluted)	23,510	72.9	27,370	76.2	27,819	77.4	28,082	78.1	28,037	77.6	27,633	76.03
Class 2 (doubtful)	4,613	14.3	5,297	14.7	5,260	14.7	5,062	14.1	5,458	15.1	6,210	17.09
Class 3 (poor)	2,059	6.4	1,724	4.8	1,512	4.2	1,526	4.3	1,449	4.0	1,757	4.83
Class 4 (Grossly Polluted)	2,058	6.4	1,533	4.3	1,340	3.7	1,275	3,5	1,178	3.3	744	2.05
Totals	32,240	100.0	35,924	100.0	35,930	100.0	35,944	100.0	36,123	100.0	36,344	100.0
Classes 1 & 2	28,123	87.2	32,627	90.9	33,079	92.1	33,144	92.2	33,495	92.7	33,843	93.12

Notes:

a) Source from DOE/WO River Pollution Survey of England and Wales 1970. London, HMSO. 1971 Table 1, p.1.

b) Source from DOE/WO River Pollution Survey of England and Wales Updated 1975. London, HMSO. 1978 Table 2.1, p.5.

c) Revised 1975 data is shown in Table 3.2.

d) NWC River Quality - the 1980 Survey and Future Outlook. London, NWC. Dec. 1981 table 8.

TABLE 3.2. River Surveys 1975 and 1980, changes in classified lengths of Non-tidal rivers, due to changes in a) Quality and b) Measurement

Year / Units	1975 km b.	%	Revised 1975 km. c.	%	75-80 Change On the basis of a. Quality 1980 km.d.	%	b. Measurement 1980 km.e.	Total 1980 km.f.	%
Chemical Class[a]									
Class 1 (Unpolluted)	28,037	77.6	27,635	76.39	27,563 (-72)	76.2 (-0.19)	+ 70	27,633	76.03
Class 2 (Doubtful)	5,458	15.1	5,835	16.13	6,109 (+274)	16.89 (+0.76)	+101	6,210	17.09
Class 3 (Poor)	1,149	4.0	1.518	4.2	1.758 (+240)	4.86 (+0.66)	- 1	1,757	4.83
Class 4 (Grossly polluted)	1,178	3.3	1,186	3.28	744 (-442)	2.05 (-1.23)	0	744	2.05
Totals / Totals change	36,123	100.0	36,174	100.00	36,174 (000.00)	100.0 (000.0)	+170	36,344	100.00
Classes 1 + 2	33,495	92.7	33,470	92.52	33,672 (+202)	93.09 (+0.57)	+171	33,843	93.12

Notes:
a. See for instance NWC.1981 River Quality the 1980 Survey and future outlook p.30.
b. ibid p.14 Col. c Table 5.
c. ibid p.14 col. d Table 5.
d. derived from ibid p.14 col.d + col.g Table 5.
e. ibid p.14 col. h Table 5.
f. ibid p.14 col. i Table 5.

TABLE 3.3. Total lengths of Tidal rivers in various quality classes in 6 river pollution surveys

Year	1958a		1970b		1971b		1972b		1975b		1980c	
Units	km	%	km	%	km	%	km	%	km	%	km	%
Chemical Class												
Class 1 (Unpolluted)	1,159	40.7	1,383	48.1	1,417	49.4	1,432	50.1	1,422	49.6	1,409	50.34
Class 2 (Doubtful)	934	32.8	675	23.4	667	23.2	640	22.5	720	25.1	948	33.87
Class 3 (Poor)	403	14.1	485	16.8	407	14.2	423	14.8	424	14.8	222	7.93
Class 4 (Grossly polluted)	354	12.4	336	11.7	380	13.2	362	12.6	301	10.5	220	7.86
Totals	2,850	100.0	2,884	100.0	2,871	100.0	2,856	100.0	2,866	100.0	2,799	100.0
Classes 1 & 2	2,093	73.5	2,058	71.5	2,084	72.6	2,072	72.6	2,142	74.7	2,357	84.21
Classes 3 & 4		26.5		28.5		27.4		27.4		25.3		15.79

Notes:

a. From (Adapted) DOE River Pollution Survey of England and Wales 1970 London,HMSO.1971 Table 2 p.2.

b. From DOE River Pollution Survey of England and Wales Updated 1975 London,HMSO.1978 Table 2.2, p.5.

c. From NWC River Quality - the 1980 Survey and Future Outlook. London NWC. Dec. 1981 Table 9.

TABLE 3.4. River Surveys 1975 and 1980, changes in classified lengths of tidal rivers due to changes in a) Quality and b) Measurement

Year / Units	1975 km.b	%	Revised 1975 km.c.	%	75-80 Change On the basis of a. Quality 1980 km.d	%	b. Measurement 1980 km.e	Total 1980 km.f.	%
Chemical Class[a]									
Class 1	1,422	49.6	1,364	47.94	1,421	49.95	-12	1,409	50.34
" change					(+57)	(+2.01)			
Class 2	720	25.1	779	27.38	944	33.18	+ 4	948	33.87
" change					(+165)	(+5.8)			
Class 3	424	14.8	421	14.8	247	8.68	-25	222	7.93
" change					(-174)	(-6.12)			
Class 4	301	10.5	281	9.88	233	8.19	-13	220	7.86
" change					(-48)	(-1.69)			
Total	2,866	100.00	2,845	100.00	2,845	100.0	-46	2,799	100.00
" change					(000)	(00.0)			
Classes 1 & 2	2,142	74.7	2,143	75.32	2,365	83.13	- 8	2,357	84.21
" change					(+222)	(7.81)			

Notes:
a. See for instance NWC. 1981 River Quality the 1980 Survey and Future Outlook p.30.
b. *ibid* Table 7 col.c.
c. *ibid* Table 7 col.d.
d. derived from Table 7 col.d + col.g.
e. derived from Table 7 col.h.
f. derived from Table 7 col.i.

CLASS 1: UNPOLLUTED

(a) All lengths of rivers whatever their composition, which are known to have received no significant polluting discharges.

(b) All rivers which, though receiving some pollution, have an uninhibited BOD less than 3 mg/1, are well oxygenated and are known to have received no significant discharges of toxic materials or of suspended matter which affects the condition of the river bed.

(c) All rivers which are generally indistinguishable biologically from those in the area known to be quite unpolluted, even though the BOD may be somewhat greater than 3 mg/1.

CLASS 2: DOUBTFUL

(a) Rivers not in Class 1 on BOD grounds and which have a substantially reduced oxygen content at normal dry summer flows or at any other regular times.

(b) Rivers, irrespective of BOD, which are known to have received significant toxic discharges which cannot be proved either to affect fish or to have been removed by natural processes.

(c) Rivers which have received turbid discharges which have had an appreciable effect on the composition of the water or character of the bed but have had no great effect on the biology of the water.

(d) Rivers which have been the subject of complaints which are not regarded as frivolous but which have not been substantiated.

CLASS 3: POOR

(a) Rivers not in Class 4 on uninhibited BOD grounds but which have a dissolved oxygen saturation, for considerable periods, below 50 per cent.

(b) Rivers containing substances which are suspected of being actively toxic at times.

(c) Rivers which have been changed in character by discharge of solids in suspension but which do not justify being placed in Class 4.

(d) Rivers which have been the subject of serious complaint accepted as well-founded.

CLASS 4: GROSSLY POLLUTED

(a) All rivers having an uninhibited BOD of 12 mg/1 or more under average conditions.

(b) All rivers known to be incapable of supporting fish life.

(c) All rivers which are completely deoxygenated at any time, apart from times of exceptional drought.

(d) All rivers which are the source of offensive smells.

(e) All rivers which have an offensive appearance, neglecting for these purposes any rivers which would be included in this class solely because of the presence of detergent foam.

Source: NWC. River Quality - the 1980 survey and future outlook. London, NWC. December 1981, p.31.

4. THE SCALE OF SEWAGE SLUDGE DISPOSAL, SOME PRESENT AND LIKELY FUTURE CONSTRAINTS

4.0 Introduction

The pollution of a water course or a body of water may be as a result of countless inputs of contaminants from very small point and diffuse sources. But, with few exceptions, the main identifiable sources of pollution have been point sources arising from a concentration of human activity. The development of sewage works and the attempts to control the quality of the resultant effluents and those from trade sources may be seen as ongoing sequels to this concentration process.

The continued use of controls allowing the right of discharge of trade effluents to sewers has led to the complexing of potentially toxic with organic and inorganic substances in sewages requiring treatment. As seen in the river surveys, this strategy has been encouraged in the drive to maintain, or possibly improve, the quality of rivers.

In addition to aesthetic and amenity requirements the more basic uses of sewage effluent receiving waters to maintain dry weather flow and subsequent re-use for amenity, transport or trade and/or public water supply are fundamental requirements in many areas.[1]

The 1970 Working Party on sewage disposal state: "The object of modern methods of sewage treatment is to convert the unstable sewage into a stable effluent suitable for discharge to the local water course," but then observe, "In this treatment an offensive sludge is produced which must also be disposed of."[2] They were of the opinion that "While the liquid part of sewage can be treated satisfactorily, the treatment and disposal of sludge would appear from observations and discussions during our visits and from the evidence submitted to us to be the greatest problem at treatment works today."[3]

Although earlier this century it was seriously suggested that the total destruction of sludge should be achievable by biological means,[4] the general view now seems to be that the total quantity of sludge produced is likely to rise,[5] put simply, "The greater the purification of sewage achieved, the larger is the amount of sludge produced."[6]

Purpose

In view of this prospect and of UK membership of the EEC the purpose of this section is now to assess for England and Wales or the UK the scale of sewage sludge disposal and of some present and likely future constraints, particular attention being given to disposal by utilisation on agricultural land, and to metal concentrations as a constraining factor.

In order to carry out this assessment the following are examined:

1. The scale of sewage sludge disposal within the UK context.
2. Economic and political vulnerability of current disposal practices, within a European context.
3. Legal and voluntary controls on disposals from England and Wales or UK.
4. The case for and current disposal of sewage sludge by use on agricultural land in England and Wales.
5. Implications of geographical variations in land use for sewage sludge disposal.
6. The sources and importance of metal concentrations as potential limiting factors in sewage sludge disposals.

Method

Government publications and other published material are used to examine:

A. In connection with 1, 2 and 3, in UK and European contexts, total sludge production and disposals of sludge, by incineration, to sea and to land;

and B. In connection with 4 and 5 sewage sludge disposal by use on agricultural land in more detail;

and C. For 6, results of recent surveys of sludge metal concentrations are discussed in relation to findings from A and B.

4.1. Sludge Production and Disposal

4.1.1. Total sludge production, UK and European contexts

Results for surveys published by DOE and NWC for the years 1975, 1977 and 1980 for mass of sludge disposed of, with or without prior treatment, are used when considering data in a UK context. Whereas mass of raw sludge initially produced forms the basis of published data considered in EEC or European contexts.

As anticipated, the total sewage sludge solids produced in England and Wales rose from the estimate of 1000 kt. given by the Jeger Committee in 1970,[7] to 1116 and 1136 kt. in 1975 and 1977, apparent decline to 1045 kt. in 1980 is accounted for by decrease in measured quantity applied to land. Reasons given for this decrease being: a) industrial recession; b) more accurate measurement; and c) a lower per capita estimate value, used when measured mass of sludge was unavailable.[8] See table 4.1.

In 1980 sludge production from English WAs accounted for 96.23 and 83.42 per cent of that from England and Wales and the UK, respectively. See table 4.1.

On the basis of assumptions given in the 1980 survey, UK annual production of 1205.6 kt. of sludge was equivalent to 1420 kt. of raw sludge produced.[9]

European context

UK raw sludge production and disposal is compared with that of 15 other European countries in table 4.2, the rounded data shown is dated to several different years. Comparisons are made with that reservation in mind.

Of the countries with populations greater than 50m persons FGR the highest producer, UK, Italy and France, EEC member states produce respectively 2200, 1420, 1200 and 840 kt. y^{-1} dry solids of raw sewage sludge. Production in the other six EEC member and six EEC non-member states totalled 464 and 730 kt. D.S.y^{-1} respectively, UK production being 20.72% of raw sludge produced by the 16 European states.

From the above figures it is seen that the way in which UK disposes of sewage sludge, because of the scale of disposal required, is politically important to EEC and other European states.

UK disposals are now considered on a 'route' basis each followed by a brief resume of legal controls.

4.1.2 Disposal by incineration

As shown in table 4.1, Welsh use of incineration of sewage sludge has been very slight and was reported in 1981 to have ceased.[10] In England the increase from 3 to 4 per cent between 1975 and 1977 has flattened out to 4.31 per cent in 1980 and is slightly above the UK 3.7 per cent. These results are accompanied by the statements that, "There is about 50 per cent reserve in sludge incineration capacity,"[11] and that, "It is unlikely that more incinerators will be constructed in the UK within the foreseeable future,"[12] suggesting that this high cost route is now regarded as a minority expedient. A view reinforced by the Standing Technical Committee in their 1981 report who advise, "Although incineration is effective and reliable, there is a case for its adoption only where it is the most economic option, the only acceptable solution, or where it is strategically justifiable to complement other sludge disposal methods."[13]

By comparison with other European countries for which data is shown in table 4.2, UK percent disposal by incineration is low, 4 per cent, compared with France 20 per cent, FGR 8 per cent and Italy 5 per cent which have a similar size population. It is noticed that countries with less than 5m population do not appear to incinerate sewage sludge. Of other countries Austria and Denmark with 7.5 and 5.1m population have relatively high incineration usage of 30 and 10 per cent respectively, presumably reflecting pressure to reduce use of other disposal routes. But economic and/or political pressure to reduce incineration may itself be reflected in the sludge disposed by Belgium formerly reported by the Oslo commission as being 85 per cent is in 1979 2 per cent, while disposal to 'other land' has increased from 0 to 83 per cent.[14]

Control of incineration

In the UK air pollution by emissions from incinerators are controlled by the Clean Air Acts 1956 and 1968 and by the Health and Safety at Work Act 1974.[15,16,17] Tipping of waste to landfill is subject to Part 1 of COPA 1974. Unless exempted by S1 1976 No. 732.[18] The siting of incinerators, sometimes the cause of severe local opposition,[19] is subject to the Town and Country Planning Act 1971.[20]

4.1.3. Disposal to sea

In the UK context sludge disposed to sea from English and Welsh WAs increased from 20 to 24 per cent between 1975 and 1977 with a slight increase to 24.46 per cent in 1980. Disposal from the Welsh WA although slightly below the UK average of 30.62 per cent is considerably higher than the 24.28 per cent average of sewage sludge disposed to sea by English RWA in 1980. See table 4.1.

In a European context, although the basic data shown in table 4.2 does not all derive from the same year, the pattern of disposal strategies that emerge is quite clear. Only 5 out of 16 countries disposed sewage sludge to sea. Of the 4 countries producing more than 2.3×10^5 tonnes y^{-1} raw sludge, only UK and FGR use sea disposal, 30.4 and 2 per cent of raw sludge produced being disposed by this route. The 2 per cent of FGR sludge from Hamburg has, since 1980, been disposed to the Atlantic Ocean rather than to the North Sea as previously.[21] Of the countries with lower sludge outputs, 45, 20 and 11 per cent of raw sludge output from Eire, Spain and Netherlands respectively is disposed to sea.

Raw sludge equivalent disposed to sea are 431, 44, 9, 20.7 and 9 kt. y^{-1} from UK, FGR, Eire, Netherlands and Spain respectively, equivalent to 83.90, 8.57, 1.75, 4.03 and 1.75 per cent of total sea disposal. Output from England and Wales accounting for 62.1 per cent of the total. See table 4.3.

Comment

It is clear that however calculated the scale of sewage sludge disposals to sea from the UK or from England and Wales is far higher than from any, or all, other European states and therefore vulnerable to co-ordinated EEC or other European political pressure.

The implications of this disposal strategy will now be considered in connection with national and international controls.

Control of Sewage Sludge disposal to sea

1. Dumping at sea

The Dumping of Wastes at Sea Act 1974 is the main controlling UK legislation by means of which the Oslo Convention on the prevention of marine pollution by the dumping from ships and aircraft covering the North Sea and the NW Atlantic,[22] and the London Convention on the dumping of wastes at sea world wide,[23] both ratified by the UK in 1975, are given effect. Dumping is controlled by licence.[24] In England and Wales MAFF, the licensing authority is instructed by the Act:

> In determining whether to grant a licence a licensing authority shall have regard to the need to protect the marine environment and the living resources which it supports from any adverse consequences of dumping the substances or articles to which the licence, if granted, will relate; and the

> authority shall include such conditions in a licence as appear to the authority to be necessary or expedient for the protection of that environment and those resources from any such consequences.[25]

Clearly an environmental quality approach, reflecting the view that

> ...the resources of the sea may legitimately be used for the disposal of wastes provided that any adverse effects are kept within acceptable limits.[26]

Constraints on particular substances such as 'heavy metals' are not specified directly in the Act but Section 6 makes provision for the enforcement of the Oslo and London conventions.[27]

The Oslo Convention

The first requisite of the Oslo Convention is

> ... contracting parties pledge themselves to take all possible steps to prevent pollution of the sea by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.[28]

This carefully worded sentence offers some latitude for interpretation and judgement required by the terms 'pollution', 'harm' and 'harmless'. The convention does not seek to prohibit the dumping of wastes per se.

Control over specific potentially toxic substances including heavy metals is extended by the inclusion of 3 annexes. Annex I lists substances, the dumping of which is prohibited - except where these substances occur as "trace contaminants" of the waste, provided they have not been added to that waste for the purpose of being dumped. Control is by special permit.

Wastes containing 'significant quantities' of Annex II substances may be dumped, subject to a general 'specific permit' and that 'special care is taken in doing so'.

The metals mercury and cadmium and their compounds are included in Annex I, arsenic, lead, copper, zinc and their compounds and under some circumstances chromium and nickel are included in Annex II.

Copies of all permits, along with information as to alternative disposal routes being communicated by the licensing authority to the Oslo Commission.

Annex III of the convention stipulates certain administrative requirements including criteria to be considered before permits are granted, also tests for evaluating persistence, toxicity and potential for bio-accumulation.

The interpretation of the convention is in part still semantic, the meaning of 'trace contaminant' and 'significant quantities' require consensus in order to approximate to uniformity of application. A DOE/NWC report dated June 1981 states,

> It has not been formally resolved what constitutes a trace contaminant but it has been informally agreed that there is a typical range of values for sewage sludges not contaminated by large industrial discharges and any sludge having a substantially greater concentration may not be exempted from the provisions of Annex I on the grounds of its trace contaminant content.[29]

This definition is administratively helpful but does not state what the range of values is. An earlier DOE/NWC report, having given the same definition, goes on to state,

> Such sludges would, in UK experience, not normally contain more than 40 mg/kg cadmium or 20 mg/kg. mercury on a dry weight basis.[30]

These concentrations are quite high when compared with analyses of 'domestic sewage'. (See tables 8.40 and 8.41). The Cd concentration of 40 $mg.kg.^{-1}$ is, however, the same as the mandatory limit on sewage sludge used in agriculture specified in the EC proposal for a directive of 8.10.1982.[31]

'Significant quantities' of Annex II substances have now been agreed by the Commission as representing more than 0.1% of the waste disposed.[32]

2. From water courses, pipelines and other man-made structures.

The Paris Convention

In 1978 the UK government ratified the Paris Convention for the prevention of marine pollution from land-based sources, classified as a) through watercourses, b) from the coast, including introduction through underwater or other pipelines, and c) from man-made structures placed under the jurisdiction of a contracting party.[33] The Paris Convention also applies to the North Sea and NE Atlantic area.

Contracting parties undertake:

> a) to eliminate, if necessary by stages, pollution of the maritime area from land-based sources by substances listed in Part 1 of Annex A to the present convention;
>
> b) to limit strictly pollution of the maritime area from land-based sources by substances in Part II of Annex A.[34]

Parts 1 and 2 of Annex A are similar to the 'black' list and 'grey' list substances listed in Annex I and Annex II of the Oslo Convention. Legislative control required by the Paris Convention is written into COPA 1974, which as yet is not fully implemented.[35]

The EEC

A council decision of 3rd March 1975 made the EEC a party to the Paris Convention.[36] A council resolution of the same date "Invites the Member States affected by the convention... to sign the convention as soon as possible, and in any case before 31 May 1975."[37]

On 20 February 1976 the EEC Commission published a 'Proposal for a Council Directive concerning the dumping of wastes at sea' similar in format to the Oslo Convention. If such a directive is published in the future its implementation may also be justified by reference to the same harmonization clauses as the proposed sewage sludge use on agricultural land.[38]

Comment

In view of the high percentage of sludge disposed to sea from

England and Wales and the UK, shown in tables 4.2 and 4.3, and that all sewage sludge dumped in the North Sea is of UK origin,[39] and that "...UK is likely to remain the world's major disposer of sewage sludge to sea..."[40] UK disposals are highly vulnerable.

Pressure is being brought to bear to ensure that sea disposals are not used as a means of disposing sewage sludges too contaminated for use on agricultural land.[41] Concern over metal and nutrient loads entering the North Sea and particularly the southern North Sea are reflected in attempts being made by WRC to quantify inputs from various categories of sources.[42,43]

UK vulnerability is also reflected in evidence submitted by MAFF to a House of Lords Select Committee in 1983 that,

> The United Kingdom is already under international pressure to reduce the present amounts disposed of at sea and some sludge dumping areas could not take any substantial increase in sludge (particularly sludge contaminated with heavy metals and other trace elements) without undesirable environmental effects.[44]

Indicating that a) reducing the limiting or potentially limiting effects of 'heavy' metals must now be a high priority if sea disposal of sludge is to continue;

b) Pressure to reduce volume of sludge disposed is likely to increase bringing about increased pressure on other disposal routes;

and c) If volume is reduced by stabilisation for the above or hygienic/ aesthetic reasons, even further reduction in metal inputs to sewers will be required to prevent metal concentrations in sludge rising.

4.1.4. Sewage sludge disposal to land

In view of present and probable future constraints on incineration and sea disposal of sludge it is now necessary to examine in more detail disposal to land.

The UK context.

Sewage sludge disposed to land in England and Wales and the UK has decreased from 77 and 74 per cent of total sludge produced respectively in 1975 to 71.37 and 65.68 per cent in 1980. As reported totals of sludge produced also fell in the same period; this would seem to represent a real reduction in sewage sludge mass disposed to land. Reduction would seem to be accounted for by a) the reduced total mass of sewage sludge disposed to land given in the 1980 survey, (see ref.8); b) a slight increase in use of incineration; and c) increase in percentage disposal to sea. See table 4.1.

Of sludge disposed to land annual percentage utilised in England and Wales and the UK increased from 66.5 and 67 to 68 and 68 per cent respectively during the period 1975-1980. But percentage of reported total production fell from 51.2 and 49.58 to 48.53 and 44.66 respectively in the same period. See table 4.4. Percentage utilisation by English WAs was lower than that by the Welsh WA being 66-67 and 80.5 - 89 per cent respectively of sludge disposed to land or 51.48 - 47.84 and 61.18 - 62.73 per cent respectively of total sludge produced in the 1975-80 period. See table 4.4.

It is apparent that disposal by utilisation on land is still an important outlet accounting for approximately half of all sludge disposed by English WAs, in excess of $^3/_5$ of all disposals by the Welsh WA. and $^9/_{20}$ of UK sludge produced. Presumably the scale of disposal by this means reflects the expediency of using this method of disposal within each administrative area.

As UK voluntary and proposed EEC controls on sewage sludge utilised on agricultural land, to be discussed later, are strongly land-use related, it is now necessary to consider sludge disposal in relation to geographical variation of land use particularly in England and Wales.

Major land uses to which utilised sludge is disposed, in England, England and Wales and UK, are to general arable land, followed by grassland, the order is reversed in Wales. These two major uses increased between 1975 and 1980 from 55 to 57, 77 to 80, 55.8 to 58 and 56 to 59 per cent by English WAs, Welsh WA, in England and Wales and in the UK respectively. But as percentages of all sludge disposed, there was an apparent decline from 42.9 to 40.7, 58.5 to 56.4, 43 to 41.4 and 41.4 to 38.75 per cent in the same respective areas. See table 4.5.

In rounded terms, general arable and grassland receive two fifths of total sludge produced by English WAs, in England and Wales and in the UK.

Utilisation for land reclamation and amenity areas remain important minor disposals, together accounting for 7 per cent of disposals to land by English WAs, in England and Wales and in the UK, and 8 per cent of land disposal by the Welsh WA in 1980. In each area accounting for over 5 per cent of all sludge disposals. See table 4.5.

As there are important differences in control of sewage sludge application and after-use when applied to general arable, temporary and permanent grassland reflected in controls recommended in the UK guidelines and in the EC proposal for a directive, both discussed later, the 1980 disposals to temporary and permanent grassland by the ten RWAs are now examined.

Percentages of sewage sludge disposed to temporary and permanent grassland are shown in table 4.6, where English WAs are ranked by quantity of sewage sludge disposed to land. There are large differences in quantities of sludge produced, quantities of sludge disposed to land and in percentage disposals by use on temporary and permanent grassland by the 10 RWAs in 1980. Disposal of sewage sludge to land ranging from 188,700 dry kt. from STWA which has no direct access to sea, to 12,300 dry kt. from SWWA which has a low total, 18.9 kt. sludge production. Yorkshire WA is ranked third with 100.1 kt. dry sewage sludge disposed to land.

Disposals to temporary grassland range from 33 (30.08) to 0 (0) per cent of sludge disposed to land and (of all sludge disposed) by Northumbrian and South West WAs, and include 8 (6.04) per cent by Yorkshire WA. Disposal to permanent grassland range from 50 (32.54) to 1 (0.82) per cent of sludge disposed to land and (of all sludge disposed) by South West and Southern WAs and include 31 (21.85), 25 (12.5), 15 (11.77) and 7 (5.6) per cent of the same respective disposals from Welsh WA, NWWA, Wessex WA and YWA.

Clearly disposal to temporary and/or to permanent grassland form an important part of the sludge disposal strategies accounting for 40-50, 30-40, 20-9, 10-19, $<$ 10 per cent of disposal to land from South West and Welsh; Northumbrian North West and Wessex; Severn and Trent and Thames; Yorkshire and Southern; and Anglian Water Authorities respectively.

In view of the strategic importance of disposal to grassland in England and Wales it will be necessary to consider this type of disposal carefully in relation to voluntary controls on sewage sludge disposal recommended in the UK guidelines, and particularly in relation to pH and after-use controls in the proposal for an EC directive discussed respectively in sections 5 and 6.

Legal constraints on the disposal of sewage sludge to land

Control of Pollution Act (COPA) 1974.

As Part 1 of this act is concerned with controlling the disposal of wastes on land it might have been expected to include control over disposal of sewage sludge by use on agricultural land.

However, S.I. 1976 No. 732 stipulates:

> "For the purpose of s.3 to 11, 16 and 18(1) and (2) waste of the following descriptions shall be treated as being industrial waste ...
>
> (c) Sewage sludge deposited on land other than -
>
> i. Sewage deposited, whether inside or outside the curtilege of a sewage treatment works, as an integral part of the operation of these works; and
>
> ii. Sewage spread on land for agricultural purposes."[45]

The term sewage is taken to include sewage sludges.[46] As a result of the S1, disposal of sludge to landfill is subject to licensing or consent by the waste disposal authority,[47] but disposal to agricultural land is exempted from Part 1 of the Act. Interpretation of the term agricultural land becomes critical.[48]

Disposal of sewage sludge to land is also controlled in Part 2 of the Act in relation to pollution of streams, controlled waters or specified underground waters.

Sale of sewage sludge for use on land is subject to Part 4 of the Agriculture Act 1970, Sale of Goods Act 1893 and the Trade Description Act 1968.[49]

Where disposal of sewage sludge to land may be considered 'a material change of use' planning permission may be required under the Town and Country Planning Act 1971.[50] So constraining, for example, the use of 'sacrificial land' for the disposal of sewage sludge.

Nuisance

In addition to controls listed above treatment, storage, disposal operations and the effects of sewage sludge disposed to land are subject to nuisance clauses in the Public Health Acts of 1936 and 1969 (Recurring Nuisances) and also to Common Law.

Locally byelaws may also control aspects of disposal of sludge to land.[51,52]

Voluntary Controls

As there are only ten RWAs in England and Wales it has been possible to exert a considerable degree of control over the utilisation of sewage sludge on land by means of Working Party Guidelines and the main associated documents discussed in sections 5 and 6.

Although non-legal, the guidelines provide norms and references to good practice which may be used in a court of law.

The speed with which revision of recommended limit values or practices can be incorporated into the guidelines is also claimed as an advantage.

EEC

Several directives, concerned with water pollution, through their implementation in COPA 1974 constrain disposal of sewage sludge on land.[53] But in October 1982 a proposal for a Council Directive on the use of sewage sludge in agriculture was published. In view of the exemption of this use from Control by Part 1 of COPA 1974, such a directive, if and when adopted, would require implementation by statutory controls and thus have a considerable constraining influence on disposal. The proposal for a directive is compared with the UK Guidelines in Section 6. Limit values proposed in Annex 1A on metal concentrations in sewage sludges used in agriculture are now discussed in relation to the results of a recent survey.

4.2. Metal concentrations in sewage sludges disposed to land

It is now necessary to consider the sources and importance of metal concentrations as potential limiting factors in sludge disposal. Discussion will, in the main, be limited to metal concentrations in sewage sludges disposed to land.

As a result of an extensive survey carried out in 1980, ranges of metal concentrations found in sewage sludges disposed to land in the UK were reported as:

Zn	89 - 25000	$mg.kg^{-1}$ D.S.	
Cu	20 - 12754	"	
Ni	1 - 1385	"	
Cd	0.1 - 1192	"	
Pb	10 - 8560	"	
Cr	1 - 13450	"	(54)

The most striking feature of this list of values is the breadth of range. For each metal the maximum concentration far exceeds maximas of sewage sludge utilised on land[55] or disposed to sea.[56]

In the year following the survey a Standing Committee report stated:

> A wide variety of sources contribute to the presence of heavy or toxic metals in sewage sludges. The problem is mainly centred on the conurbations and requires the water authorities to undertake systematic and sustained control, locally, of discharge to sewers.[57]

High concentrations are attributed to industrial sources but the deliberate inclusion of the word 'sustained' may be a reference to economic and political influences, such as Government Circulars, used to soften controls in times of recession.

Metal concentrations in sewage sludges disposed to land in 1977 and 1980 are compared in table 4.7. Although the 1977 survey included analytical results for 193 WPC works, and claimed to represent 31 per cent of total sludge disposed to land,[58] the 1980 results are part of a much larger survey.[59]

With this reservation it is seen that for the six metals shown: Over the 1977-80 period

a) In all cases the median reduced, for Ni, CD and Cr by over 50%.

b) In all cases the mean reduced, most noticeably in the case of Cd by over 46%.

c) Zn and Pb maxima reduced but maxima for Cu, Ni, Cd and Cr increased. But apparently Cd maxima at 158 mg kg^{-1} is atypical and it has been suggested that apart from this sample 60 $mg.kg^{-1}$ was the maximum.[60]

Cu maxima has increased by over 50%.

d) In all cases distributive curves are positively skewed, median being less than mean values indicative of relatively low numbers of sludges containing exceptionally high metal concentrations, as also found in smaller surveys.[61, 62]

e) Of sewage sludges used on agricultural land mean concentrations of Zn, Cu, Ni Cd and Pb reported in the 1980 survey results were 1123, 519, 101, 16.3 and 329 $mg.kg.^{-1}$ DS respectively, being 37.43, 34.6, 25.25, 40.75 and 32.9 per cent of mandatory limit values specified in the 1982 proposal for an EC directive.[63] No mandatory limit is specified for Cr. See table 4.7.

Comment

From the above it is concluded that although there have been considerable reductions in median and mean concentrations of the 6 metals shown in table 4.7, some sludges are still highly contaminated by metals from relatively few industrial/trade sources. Indeed, maxima of Cu, Cd and Cr appear to be increasing.

On the basis of 1980 survey data Cd mean concentrations might limit the use of more sewage sludges in agriculture than other metals if proposed EC limits are adopted. This expectation is borne out by distribution graphs shown in the survey report. Less than 89% of sludges met the EC mandatory limit proposed but more than 98% of sludges met Zn Cu and Pb limits and 96% Ni limit.[64]

If requirement for stabilisation of sludges increases this will, by reducing organic mass, have the effect of increasing metal concentrations in the resultant sludges still further. Reduction of metal inputs to sewers will then be necessary if proposed mandatory concentration limits are to be achieved.

4.3. Conclusions

1. Production of 1420 kt. of raw sewage sludge dry solids in 1980 was the second highest of 16 European states. With this scale of production, sludge disposal in and from the UK is regarded as politically important to EEC or European states.

2. Although use of incineration remains a high cost strategic option further increase may lead to strong local opposition. Residues remaining after incineration may themselves be difficult to dispose of.

3. Sea disposal from England and Wales appears to have increased from 20 to 24.46% in the 1975-80 period. However convenient this method of disposal may be, disposals from the UK, particularly to the North Sea by 'dumping' are highly vulnerable to international political pressure to reduce quantity and improve quality of sludges disposed. International pressure is exercised mainly through the Oslo and Paris Conventions, but may in future be vulnerable to harmonization clauses in the EC Environmental Programme.

4. Any reduction in sludge disposal to sea may increase pressure on disposal to land. Of total sludge produced in England and Wales and in the UK 71.37 and 65.68 per cent, respectively, were disposed to land in 1980.

5. While sludges with high metal concentrations have been disposed to landfill, competition for use to dispose of other wastes may restrict the availability of suitable sites, particularly when sludges are contaminated by 'black list' substances.

6. Occurrence of sludges with high metal concentrations appear to be

localised and due to inputs to sewers from relatively few industrial/ trade sources.

7. Any attempt to reduce volume, increase pathogen control or aesthetic qualities of sludge by increasing the percentage of sludge digested, will itself lead to higher metal concentrations, but not loads in the digested sludges and/or require inputs of metals to catchment sewers to be reduced.

8. In the UK 45% of all sludge produced is disposed by use on agricultural land. Because exempted from Part 1 of COPA 74, control is, in the main, by means of voluntary guidelines and is vulnerable to external political pressure, such as through the EC proposal for a Directive on the use of sewage sludge in agriculture, which states maximum concentrations of metals in sludges disposed in this way.

9. On the basis of maximum Cd concentrations proposed and those found in the 1980 survey, in excess of 11% of sewage sludges sampled would have exceeded mandatory limit values.

10. It is now timely to consider how high metal inputs can be reduced.

11. In view of the strategic importance of disposal of sewage sludge to grassland in some English and Welsh WA areas, it is necessary to consider this disposal use carefully in relation to the recommendations of the UK guidelines and controls stipulated in the proposal for a directive.

12. It must also be remembered that any use of sewage sludge in agriculture is subject to the individual and collective goodwill of the farmers themselves.[65]

TABLE 4.1

Sludge production and disposal from English and Welsh WA areas and the UK, 1975, 1977 and 1980 survey data

Source	Year	English WAs	Welsh WA	E & W WAs	UK
	Year	Thousand tonnes dry solid			
Sludge Production	1975	1073[b]	43[a]	1116[a]	1245[a]
" "	1977	1089[b]	47[a]	1136[a]	1300[a]
" "	1980	1005.7[d]	39.3[c]	1045[c]	1205.6[c]
Sludge Disposal		%	%	%	%
To Land	1975	78[b]	76[a]	77[a]	74[a]
"	1977		63[a]	72[a]	67[d]
"	1980	71.41[d]	70.48[d]	71.37[d]	65.68[d]
To Sea	1975	19[b]	24[a]	20[a]	23[a]
"	1977		37[a]	24[a]	29[a]
"	1980	24.28[d]	29.01[d]	24.46[d]	30.62[d]
By Incineration	1975	3[b]	0	3[a]	3[a]
" "	1977	4[b]	0	4[a]	4[a]
" "	1980	4.31[d]	0.51[d]	4.17[d]	3.7[d]
Totals	1975	100	100	100	100
	1977		100	100	100
	1980	100.00	100.00	100.00	100.00

Notes

a) Ex table 4 DOE/NWC STC Report 20 June 1981.

b) Calculated from a.

c) Ex table 1 DOE/NWC. Sewage Sludge Survey 1980 data August 1983.

d) Calculated from c.

TABLE 4.2. Annual Sludge Production and Disposal in 16 European Countries

Country	Population	Raw Sludge Production	Percentage of sludge produced disposed to					
			Land		Various	Sea from		Unspecified
	10^6 persons	10^3 tonnes yr^{-1}	Agricultural (g)	Other (h)	Incineration	Vessels	Pipelines	
*UK (f)	55.9	1420 j d	41.4 k	24.5 k	3.7 l	28.7 m	1.7	0
*Belgium	9.9	70 c	15.0	83	2	0	0	0
*Denmark	5.1	130 a	45.0	45	10	0	0	0
*France	53.6	840 d	30.0	50	20	0	0	0
*FGR	61.7	2200 a	39	49	8	2	0	2
*Greece	9.5	3	0	100	0	0	0	0
*Eire	3.4	20 d	4	51	0	45		0
*Italy	56.7	1200 c	20	55	5			20
*Luxembourg	0.4	11 c	90	10	0	0	0	0
*Netherlands(f)	13.9	230 c	60 (i)	27	2		11	0
Austria	7.5	140 d	small	large	30	0	0	0
Finland	4.8	130 d	40	45				15
Norway	4.1	55 b	18	82	0	0	0	0
Spain	37.0	45e	60	20		20		0
Sweden	8.3	210 e	60	30		0	0	10
Switzerland	6.4	150 d	80	10	10	0	0	0
16 E. countries	338.2	6854	37	43	8	7		5

NOTES ON TABLE 4.2

* EEC member state

a	1977)	
b	1978)	Date of information.
c	1979)	For data other than UK see
d	1980)	A.J. Vincent & R. F. Critchley 1983(65).
e	1982)	

f values given are % of sludge as disposed.

g including horticulture allotments and gardens.

h mainly landfill, but including stockpile, land reclamation and forest.

i including 19% used to produce commercial soil conditioners.

j UK data calculated on the basis of results shown in Table 1 and assumptions given in para. 2.9 of DOE/NWC Sewage Sludge Survey 1980 data August 1983.

k Similarly calculated from Tables 1 and 4 -ditto-

l " " " 1 -ditto-

m " " as above para. 2.24.

TABLE 4.3.

Raw sludge equivalent of sewage sludge disposed to sea and percentile of total input from 5 European States, England and Wales.

State	Information Date	Mass of Raw Sludge 1000 tonnes y^{-1}	% total mass disposal %
UK (E+W)	1983 (1983)	431 (319)	83.90 (62.10)
FGR	1977	44	8.57
Eire	1980	9	1.75
Netherlands	1979	20.7	4.03
Spain	1982	9	1.75
TOTAL	77-83	513.7	100.00

Notes

Calculated on the basis of raw sludge production and percent disposals to sea from vessels and pipelines from states shown in table 4.2.

TABLE 4.4

Percentages of sludge disposed to land (and of all sludge disposed) utilised and disposed to landfill or stockpile in the UK.

Calculated on the basis of 1975 and 1980 Sewage Sludge Disposal Survey data

Disposal	English WAs		Welsh WA		England & Wales		UK	
	1975[a]	1980[b]	1975[a]	1980[b]	1975[a]	1980[b]	1975[a]	1980[b]
	Percent of sludge dry matter disposed to land - (per cent of all sludge dry matter disposal)							
to utilise c	66	67	80.5	89	66.5	68	67	68
(d)	(51.48)	(47.84)	(61.18)	(62.73)	(51.2)	(48.53)	(49.58)	(44.66)
to land fill or stockpile	34	33	19.5	11	33.5	32	33	32
TOTALS	100	100	100	100	100	100	100	100

Notes.
a. Calculated on the basis of data shown in Table 4 of DOE/NWC STC 8 January 1978
b. " " " " " of DOE/NWC Sewage Sludge Survey August 1983.
c. Of sludge disposed to land.
d. Of all sludge disposed.

TABLE 4.5

Percent land use to which sewage sludge disposed in the UK (and major usage as percentage of all sludge disposed) calculated on the basis of 1975 and 1980 Sewage Sludge Disposal Survey Data

	English WAs		Welsh WA		Eng.& Wales		U.K.	
	1975[a]	1980[d]	1975[a]	1980[c]	1975[b]	1980[c]	1975[a]	1980[c]
Land Use	Percent of sewage sludge dry matter disposed to land							
Grazing, temporary	21	11	39	15	21.7	11	21	12
Grazing, permanent		9		31		10		10
General arable	34	37	38	34	34.1	37	35	37
Horticulture	3	1	1	1	2.4	1	2	1
Forestry	1	1	1	0	1	1	1	1
Allotments	1	1	0	0	0.9	1	2	1
Amenity		2		0		2		2
Land reclamation	7	5	1	8	6.9	5	7	5
Land tip	34	23.7	20	6	33.5	23	33	23
Stockpile		9.3		5		9		9
Other	0	1		0		1		1
Totals	100	100	100	100	100	100	100	100
Grazing & Arable	55	57	77	80	55.8	58	56	59
Grazing & arable[e]	(42.9)	(40.7)	(58.5)	(56.4)	(43)	(41.4)	(41.4)	(38.75)

Notes:

a. On the basis of data shown in Table 4 DOE/NWC STC8 January 1978.

b. Calculated " " " " " "

c. On the " " " DOE/NWC Sewage Sludge Survey Aug.'83.

d. Calculated " " " " " " "

e. On the basis of percentages of all sludge disposed to land shown in Table 1.

TABLE 4.6

Quantities of sewage sludge disposed to land and of all sewage sludge disposed, and percentages of these quantities disposed to temporary and permanent grassland by ten Regional Water Authorities

	QUANTITY OF S.SLUDGE		PERCENTAGE USE OF SEWAGE SLUDGE ON					
	Disposed to land(a)	All Disposals(c)	Temporary Grassland of land disp.	of all disp.	Permanent Grassland of land disp.	of all disp.	T and P Grassland of land disp.	of all disp.
Units	Tonnes DS x 10^3		%(c)	%(e)	%(c)	%(e)	%(c)	%(e)
R.W. Authority								
Severn & Trent	188.7	205.9	14	(12.83)	7	(6.42)	21	(19.25)
Thames	146.3	269.7	13	(7.05)	7	(3.80)	20	(10.85)
Yorkshire	100.1	125.1	8	(6.40)	7	(5.60)	15	(12.00)
Anglian	87.5	101.1	1	(0.86)	3	(2.60)	4	(3.46)
North West	79.7	159.4	9	(4.5)	25	(12.5)	34	(17.00)
Southern	47.4	57.7	9	(7.39)	1	(0.82)	10	(8.21)
Wessex	36.4	46.4	16	(12.55)	15	(11.77)	31	(24.32)
Northumbrian	19.6	21.5	33	(30.08)	6	(5.47)	39	(35.55)
South West	12.3	18.9	0	(0)	50	(32.54)	50	(32.54)
All English RWAs	718.2[b]	1005.7[d]	11[d]	(7.85)	9[d]	(6.43)	20	(14.28)
Welsh WA	27.7	39.3	15	(10.57)	31	(21.85)	46	(32.42)
England & Wales	745.9	1045	11	(7.85)	10	(7.14)	21	(14.99)

Notes for Table 4.6

a. Data extracted from DOE/NWC, August 1983 Table 1.

b. Calculated on the basis of England and Wales - Welsh WA, discrepancy of .2 with total of 9 WAs is due to rounding up.

c. Data extracted from DOE/NWC August 1983 Table 4.

d. Calculated on the basis of England and Wales - Welsh WA, August 1983, Table 4.

e. Calculated using the ratio of quantities of sludge disposed as shown in Columns 1 and 2.

TABLE 4.7

Concentrations of six metal elements in sewage sludge utilised on agricultural land (1977), or utilised on land (1980), and proposed mandatory limit values of trace elements in sewage sludge used in agriculture

Survey Date	Metal / Unit / Norm	Zinc	Copper	Nickel	Cadmium	Lead	Chromium
	Unit	$mg\ kg^{-1}$ sewage sludge dry solids					
1977a	Median	1260	565	94	17	334	253
" a	Mean	1423	576	125	30	519	574
" a	Max.	5940	1929	537	135	3538	10356
1980b	Median	1002	440	45	7	260	105
" b	Mean	1123	519	101	16.3 (60)d	329	434
" b	Max.	4920	2900	615	158c	3106	11743
Proposed Mandatory Limit e		3000	1500	400	40	1000	-

Notes:
a. Derived from Table 3 DOE/NWC Survey of Sewage Sludge Composition (1977 data) DOE Dec. 1981.
b. Derived from Table 11 DOE/NWC Sewage Sludge Survey 1980 data DOE August 1983. In Table 21 of the same source means are given as 'utilised on agricultural land'.
c. DOE evidence 'an isolated case'. H. Lords S.C. Session 1983-84 1st Report p.9.
d. " " estimate " " " " " "
e. Annex 1a OJC 264/6 8.10.82.

5. CONTROL OF SEWAGE SLUDGE DISPOSAL BY UTILISATION ON AGRICULTURAL LAND

Evolution of the DOE/NWC 1981 Guidelines

5.0. The control of sewage sludge disposal by utilisation on agricultural land is still, in 1984, mainly by non-legal means. Disposal of sludge to agricultural land has already been shown to account for nearly half of the sludge produced in England and Wales. In view of the strategic importance of this type of disposal the effects and effectiveness of the voluntary control policy will now be examined.

As the main focus of this study is concerned with the contaminating effects of metals in sludges, and in view of the importance of sludge disposal by use on grassland in some RWA areas, and as the policy instrument currently operative the 1981 Guidelines is not the product of parliamentary procedure, the purpose of this section is to examine:

1. The evolution, constraints and declared purposes of the Guidelines;
2. The scientific evidence and assumptions on which the Guidelines are based, particularly when related to the control of potentially toxic metals;
3. The pressures, tensions and transactional processes by which the Guidelines have evolved;
4. To obtain some indication of the strengths and weaknesses of this voluntary control as formulated in 1981;
5. To gain some indication of likely future changes.

In doing so -

6. To assess the ongoing effectiveness in facilitating and controlling the disposal of sewage sludge to agricultural land, particular attention being given to
7. The problems of controlling metals in sludges so disposed; and

8. The problems of controlling applications to grassland.

Because of their potentially limiting effects on sludges so disposed, also consider -

9. Control of plant nutrients supplied in sludge; and

10. Implications of recommended procedures for pathogen control.

Method

The evolution of the 1981 'Guidelines' is treated as a case study of the development of a voluntary control. In view of this a mainly chronological sequence is used, 1970 being an expedient base line.

By means of publications and two conference reports the tensions and pressures between the main actors DOE, particularly through its Water Engineering Division, MAFF, particularly through its advisory arm ADAS, and from April 1974 the RWAs. are considered.

Two main lines of development are identified,

a) MAFF (ADAS) advisory publications in 1971, 1978 and 1982;

b) Also based on the ADAS 1971 paper, Draft guidelines, interim guidelines and Guidelines circulated or published in 1976, 1977 and 1981 jointly by DOE and the now deceased intermediary body the National Water Council.

Two subsidiary insights into the development of the Guidelines are provided by:

c) Reports of two conferences organised in 1977 and 1978 by ADAS and by WRC respectively, providing a forum of comments, basic concepts and ideas.

and d) The seventh Report of RCEP acting in a 'watchdog' role.

The whole process of Guideline formulation being seen against the backdrop of

e) The exclusion of sewage sludge used in agricultural land from control by COPA 1974;

and

f) The EEC environmental programme to which the UK has been a signatory since 1973.

The main bodies concerned, publications and chronological sequence are shown in Fig. 5.1, which also indicates the general sequence of analysis which now follows.

5.1. 1971 ADAS Advisory Paper 10, a foundation document.

In 1970 sewerage, sewage treatment and sewage disposal were the responsibility of local government, administered by about 1,400 authorities serving populations ranging from 1,460 to 8 million people.[1] The Working Party on sewage disposal reported that "Many authorities are too small to be able to employ qualified staff and lack the resources to allow expenditure on effective methods of sewage disposal."[2]

One of the major recommendations made was, "Wherever possible encouragement should be given to the application to agricultural land of suitable sewage sludges."[3] The Working Party included controls over sewage disposal to rivers and canals, estuaries and tidal rivers, coastal discharges and dumping at sea but controls over sewage sludge disposal to land are not discussed in the report. The Working Party do, however, recommend that "Where an authority is proposing to dispose of sludges on agricultural land it should be a prerequisite that metals content....be determined...and declared."[4] It also points out that the agricultural advisory service is available to give advice on the suitability of sludge use as a manure on different types of soils.[5]

Perhaps stimulated into print by the Working Party enquiries and recommendations, in 1971 ADAS Advisory Paper 10 "Permissible levels of toxic metals in sewage sludge used on agricultural land" was published by MAFF. The author of the advisory paper, a soil scientist C.G.Chumbley, observes, "Various forms of sewage have been extensively used in some parts of the country by farmers and market gardeners mainly as cheap sources of nitrogen and phosphorus."[6] Use of sewage being ancillary to the growing of crops, a use which is differentiated from land where, for a time, the main purpose has been to dispose of sewage and which is later cropped. The term sewage being used to include all types of sewage sludge.[7] A systematic attempt is made to give guidance on the calculation of safe application rates of sewage when applied to agricultural land, particular attention being given to how phytotoxic effects of Zn Cu Ni and Boron may be avoided.

Two key concepts inherent in the guidelines used today are basic to the advice given in 1971.

1. <u>The Zinc equivalent concept</u>

The zinc equivalent (Zn≡) concept used contains 3 basic assumptions. First that the toxicity effects of Zn, Cu and Ni to plants are additive. Second that Cu and Ni are respectively 2 and 8 times as toxic as Zn.[8] Third, that the toxicity of the metal can be expressed as a single value, Zn≡ of sewage being expressed in parts per million.

Justification for this choice of assumptions were given then, and restated since, as being based on "Advisory experience and the results of pot experiments."[9,10]

When used on land without previous 'contamination' of the soil with toxic metals it was stated "...the conclusion from various experiments is that it is permissible to add to the soil zinc equivalent amounting to 250 ppm of the top soil," and recommended that this should take place over a thirty year, or more, period.[11] Then showing how rate of application could be calculated for sludges of known analyses. Recommended maximum single application being 5 times the annual rate.[12]

2. The 'available' metals concept

Chumbley goes further in proposing that when land has been contaminated for some time, "say more than three years" available metal content of soil can be used as a basis for calculation of Zn, Cu and Ni and hence Zn≡.

In addition to the assumptions underlying the Zn≡ concept three assumptions underlying the use of the available metals concept are:

a) that metals measured as 'available' are available to the range of crops grown; but more importantly,

b) that metals not measured as 'available' are not available to the range of crops grown,

c) that after 3 years, metals not measured as available, "probably will not become available to plants."[13]

Justification for these assumptions is not given in the advisory paper, though differences in the sensitivity of crops to metal toxicity is acknowledged.[14]

Assumptions 1 and 2 must be considered with analytical procedures given, in which 'available' Zn and Ni are extracted from soil by 0.5M acetic acid and Cu by 0.5M. EDTA. The generalised assumption that the Zn Cu or Ni extracted = or ≙ Zn, Cu or Ni available to a wide variety of crops is a pre-requisite to this approach.[15]

On the basis that 'available' Zn≡ calculated is subtracted from the total limit of 250 ppm, the difference is used to calculate permissible sludge application rates.

Both total and 'available' Zn concepts are subject to the assumption that pH of the soil will be maintained 'close to' 6.5.[16] But also pointing out that harmful effects of Zn, Cu and Ni in soils already contaminated "... may be minimized by liming the soil up to pH 7.0 or above."[17]

In order to avoid the direct ingestion of metals from sewage on soils or on herbage it is generally advised "livestock should not be allowed to graze fields to which sewage has been recently applied until after rain has washed the herbage clean."[18]

Comment

In spite of the apparent lack of formalised controls over the spreading of sewage sludges on agricultural land, the 1970 Working party firmly recommend that use for 'suitable' sewage sludges, but were concerned that metal content of sludges used should a) be determined, and b) be declared.

ADAS Advisory Paper 10 provides systematic advice on determining metal content of sludges and calculating safe application rates.

In view of the rather tenuous evidence used to substantiate assumptions, it might be expected that the Zn≡ concept and particularly the relative toxicity multipliers used might be regarded as a short term control, a temporary expedient, requiring refining or replacement. Chumbley reports that experiments are being undertaken at three centres to investigate the effects of Zn, Cu, Ni and Cr on crops.[19]

By introducing the use of 'available' metals into recommendations, on the basis that metal not measured as 'available' "...probably is not and will not become available to plants",[20] an ambiguity arises. Although an upper limit of 250 ppm of Zn≡ is specified, if 'available' metals were, say, 50% of 'total' metals and the available methods were used over a period of time up to 500 ppm of 'total' metals could be applied. An ambiguity which it will be seen is inherent in the 1981 Guidelines, as is the Zn≡ concept with its 1971 multipliers. Both are in use thirteen years later.

5.2. Evolution of the DOE Working Party Interim Guidelines

Further to the formation of the DOE in November 1971 and the accession of the UK to the EEC in 1973, and in anticipation of the re-organisation of local government, and of the Water Industry on 1st April, 1974, DOE Directorate General of Water Engineering set up a Working Party on the disposal of sewage sludge to land in February 1974.

Terms of reference include the following:

"a. To review the need to dispose of sewage sludge on land. ....

g. To advise on the application of the Zn equivalent concept and the recommendations in MAFF, ADAS Advisory paper 10 and to recommend permissible limits for significant substances present in sewage sludge but not covered by the advisory paper. ....

i. To draft a code of practice for the disposal of sewage sludge on land."[21]

Terms given in g and i, particularly relevant to the present discussion, became the main concern of one of four sub-committees of the Working Party. DOE involvement in these matters may be seen as in response to the duty imposed upon the Secretary of State as a result of S.1.2b of the Water Act 1973.

Although responsibility for all aspects of the Water cycle, including sewerage, sewage treatment and sludge disposal in England and Wales were to be transferred to 10 RWAs on 1st April 1974, they "...were not represented on the Working Party at the outset because it had been constituted before the reorganisation of the Water Industry."[22] Subsequently in July 1975 DOE and NWC formed a Standing Committee and the duties and members of the former Working Party were incorporated into a larger sub-committee with wider representation. By this time the 1974 Working Party had prepared a report, a draft of which, dated April 1976, was circulated on behalf of the Standing Committee on the Disposal of Sewage Sludge (SCDSS) by DOE and NWC.[23]

With a few minor exceptions this may be seen as the basis of DOE/NWC Standing Technical Committee (STC) Report No.5, Report of the Working Party on the Disposal of Sewage Sludge to Land, published in July, 1977. In view of the report's title and the practice adopted in the Seventh Report of RCEP, the authors of STC report No. 5 are referred to below as 'the working party'.

The working party observe,

> The interest of Water Authorities and others responsible for sewage treatment, who wish to dispose of sludge in the most economical way, have on occasions appeared to be opposed to those of land owners and tenants who are unwilling to accept sewage sludge without reliable assurances that it will not harm their land, crops or animals."[24]

They state:

> The need for guidelines on the disposal of sewage sludge to land has been stressed by Water Authorities, the farming community and others.[25]

It can be seen that as well as being a scientific forum the working party, and subsequently the Sub Committee, provided a meeting place of interested parties as expressed in the unpublished draft: "It is believed that the Working Party comprised or had access to representatives of all those who have major interests in sludge disposal." It was then conceded: "To a limited extent the guidelines are a compromise between opposing requirements and views."[26]

That the working party had access to a wide range of interests cannot be disputed. However, as listed in April 1976 5 of the 10 members of the working party represented government departments, as did the technical and administrative secretaries, 2 members represented institutions directly accountable to government departments and 3 members represented professional associations.[27] In view of this membership it is not surprising that there were criticisms of the interim guidelines by RWA officials, responsible for sludge disposal operations.[28]

The working party's 1977 report comprises 5 chapters of introduction, background information and discussion, a sixth chapter presents "Guidelines for the disposal of sewage sludge to land," 44 paragraphs of which are concerned with applications to agricultural land. After considerable discussion the working party state:

> It is our opinion that the application of treated sewage sludge to agricultural land is good practice; a view which coincides with that reached by the Jeger Committee. This is an economical method of disposal which utilises the nutrients in sewage sludge; when practised under proper control and in accordance with the sound rules of good husbandry, there is little effect on the environment and the benefits far outweigh any possible disease hazards.[29]

With this firm policy commitment the crux of the matter rests on what is considered 'proper control' and 'sound rules of good husbandry'. The interim guidelines put forward by the working party are now considered.

The significance of the phrase 'treated sewage sludge' will be discussed in relation to pathogen control. Introducing the interim guidelines the working party acknowledge that although based on the best information available at the time recommendations will require revision and extension as further information and results of research become available.[30]

Control of Phytotoxic metals

The concept of Zn≡ and the relative toxicity multipliers recommended by Chumbley are used by the working party although they regard the underlying assumptions as "... unlikely to be universally correct," they claim the Zn≡ concept to be "... a reasonable working hypothesis."[31]

The working party recommend that total additions of Zn≡ to soil over 30 yrs. or more should not exceed 560 kg ha^{-1}.[32] Corresponding to 500 lb. acre stated in ADAS 10 to be equivalent to 250 ppm in soil.

The use of the 'available' metals concept is also continued for Zn, Cu, Ni and Zn≡ so continuing the ambiguity caused by the 'total' and 'available' limits specified. But the working party now warn "It seems likely that metals in sewage sludge to a large extent become combined with or bound to organic matter in soils, and when this decomposes the metals may become available to crops."[33] Appearing to contradict the statement by Chumbley that unavailable metals are '...likely to remain so,' used to justify the 'available metals' strategy. The working party then advise, "The 'total' metals may therefore be considered as an indicator of the likely ultimate effect of sludge on crops and should be used in calculating sludge application rates."[34]

Again in contrast to Chumbley's use of the available metals strategy "Where contamination has been in the soil for a long time (say three years) (see ref.), the working party advise, "When there is a need to determine the immediate effect, this may be better indicated by the 'available' fraction of the metals..."[35] The working party appear to be trying to limit the use, or misuse, of the available metals concept but in doing so add to the confusion as to its basic assumptions and scientific foundations. They are concerned at the potential harm of adding excess metals "since excess metals will tend to remain in the soil almost indefinitely."[36]

In addition to continuing the concepts of Zinc equivalent and 'available' metals when calculating application rates the working party now recommend that "Whereas the rates of application of zinc, copper and nickel suggested by ADAS 10 allowed for the growing of more sensitive crops, dressings may be increased by a factor of up to 2 on pasture where there is no possibility of this being ploughed for crops. On calcareous soils and where the pH is likely to remain above 7.0 for the foreseeable future a similar increase is acceptable."[37]

To what extent it is possible to say of any 'permanent' pasture "...there is no possibility of this being ploughed for crops" is not discussed.

Applications to permanent pasture must also be seen in relation to soil sampling procedure discussed later.

Control of metals potentially toxic to man

The interim guidelines also include voluntary constraints for the elements Cr, Cd, Pb, Hg, As, Mo and selenium which may, in excess, be toxic to livestock and in some circumstances to man. Limits on the total amounts of Cr, Cd, Pb, As and Hg to be applied over a period of 30 years or more are stated, and are in accord with those shown for the 1981 Guidelines, shown in table 5.1. Thirty year limits on the total applications of Mo and Se are also specified.[38]

Maximum single application rate

With the exceptions of boron and available nitrogen for which annual limits are stated[39]. Maximum single applications of metal recommended are equivalent to one fifth of the 30 year application limit, followed by the proviso that "...no further sludge should be added until the running average has fallen to the long term average."[40] Thus these large dressings with up to 6 years equivalent of metal may only take place on an intermittent basis, rather than a short term regime of visits in which the thirty year limits are reached in relatively few years.

The maximum, even without relaxations, is higher than the 5 year maximum given by Chumbley, and particularly so where relaxations apply. It is double the 'one tenth' rate recommended in the 1976 draft where the relaxations were first stated, presumably reflecting pressure from the disposers, the RWAs.[41]

Other limiting factors

Lead

When grazing animals might ingest sewage sludge or contaminated soil, sludges used should be restricted to "those with a lead content not exceeding

2000 mg kg^{-1} dry solids".[42] Although voluntary, this recommendation creates a precedent, reinforced and extended in future advice by specifying a concentration limit, or emission standard, for sludges used on grassland. A point which will be discussed further in relation to the 1981 Guidelines and in section 6 when considering the EC proposal for a directive on the use of sewage sludge in agriculture.

pH

Whereas ADAS 10 recommendations were for soils of about pH 6.5, the working party recommendations require maintenance of soil pH on arable land or grassland at 6.5 or 6.0 respectively.[43] As with the exception of Mo and Se solubility of metals increases with decreasing pH.[44] The lowering of specified pH on grassland to 6, acknowledging good practice, is a further relaxation.

Nitrogen

Pointing out that both N_2 and P_2O_5 in sludges can make an important contribution to growing crops, but warning against the damaging effects of over-supply of N_2.[45] The working party imply that unless limited to a lower level by other 'element' content, sludge application should be limited by N_2 content.

Although recommending that it can be assumed that nitrogen is 85 or 33 percent available in liquid digested or dried sludges respectively.[46] Or when analyses are available, all the soluble N_2. As application recommended by MAFF are economic optima, they recommend up to 50% increases on MAFF values may be permitted.[47]

Control of Pathogens

Working party recommendations to control pathogens are based on sludge treatment, land use and specified delay periods and constrain the application of sewage sludges to agricultural land. Although not as detailed as in the 1981 Guidelines, the working party attempt to be facilitating, rather than prohibitive, in recommending controls over the disposal of a range of sludge types including untreated sludge.[48]

Further discussion of pathogen control will be delayed to consider recommendations of the 1981 Guidelines.

MAFF Advisory leaflet ADAS AF51

Following the publication of the Working Party 'interim' guidelines in 1977, MAFF in 1978 published AF51, "The use of sewage as a fertilizer." The main author, C. Chumbley, being the author of the 1971 ADAS 10.

Whereas the target audience of the working party appear to be disposers, that for AF51 appears to be farmers. Although written with an emphasis on good practice rather than achieving disposal, the advice generally supports and does not contradict advice given in the 'interim' guidelines.

Liquid digested sludge is regarded as "a useful although dilute source of nitrogen and phosphate,"[49] and that "Experiments have shown about 85% of total N_2 is available in the first season together with 50% of the phosphate," and of raw sludge "... only about 33 percent of nitrogen content is available in the first season from a spring application."[50] The leaflet advises that application rate should be adjusted to the needs of the following crop. No mention is made of a limit 50% above recommended N_2 rates. Advice on timing of application is also given, spring and summer applications being recommended.[51]

Zn, Cu, Ni and Zn≡ limits are as recommended in the interim guidelines and carry the same relaxations, annual limit on boron and 30 year limits recommended for Cr, Cd, Pb, As, Hg, Mo and Se are also the same, pathogen controls are similar.[52]

Recommendations made in ADAS AF51 while attempting to serve the interests of the farmer and consumer are supportive of recommendations made in the interim guidelines.

5.3. Some post publication criticisms and responses to the 1977 'interim' guidelines.

The working party's 'interim' guidelines were published in July 1977, three and a third years after the RWAs had assumed responsibility for managing all aspects of the water cycle including sewerage, sewage treatment and sewage sludge disposal, RWA representatives were not included in the list of signatories to the voluntary controls recommended. In view of this some criticisms and RWA responses to the interim guidelines are now considered.

At a conference on 'utilisation of sewage sludge on land' held in Oxford in 1978, Thames WA officials attacked the limits on metals particularly on Zn Cu and Ni. It was pointed out that in a paper given the previous year an ADAS regional soil scientist had 'thrown doubt' on the zinc equivalent concept and suggesting the relative toxicity multipliers of 2 and 8 for Cu and Nu had been overestimated, and consequently that "Reduction of these factors would also help to relieve the pressure on the zinc equivalent limitation."[53] They would have liked to have seen the concept of assessing 'available' metals in soils extended to calculating Cd applications.[54]

Thames Water Authority has in its catchment area the largest conurbation in the country, and had problems not only of quantity and quality of sludge to be disposed but also of prior contamination in some areas of accessible surrounding agricultural land. Their position was stated quite bluntly by two officials, one of them the Divisional Manager of Metropolitan Public Health (MPH) division, a member of both the Standing Committee on Sewage Disposal and of the Sub-committee for disposal of sewage sludge to land, since their formation in 1975.

> For the present then, the metal constraints which Thames Water intend to apply will conform to the concentration limits implied by the Guidelines for those metals which relate to human and animal toxicity. In respect of metal phytotoxicity, account will be taken of the experiences of the M.P.H. Division. It will be shown in a later paper (No.16) that for a typical mixed domestic/industrial sewage sludge, providing the cadmium limit is adhered to, problems are unlikely to be encountered for other metals and in general constraints will resolve to that due to cadmium. The constraint for nitrogen will only be adopted in areas where water contamination is at risk."[55]

So at an international conference at which 32 papers concerned with utilisation of sewage sludge on land were given, with a listed attendance of 294 delegates, the officials of the largest Water Authority openly rejected the voluntary constraints on a) Zn Cu Ni and zinc equivalent and on b) application of N_2 contained in the interim guidelines. Their case was based on the practicalities and economic constraints of the situation inherited from previous authorities and was particularly acute in Western London.

During the ensuing discussion concern was expressed at the TWA officials' stance. Indeed some delegates thought that the limits recommended were too lax. Dr. D. Purves, a prominent member of the Council of Scottish Agricultural Colleges, suggested the introduction of a statutory limit of 10 ppm Cd in sewage applied to land.[56] The farmers' view including the need for a high standard of service, provision of accurate information, and the avoidance of risks was also presented at the conference.[57]

The Royal Commission on Environmental Pollution 7th Report

The RCEP in their 7th report Agriculture and Pollution, chose to consider disposal of sewage sludge by use on land. Having weighed the potential beneficial or toxic effects of elements and nutrients normally present in sludge, the commissioners observed:

> "The practice is attractive to the authorities responsible for sludge disposal since it frequently offers the cheapest option."

Then they comment:

"Nevertheless, at least at the present stage of knowledge, the balance of risk and benefit appears fine..."[58]

The commissioners noted the strong opposition of TWA officials to a) the rate of nitrogen application, and b) the limits on phytotoxic metals as specified in the guidelines, and c) that YWA had questioned "... the working party's views on the efficiency of sewage treatment, including anaerobic digestion, in destroying pathogens..." and criticized their vigorous promotion of the disposal of untreated sludge to agricultural land in the region. The commissioners also reported that some authorities had questioned the basis for the recommended delay periods between sludge application and use of crop.[59] They considered "The main risk to human health is from the contamination by raw sewage, or new sewage sludge, of foods that are eaten uncooked or of milk that is unpasteurised."[60]

Of attitudes to use on agricultural land the commissioners reported:

"Generally, agricultural interests recognise the problems of sludge disposal faced by the water authorities and accept that the material has a modest value in terms of its nutrient content and as a soil conditioner. They are, however, naturally anxious about the possible risks posed to crops and livestock and they are concerned that because of the pressures to adopt the least expensive method of sludge disposal, there may be insufficient caution in expanding its agricultural use."[61]

and

"It is important to instil confidence in the farming community that the assessment of benefits and risks of sewage sludge application is established on a sound scientific basis."[62]

Comment

The Royal Commission on Environmental Pollution provided a forum from which a more detached view of the problems of sewage sludge disposal to agricultural land could be considered and weighed. It is difficult to assess the impact of the report itself, as other forces were at work such as the impending threat that sewage sludge disposal might be the subject of one or more EC directives. But it does seem to this observer that a more mature, if more costly, view is emerging of the monitoring record keeping and discipline involved if the confidence of the farmer and that of the public in the Guidelines is to be maintained. Since this report was published the views of Environmental Health officers appear to have taken a more prominent place.

It is against this background that the Guidelines published in June 1981 are now considered.

5.4. The 1981 Guidelines

In June 1981 current Guidelines were published in the "Report of the sub-committee on the disposal of sewage sludge to land" jointly by DOE and NWC.

The sub-committee, like the working party that preceded it, was chaired by T.W.G. Hucker of the DOE Directorate Water Engineering 1. Membership of the committee was now much wider. Of the 26 members 2 members including the chairman were from DOE, 2 from DHSS, 4 from MAFF, 1 from DAS, 2 from WRC, 1 from ARC, 5 represented the RWAs, 4 the County and local councils, 2 the Institute of Water Pollution Control, 1 the CBI, 1 the NFU and 1 the Association of Consulting Engineers.
G.C. Porteous, also of DOE, Directorate of Water Engineering 1, technical secretary of the preceding working party continued in that role.[63]

It can now be seen that agricultural, water authority and county and local council interests are more fully represented than in the working party which produced the 1976 and 1977 Guidelines already considered. The sub-committee, backed up by four working groups with wider representation, are able to report,

> The sub-committee acquired an appreciation of the Water Authorities' sludge disposal problems and of the considerable progress made since the reorganisation of the water industry in the rationalisation and improved control of

disposal operations. At the same time the sub-committee strengthened its understanding of the problems facing agriculturalists in accepting sewage sludge on land.[64]

The report is again made up of 5 chapters of background information and discussion, including 1 chapter entitled 'The optimisation of sewage sludge disposal to land'. The findings are given as recommendations in Chapter 6 and it is, in the main, these recommendations which are now considered in relation to previous recommendations and criticisms.

Policy towards land use of sewage sludge

The sub-committee point out that "Optimisation of the practice of disposing sewage sludge to land requires the balancing of economic, health and environmental considerations"[65] but point out that "It is incumbent on water authorities to dispose of sewage sludge at lowest cost compatible with the avoidance of harm or nuisance,"[66] and report that analyses of disposal costs "...have shown for inland works without reasonable access to the sea, disposal on land, particularly of liquid sludge, is often the cheapest option."[67]

Commenting on the Working Party's 1977 Guidelines, they warn that some countries have introduced 'more restrictive' guidelines. But are of the opinion that "... any new restrictions should be fully justified by adequate evidence not least because the economic consequences of major changes in sludge disposal practice could be severe."[68]

The committee suggest that in spite of the high per capita sludge disposal "...in most cases this is dealt with effectively economically and with little impact on the environment," but warn that there are locations where improvement is needed and appear to be once again urging the RWAs of the expediency of complying with the voluntary guidelines.[69]

Recommended controls

In view of the cost conscious optimisation statements above controls recommended are based on the working party's guidelines. Changes are incremental, in some cases amounting to modifying clauses, in others additional constraints are added.

Controls of interest to this study are as follows:

Control of potentially phytotoxic elements

Despite the questioning of the basic assumptions of the zinc equivalent concept and particularly of the current multipliers, 1, 2 and 8 for Zn, Cu and Ni when sewage sludge is applied at normal operational levels by, for instance, Wood et al.[70] Marks, M.J. et al.[71] Beckett, Davis and Brindley[72] and Doyle, Lester and Perry[73] and of the sub-committee's own comment that "The zinc equivalent concept has been dropped in the USA and has not found acceptance in Europe,"[74] (where controls are based on the preferred assumption that the toxic effects of metals are not significantly additive,[75]) the Zn≡ concept and the multipliers proposed in 1971 are retained. The grounds for retention being, "...it remains a convenient and reasonable guide for avoidance of phytotoxic effects on the most sensitive of crops" but concede that experimental work should be pursued with a view to improving or replacing the concept.[76] Also retained is the relaxation that twice the Zn≡ allowed on non-calcareous arable land may be applied to calcareous land with pH >7, and to permanent pasture "where there is no possibility of this being ploughed for crops."[77] Of the latter, however, the sub-committee state reservations because of inadequate evidence of grass yields and "...herbage such as clover is much more sensitive than grass to phytotoxic metals". The relaxation being allowed to stand "... until further research is complete and, if necessary, the recommendations are amended."[78]

Recommended applications for Zn, Cu, Ni, and Zinc equivalent are shown in table 5.1, but the Zn≡ concept and limits are being seriously questioned.

Application limits on other elements

Maximum applications of Cr, Cd, Pb, Hg, As and Se over a period of 30 years or more are as stated in the working party's interim guidelines, shown in table 5.1 col.D. The 1981 text focussing attention on potential phytotoxic as well as zootoxic effects of cadmium in sewage sludges applied to land.[79]

On grassland

Following a serious outbreak of Fluorosis in cattle, when sludges containing fluorine, scrubbed from flue gases, were applied to grassland,[80] a 30 year maximum limit is now applied to fluorine as mentioned in table 5.2.[81] Minor changes are also made to application rates of Boron and Molybdenum but these are not of concern in this study.

Maximum single application rate

Maximum single application of sewage sludge is usually limited by the nutrient requirement of the crop, N_2 requirement, but no upper limit is now stated, or by 1/5 of the 30 year, or more, total maximum of the most limiting metal or Zn≡ or by the annual application rate of Boron, as shown in table 5.1 col.E.[82]

Concentrations of metals in soils

The 1981 Guidelines go further than previous recommendations in specifying assumed uncontaminated soil background concentrations and 30 year or more soil concentration maxima.

The 'available' concept of Chumbley is retained but the term available is now dropped, background and limit values for Zn Cu Ni, Zn≡ and also of Boron now being stated as 'extractable'. The concept is extended by recommending 'extractable' $mg.l^{-1}$ limit values in arable soils. See table 5.1.

Of the future of the availability concept the sub-committee now warn "ADAS has under consideration the introduction of recommended limits of 'total' metal concentrations in sludge amended soils..."[83]. Values for 'total' metals in soil being used for Cr, Cd, Pb, Hg, Mo, As, F and Se.[84] Variation in actual background levels is expected to be taken into account for 'uncontaminated' land as well as previously specified for land which has already received prior sewage sludge applications.[85]

Soil concentration limits are not specified for permanent pasture land as "more information is needed on the distribution of added metals through the soil profile over relevant sampling depths before formal guidance can be given on maximum metal concentrations in pasture soil."[86] Specification of limits in terms of soil concentrations is in keeping with the UK Government's declared policy of using environmental quality objectives as the preferred means of pollution control.[87]

The Chairman of the sub-committee, in the foreword to the 1981 report makes a point of admitting,

> Whilst we would like to have recommended soil concentrations for all soils, we are only able to give those for arable soils at this point in time and, even then, there are so many uncertainties that it is still necessary to have application limits.[88]

Limits to element concentrations in sewage sludges

In addition to restating the limit of 2000 mg. kg^{-1} of Pb in dry solids of sewage sludges applied to grassland, previously stipulated in 1977, the sub-committee extend this limitation to sludges applied to 'gardens and amenity' areas because of the dangers of surface contamination and the subsequent ingestion by animals or small children.[89] A new limit on F of 3500 mg.kg^{-1} DS in sewage sludge applied to grazing land is also recommended.[90]

Although recommending that the supply of sewage sludge to the general public should be phased out, the sub-committee recommend, "...only sludges (mesophilic anaerobic digested or heat processed) with less than 20 $mg.kg^{-1}$ of Cadmium in dry solids should be provided."[91] See table 5.2.

So it can now be seen that in addition to specifying limit metal concentrations in arable soil, in keeping with the EQO approach and specifying 30 year, or more, limits on 12 different elements, two of which, B and F, are also controlled on an annual basis, the sub-committee found it necessary to state concentration limits on Pb, Cd and F in sludge when used for specified purposes. Although voluntary, this last type of constraint may be interpreted as an example of 'uniform emission standards', thus weakening any future negotiation for an entirely EQO approach to sludge disposal by utilisation on agricultural land.

Control of Pathogens and Parasites

The sub-committee report that the efficiency of some sludge treatment processes has been called into question. For example, research carried out by WRC found that in 9 works using mesophilic anaerobic or aerobic digestion the Salmonellae count was reduced by between 13 and 85 percent of the level in raw sludge. The efficient feeding and mixing in sludge treatment appearing to be important factors.[92]

The sub-committee are firmly committed to some form of sludge treatment as a method of pathogen control as shown in the recommendations summarised in table 5.4.

Sludge treatment is seen as a partial barrier to pathogens and parasites, a second barrier is in the length of delay period between application and specified after use, limiting location and crop provides a third barrier.[93] It is therefore logical and convenient to consider sludge treatment, delay periods and after use together.

As shown in table 5.4, mesophilic anaerobic digested and heat processed sludges are eligible for all classes of use shown. The delay period specified when these sludges are applied to grazed crops are dependent on the efficiency of the treatment used as measured by organic matter destroyed during sludge treatment. When 40% OM, or more, is 'destroyed' delay periods between sludge application and grazing are 3 weeks, "... as a precaution against salmonella infection,"[94] or 5 weeks if any milk is to be produced and not pasteurised. When less than 40% OM is 'destroyed' the delay period is increased to 6 months. When these sludges are used on land where crops for human consumption uncooked are to be grown a 12 months delay is recommended between application and sowing, but other crops may be grown in the interim.

Sludges lagooned for 2 years, cold anaerobic digested or sludge cake stacked for at least one year may be applied to land for 5 out of 7 classes of use, recommended delay periods when used on grazed crops are as for mesophilic digested and heat processed sludges, delay periods are increased to 6 months if lagooned sludge or sludge cake is less than the recommended age or if cold anaerobically digested sludges produced have less than 40% reduction of organic matter. A 12 month delay period is recommended when these sludges are used on land where crops for human consumption uncooked are to be grown.[95]

Similarly aerobically digested, lime stabilised or conditioned sludges, or from full biological treatment of settled sewage can be used in 5 out of 7 classes of after-use. The delay period when applied to 'grazed crops' grazed by cattle or pigs is 6 months "as a precaution against infection by tape worm eggs."[96] When applied to orchards or land for turf use, fruit or turf must not be harvested within 3 months of sludge application. The 12 month delay period is again specified when these sludges are applied to land on which crops for human consumption are grown.[97]

In the case of liquid sludges stored for two weeks, cake without lime conditioning, or from partial biological treatment of settled sewage or from limited aeration of unsettled sewage, it is recommended that application should be limited to land with 3 out of the 7 after uses. The extended delay periods are 6 months when used on crops grazed by cattle or pigs or 3 months when applied to land from which fruit or turf is to be harvested.

Raw sludge use is recommended for only 2 out of 7 classes of land use, 6 months delay period applying when cattle or pigs are to be grazed.

As can be seen from the overall view presented in table 5.4, a wide variety of locations and uses are related to a league table of sludge treatment, predicted effectiveness in pathogen reduction being reflected in the number of categories of recommended after use and the length of recommended delay periods between sludge application and after use.

Results of the 1980 survey indicate that of sludges utilised on agricultural land 57, 32.6, 0.2 and 7.2 per cent respectively were used on general arable, grassland, forestry and land reclamation and total 97 per cent of all sludges so used.[98]

As percentage of sludge used on land from which turf is harvested, or on which crops are grown for human consumption uncooked, or of seed potatoes or nursery stock are grown for export is likely to be small then Classes A and B, shown in table 5.4, which most nearly fit the 4 categories shown above, receive by far the greatest percentage, possibly in excess of 90 per cent of all sludges utilised in agriculture. On the basis of the 1981 guidelines all treated sludges and even raw sludge are eligible, subject to appropriate delay periods, for use on land with by far the most extensive classes, A and B, of after use.

Comment

In spite of its shortcomings the Zn≡ concept adopted from MAFF, ADAS 10 has become institutionalised and defended. In part this would seem to be because of the design of experiments set up in 1968 to refine the concept have led to results with very high standard errors, making significant differences hard to show.[99] While the assumptions underlying the Zinc equivalent concept have been discarded in the controls used by most other countries.

The 'availability' concept also adopted from ADAS 10 is still maintained and rationalised. Use of soil metal concentrations is extended in an attempt to arrive at an EQO set of controls.

Two further trends emerge. First incremental additional controls are added as expediency requires, but relaxations once given, although subsequently questioned, are qualified and caveats added, but appear difficult to withdraw.

The approach is facilitating rather than restrictive and makes provision for use of expert opinion as for instance where grassland soil pH is less than 6,[100] and on the spot judgement as in the case of N_2 application rates, which have usually been the first limiting factors to determine actual disposal rate used. Pathogen and parasite control is no exception to this approach, where possible allowing conditional use, rather than prohibition, to facilitate the disposal of a wide range of sludges.

By specifying few metal concentration limits in the sludges themselves, sludges with relatively high concentrations can be permitted to be used on agricultural land; choice as to whether it is economically justified, or expedient to do so being left to the disposers, the RWAs, who in turn are responsible also for trade effluent control. The importance of reducing metal inputs to sewers particularly in cities and conurbations is frequently emphasised.

The Standing Committee on the disposal of sewage sludge, in a report published in July 1981, urged:

> Where metals or other persistent substances cause harmful effects and/or limit disposal every effort should be made to reduce at source the amount of those substances that appear in the final sludges.[101]

In some areas the success of the guidelines in facilitating the disposal of sludges with quite high potentially toxic metal content may itself be a reason why causal inputs to sewers are allowed, tolerated or remain undetected.

5.5. Advice to farmers 1982 - a divergence of opinion.

In 1982 revised advice to farmers and others was published by MAFF in ADAS Booklet 2409, 'The use of sewage sludge on agricultural land'.

As in 1978, advice is non-committal regarding the sewage sludge disposal to land policy, but recognises that sludge is offered to farmers by Water Authorities and "Although bulky to handle, sewage sludge is a useful source of nitrogen and phosphorus."[102]

Nutrients

As might be expected, considerable attention is given to the use, calculation of nutrient application, timing and good practice aspects of sewage sludge use on arable and grassland.

Metal limits

The Zn ≡ concept is retained with the same multipliers as originally stated by ADAS in 1971 and with a total limit of 560 kg ha^{-1} over a period of 30 years or more on arable land.

The relaxation of this limit to double the quantity on pasture land made in the interim guidelines in 1977 and the guidelines in 1981, and allowed in ADAS, AF51 (1978) is now withdrawn and the total of 560 $kg.ha^{-1}$ may be applied to "... pure grass swards where pH is maintained at pH 6.0 or above without affecting crop growth".[103] So the recommended long-term limit on Zn≡ application would appear to have returned to the limit as given by Chumbley in ADAS 10, but now applied to arable and pure grass swards rather than to 'grassland' or 'pasture' specified in ADAS 10 or the interim guidelines respectively. The reason for this may be due to the finding that "... herbage such as clover, is much more sensitive than grass to phytotoxic metals..," a reservation expressed in 1981.[104]

The second major change from the 1981 Guideline recommendations is in absence of mention of 'available' or 'extractable' metal concentrations in soils. Emphasis is now on records being kept of quantities and analyses of sludge applied "... so that total quantities of metal applied over a period of years can be calculated." Application rates being adjusted when necessary as a result of monitoring at intervals "... the increase of total metals in soils." The word 'total' being printed in italic type.[105]

Although a forewarning was given of this change in 1981, the 1982 ADAS advice by omitting the 'available' or 'extractable' soil concentration limits on Zn Cu Ni and Zn≡ used in 1971, 1977, 1978 and 1981 and replacing them with 'total' limits have the effect of making a large potential reduction in sludge application tonnages possibly up to 50 percent for some Zn≡ rich sludges, and if the advice is heeded, the immediate cessation of use in some areas.

Maximum concentrations of 2000 and 3,500 mg kg^{-1} of Pb and F in sludges used on grassland are also the same. The restriction on Cd concentration in sludge when used on gardens or allotments is not mentioned nor is that use.[106]

Control of Pathogens

Although the classification of sewage sludges is not as comprehensive as that given in the 1981 Guidelines, see table 5.4, recommended delay periods specified for the classes of sludge mentioned are in accord with those shown in that table.

The 1982 booklet also advises on 'best practice', for instance in relation to the use of anaerobically digested or lagooned (for 2 years) sludge "To avoid direct ingestion of sludge by livestock in dry periods, the interval should be longer if the herbage is still visually contaminated."[107] Or with sludges applied to grassland for which a six month delay is recommended before grazing with cattle or pigs, "The best practice is to take one or more cuts of grass for hay or silage before grazing such land."[108] The best practice advice provides a further barrier against pathogens.

Comment

Although published within 13 months of the 1981 DOE/NWC Guidelines the 1982 ADAS advisory booklet 'The use of sewage sludge on agricultural land' is more restrictive in the advised maximum additions of Zn Cu Ni and Zn ≡ applied to land on which arable crops, temporary grass or permanent pasture swards are grown.

Restriction is mainly by omission of the use of 'available' or 'extractable' metal concentrations in soils and replacing by a 'total' metals strategy as used for the zootoxic metals, when calculating application rates and maxima.

Also dropped is the relaxation by which, as stated in 1978, "Larger amounts of Zinc up to 1120 kg/ha may be safely added on a) permanent grassland which is less sensitive to the effects of metals than arable crops..."[109] Advice reverts to the lower limit of 560 $kg.ha^{-1}$ of Zn, or Zn ≡ , as recommended in 1971 by Chumbley but now applying it "... to pure swards."[110]

Clearly the authors have become concerned as to the long-term effects on some soils of continued high levels of sludge application, and particularly so regarding potential damage to composition and/or yield of permanent pastures. Greater emphasis is now put on the keeping and use of records of quantity and quality of sewage sludge.

Predictably 'best practice' is advised with regard to the farmers' long-term, rather than the RWAs' short-term interests in mind. It ends with the warning, "Untreated sludge can present a health risk to humans if ingested, and care needs to be taken by anyone involved in its application to land."

Perhaps the perspective shown in the ADAS document may be summed up by the sentiment expressed in 1981 by one ADAS regional soil scientist, that in the long run it is important that the RWAs come to see, unless they wish to run the risk of curtailing the land spread option, disposal must comply with the farmers' long-term interest.[111]

5.6 Conclusions

1. The review above shows quite clearly how both ADAS advice to farmers and the DOE/NWC Guidelines on the use of sewage sludge on agricultural land have evolved from the concepts, assumptions and recommendations made in the 1971 ADAS Advisory Paper 10 written by Chumbley, subsequent advice and recommendations being extended to quantify limits of zootoxic metal application.

2. There was a high degree of agreement between the Working Party interim guidelines published in 1977 and Advice to Farmers AF51 issued by ADAS in 1978.

3. In 1981 and 1982 both the Guidelines and ADAS advice, respectively, still retain the Zn≡ concept although now discarded by the USA and not

assumed in the guidelines or regulations of other European countries.

4. The Zn≡ concept seems to have become institutionalised, perhaps through key personal commitments, in recommendations of both the DOE Standing Committee and the corresponding internal committee of MAFF.

5. Scientific evidence to refine or provide a generalised disproof of the multipliers, used in the Zn≡ calculations, being difficult to show and almost impossible to generalise on the basis of results from the long-term experiments, using sensitive minority crops and heavy dressings of metal contaminated sewage sludges, set up in 1968.

6. The 'availability' concept also used in ADAS 10 and adopted into 1976 draft and 1977 Working Party interim guidelines is extended to provide extractable background norm concentrations and extractable soil concentration limits in the 1981 Guidelines. But such scientific evidence as had been used to justify the concept in ADAS 10 was countered and almost reversed in provisos made with its continuing use in 1977 and 1981. While metals may become immobile and remain so in some mineral soils, the difficulty is again in generalising the concept to all soils crops and conditions to which the guidelines apply, so making the continued use of this concept dubious, particularly from a scientific point of view. This concept is omitted from advice given by ADAS in 1982.

7. The relaxation given in 1977 interim guidelines, and continued in 1981, allowing double the quantity of sludge to be applied to calcareous as is to non-calcareous land is still maintained in 1982 advice. The corresponding relaxation allowing double the quantity on permanent grassland has also been shown to have a dubious scientific basis due to the smaller dilution capacity offered by many pasture soils and to the phytotoxic effects on non-grass species. Again with provisos this relaxation is maintained in the 1981 Guidelines, but not in the 1982 ADAS advice adding to the divergence of recommendations in the two documents.

8. The Sub-committee on sewage sludge disposal to land appear to find

relaxations once made are difficult to withdraw. The ADAS internal committee appears anxious that the use, or abuse, of these relaxations and the basic 'availability' concept, should not be to the disadvantage of farmers and landowners and/or lead to long-term damage to farmland.

9. It may be claimed an advantage in using guidelines rather than statutory controls, that they may be quickly changed in the light of experience or additional scientific evidence. This review would seem to indicate:

a) Incremental changes particularly additions, can be made quickly.

b) Basic assumptions and relaxations require much larger timescales for change to take place, perhaps becoming institutionalised, rationalised and defended by significant individuals or groups of people. Explicit rationalisations, provisos and shifts of responsibility to on-the-spot decisions providing an insight into decision, or non-decision making.[112]

10. The 1981 DOE/NWC Guidelines and to a lesser extent the 1982 ADAS advice to farmers, are facilitating in allowing a wide range of sludges, in some cases with relatively high concentrations of metals to be disposed /utilised on a wide range of soil types, land use and pH ranges, to the point that disposal is subject to local expert advice rather than being prohibitive.

11. But the voluntary control and the facilitating approach are, perhaps, also a source of weakness. It was perhaps opportune that the RCEP, in investigations of Agriculture and Pollution, was able to bring pressure to bear in:-

Recommending a higher priority for Pathogen Control;

Further urging the need for a scientific basis for controls;

The importance of retaining the farming communities' goodwill;

Insisting on the need to reduce metal contamination of sludges at source by tighter trade effluent control;

The need for regular monitoring and "If possible, water authorities should provide an analysis of maximum metal content and fertilizer value of sludge to the farmers on request,"[113] a recommendation very similar to that made by the Working Party on Sewage Disposal in their 1970 report 9 years before; and insisting that Water Authorities should comply with the Guidelines established whether they agree or not.

12. The RCEP seem to have performed an important role in the decision-making and implementation processes. In view of their call for conformity the divergence of advice between the DOE/NWC 1981 Guidelines and the ADAS 1982 advisory booklet to farmers is all the more significant.

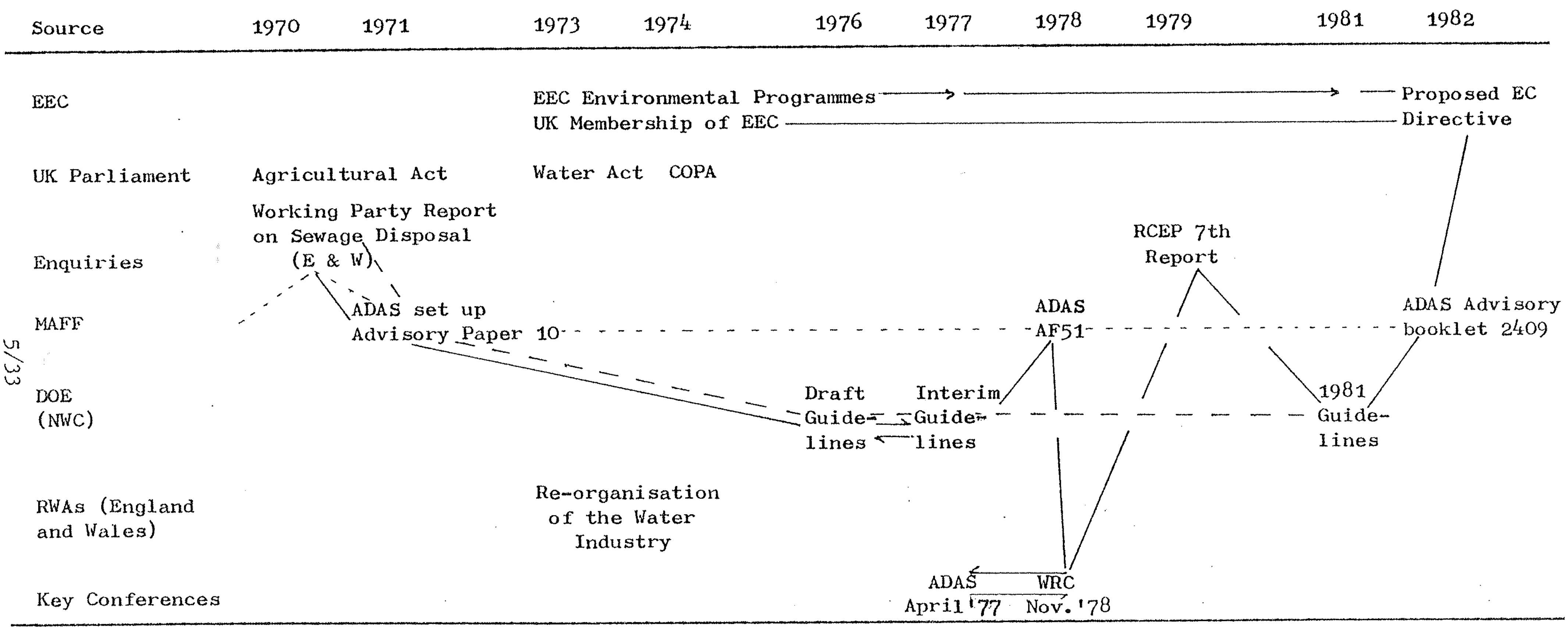
13. That this disparity should arise is in part due to the responsibility placed on the Secretary of State DOE for "... treatment and disposal of sewage..." including disposal to agricultural land, as part of a national policy for water in England and Wales by the Water Act 1973.

While further to section 103 of the Agriculture Act 1970 the Agricultural Development and Advisory Service set up in 1971 was concerned as one of its principal functions to provide information and advice to farmers and growers to help them develop financially sound farm businesses.[114]

14. This sectoral approach overlaps when sewage sludge is disposed by utilisation on agricultural land. Respective advice providing opportunities for cooperation or confusion.

With the publication in October 1982 of a 'Proposal for a Council Directive on the use of sewage sludge in agriculture', the evolution of the UK controls enters a new phase, considered in section 6.

FIGURE 5.1. Sequence of analysis of events and influences contributing to the evolution of the DOE/NWC Guidelines



Key
——— Sequence of analysis
······ Evolution of Agricultural Development and Advisory Service (ADAS) Advice to Farmers) on the use of sewage sludge on agricultural land.
- - - - Evolution of Department of the Environment/National Water Council (NWC) Guidelines)

TABLE 5.1. Recommended maximum permissible additions of metal elements in sewage sludge applied to uncontaminated non-calcareous and calcareous arable land and to permanent pasture by DOE/NWC Guidelines 1981

Column	A	B	C	D		E	
Period	30 year, or more,		Total (Max)	Average Y^{-1} $\frac{Max}{30}$		Max. Single Application $\frac{Max}{5}$	
Land use	Arable		Permanent Grassland	ColA/30	(Cols.B,C/30)	Col.A/5	(Col.B/5,C/5)
pH	pH6.5<	pH7<	pH ≥6	pH6.5<	(pH7≮ 6)	pH6.5<	(pH7≮ pH6)
Element/Unit			$kg.ha^{-1}$(C)				
Zn a	560	1120	1120	18.6	(37.3)	112	(224)
Cu a	280	560	560	9.3	(18.6)	56	(112)
Ni a	70	140	140	2.3	(4.6)	14	(28)
Zinc Equivalent a	560	1120	1120	18.6	(37.3)	112	(224)
Cd b	5	5	5	0.16	(0.16)	1	(1)
Cr b	1000	1000	1000	33.3	(33.3)	200	(200)
Pb b	1000	1000	1000	33.3	(33.3)	200	(200)
As b	10	10	10	0.3	(0.3)	2	(2)
Hg b	2	2	2	0.06	(0.06)	0.4	(0.4)

Also controlled B, Mo, F and Se

Notes:
a. Any adjustment for background contamination is based on 'extractable' concentrations of these metals in soils.
b. Any adjustment for background contaminations is based on 'total' concentrations of these metals in soils.
c. Loads given assume normal soil background concentrations as specified in DOE/NWC STC.20 Table 8.

TABLE 5.2. Recommended maximum trace element concentrations in sewage sludges used on agricultural and amenity land

DOE/NWC Guidelines 1981

Element Unit	Guideline Reference	Recommended upper limit $mg.kg.^{-1}$ DS	After use to which limit applies
Zn		none	
Cu		"	
Ni		"	
Cd	a	20	Garden, Amenity
Pb	b	2000	Grassland, Garden and Amenity
Cr		none	
As		"	
Hg		"	
F	c	3500	Grazing land

Notes:

a DOE/NWC STC. 20 June 1981 para. 6.41

b *ibid* para. 6.44

c *ibid* para. 6.50

TABLE 5.3. Provisional maximum permissible concentrations of elements in arable soils to be reached in 30 years or more, as specified in Table 9 of the 1981 'Guidelines'. (a) (b)

Metal	Form	Arable Soils		Permanent Pasture
		Non-calcareous	Calcareous	
Zn	Extractable (c)	280	560	Not stated
Cu	"	140	280	"
Ni	"	35	70	"
Zn≡	"	280	560	"
Boron		d	d	"
Cr	Total	600	600	"
Cd	"	3.5	3.5	"
Pb	"	550	550	"
As	"	10	10	"
Hg	"	1	1	"
Also given Mo, F, Se	"	d	d	"

Notes:

a. Subject to the proviso that "The recommended maximum permissible application rates are based on soil pH being maintained at 6.5 or over for arable land and 6.0 for grassland."

b. DOE/NWC. Report of the sub-committee on the disposal of sewage sludge to land Standing Technical Committee Report 20, NWC June 1981.

c. Zn, Cu and N extracted from soils using EDTA.

d. Specified but not included here.

TABLE 5.4. Recommended opportunities and constraints on the use of sewage sludges in respect of pathogen control.U.K. Guidelines. Adapted from DOE Standing Technical Report No. 20, July 1981 pp.47, 48 and Table 7.

Group		Sludge type (see notes 1,2)	Class A Crops for human consumption (cooked). Crops for conservation. Forestry. Land reclamation.	B Grazed Crops	C Orchards. Turf.	D Park flower beds	E Crops for human consumption (uncooked)	F Seed Potatoes. Nursery stock for export.	G Gardens. Allotments.
			Land use after applying sewage sludge						
1	a	Mesophilic anaerobic digested	+	+ ab	+	+	+ e	+	(+)
	b	Heat processed	"	"	"	"	"	"	"
2	a	Lagooned 2 years	+	+ ab	+	+	+ e	x	x
	b	Cold anaerobic digested	"	"	"	"	"		
	c	Cake - one year total age	"	"	"	"	"		
3	a	Aerobically digested	+	+ c	+ d	+	+ e	x	x
	b	Lime stabilised or conditioned	"	"	"	"	"		
	c	From full biological treatment of settled sewage	"	"	"	"	"		
	d	From extended aeration of unsettled sewage	"	"	"	"	"		
4	a	Liquid stored 2 weeks	+	+ c	+ d	x	x	x	x
	b	Cake without lime conditioning	"	"	"				
	c	From partial biological treatment of settled sewage	"	"	"				
	d	From limited aeration of unsettled sewage	"	"	"				
5		Raw	+	+ c	x	x	x	x	x

TABLE 5.4.

Recommended opportunities and constraints on the use of sewage sludges, Pathogen control

Notes.

1. Based on the assumption that sludge is produced from human populations at normal health levels. DOE/NWC. STC.20.1981 para.6.09.

2. Those sludges 'with significant amount of waste from the processing of hides imported from countries where anthrax is endemic, should not be used for any agricultural purpose.'
ibid para. 6.09.

a. No grazing within 3 weeks of sludge application, or 5 weeks if any milk is produced and not pasteurised.

b. No grazing period should be increased from 3 weeks up to 6 months when less than 40% organic matter is destroyed in anaerobic digestion or when lagooned or dewatered sludge period is less than recommended.

c. No grazing of cattle or pigs within 6 months of sludge application, other animals as note a.

d. Fruit or Turf not to be harvested within 6 months of sludge application.

e. Crops for human consumption uncooked should not be sown for 12 months after sludge application, other crops may be grown in the interim.

( ) This after use is to be phased out.

\+ Acceptable.

x Unacceptable.

6. EEC DIRECTIVE v. UK GUIDELINES

A comparison of constraints specified in the "Proposal for a Council Directive on the use of sewage sludge in agriculture" and the UK Guidelines.

6.0. The UK Guidelines may be described as voluntary pragmatic and facilitating; legal control of pollution is by means of Common law particularly by the torts of trespass, negligence, nuisance and strict liability built on precedent and by statute law developed piecemeal in response to specific hazards, rather than a logical code.[1] By contrast the legal systems, and therefore control philosophies of many European countries have been influenced through conquest, occupation or adoption by the Code Napoleon enacted in 1804, an attempt having been made to produce a purely rational civil law, deduced from egalitarian principle, rather than from the pressure of powerful interested parties.[2]

UK controls have largely developed in isolation whereas those of continental European countries have had to concern themselves with the problems of trans-frontier pollution and shared waterways.

Now although a representative of the CBI could say of pollution control "Par excellence the United Kingdom system is one of flexibility and consultation. It is the sort of flexible system which we should like to see more prevalent throughout the EEC"[3] the problem of Commissioners and officials in Brussels is to produce a draft directive which is applicable to a wide range of countries, conditions and traditions, to the final product of which member states are required to approximate their statutary controls.

The circulation of drafts of the proposal for a directive may have influenced the authors of, and the response to, the DOE/NWC 1981 Guidelines and of the 1982 ADAS Advisory booklet, considered previously. But with the publication in October 1982 of a 'Proposal for a Council Directive on the use of sewage sludge in agriculture' there is now the prospect of a future set of voluntary and statutary constraints to consider. Constraints that have evolved outside the assumptions and traditions of the UK which, if adopted, will apply in all EEC member states.[4]

The main stated objective of the proposal is "to provide better protection for the environment and to make use of waste."[5] In the absence of more direct powers for such action a directive is seen to be justified under Articles 235 and 100 of the Treaty of Rome on the grounds that "... disparity between Member States' current provisions.... might create an imbalance in the conditions of competition..."[6] Of this basis the HLSC conclude "Whatever may have been the basis for previous concern, ...the current draft cannot be challenged on legal grounds."[7]

Purpose and method

It is now the purpose of this section to compare the provisions and constraints on disposal made in the proposal for a directive with those in the UK guidelines, particularly in relation to:

metal concentrations in sludges - because of their limiting effect on UK sludge disposal, attention will also be given to the following:

disposal to grassland;

supply of nutrients;

pH; and

pathogen control.

The comparison will be carried out by considering in turn -

Applications to which controls apply;

Expressed attitudes to use of sewage sludge in agriculture;

Controls on potentially toxic metals in which metal concentrations or loads are stipulated;

Other limiting factors.

6.1. Comparison of constraints

Applications to which controls apply

Although primarily developed to meet a wide range of conditions found in England and Wales the 1981 Guidelines are also used in Scotland and Northern Ireland. They are relevant to all sewage sludges produced by public sewage treatment works, applied to agricultural land.

The proposed directive does not apply to sewage sludge from treatment plants serving, throughout the year, populations of less than 5000 persons.[8] If adopted it will apply throughout all member states. Provision is made to include certain non-toxic commercial or industrial and mixed sludges, raising issues which are not the concern of this study.[9]

Attitude to land use

Like the guidelines the proposed directive supports the application to agricultural land of sewage sludges subject to certain precautions being taken. But "... must not impair the quality of agricultural and forestry products in the long term."[10]

Control of potentially toxic metals

Like the guidelines the proposal for a directive is concerned with three types of control which stipulate metal concentrations or loads. They are limits on element concentrations in sludges used on agricultural land, limits on application rate including maximum single application rate and maximum permissible concentrations of elements in soils, now considered below.

Limits on element concentrations in sewage sludges used in agriculture

In a recent review of European national controls over sewage sludge disposal to agriculture, it was shown that of EEC members Italy, Eire, Luxembourg and Greece did not specify any concentration limits. Of the remainder Belgium, Denmark, France, Netherlands and F. German Republic specified Guideline or Mandatory metal concentration limits in sludges used, while UK guidelines specify use related limits on Pb, Cd and also on Fluorine concentrations in sludge used.[11]

It is therefore not surprising to find that the EC proposal specifies recommended and mandatory limits on element concentrations in sludges used in agriculture.

The 1981 Guidelines recommend upper concentration limits of 2000 and 3500 $mg.kg^{-1}$ DS. Pb and F in sludges used on grassland and 20 $mg.kg.^{-1}$ DS Cd in sludges applied to gardens and allotments. By contrast Article 4 of the EC proposal, sludges with higher concentrations than Mandatory (M) values may not be used in agriculture and requires Member states to make 'every effort' to comply with Recommended (R) values when local conditions permit. R and M values shown in Annex 1A of the proposal for a directive are respectively

for Zn	2,500 and 3000	$mg.kg^{-1}$	DS.	sludge	
Cu	1,000 and 1500	"	"	"	
Ni	300 and 400	"	"	"	
Cd	20 and 40	"	"	"	
Pb	750 and 1000	"	"	"	
Cr	750	"	"	"	
Hg	16	"	"	"	(see table 6.1).

Clearly these mandatory limits will restrict use of sludges on UK arable soils where no sludge concentrations are specified in the Guidelines and on grassland where the 2000 $mg.kg^{-1}$ DS of Pb is 200 and 266.6 percent of the proposed M and R limits. Use of sludge on gardens or allotments is not allowed by the proposed directive.[12]

The limit values stated may be seen as uniform emission standards, to which the UK has been opposed,[13] but the UK is in a weak position as the Guidelines already state the 3 use related emission standards shown in Table 6.1.

Although median and mean values of UK sewage sludges used in agriculture were less than 50 percent of R and M values respectively, maxima found in the 1980 survey indicate that, if adopted, M values shown in table 6.1 could severely reduce some current usage of sludges, particularly where these are derived from industrial towns, cities or conurbations, unless metal inputs to sewers and thus metal concentrations in sludges can now be correspondingly reduced.

Maximum permissible application rates.

Maximum annual average rates

Article 5 of the EC proposal requires Member States to "...lay down maximum amounts which may be added per unit soil surface area per year, calculated over 10 years," for trace elements in sludges.[14] UK Guidelines give recommended application limits to be reached in 30 years or more. Annual average application rates derived from these limits are compared in table 6.2.

It can be seen that whereas Guideline annual average limits on Zn, Cu and Ni spread on noncalcareous arable soils of pH 6.5 and above, those for calcareous arable soils $>$pH 7 and permanent pasture$\geq$pH 6 are greater than M values. But the guideline limits are also subject to an overriding Zn$\equiv$ constraint. When Zn$\equiv$ of R and M limits are calculated it is found that Guidelines restrict average annual application of sludges to 30.6 or 61.2 percent of Zn$\equiv$ allowed by R limits and 23.9 or 46.9 of M limits on arable soil$\geq$pH 6.5 or arable soils $>$pH 7 and permanent pasture $\geq$pH 6 respectively.

Although based on different assumptions it would seem that meeting the average annual Zn, Cu and Ni constraints proposed would not create serious difficulties except in a few Zn or Cu or Ni rich sludges normally applied to calcareous arable soils$>$pH 7 or to permanent pasture $\geq$pH 6.0 provided that application rates already comply to Guideline recommendations.

For most sludges average annual application rates of Zn, Cu and Ni would be allowed to increase considerably. For example, a sludge applied at maximum M values of Zn, Cu and Ni as shown in table 6.2 would allow 4.2, 2.1 or 2.1 times the application rate on noncalcareous, calcareous soils or permanent pasture land respectively than that recommended in the 1981 Guidelines.

Other metals, as calculated in table 6.2.

Cd. Maximum annual average application rate recommended by the Guidelines is $0.1\dot{6}$ $mg.ha^{-1}y^{-1}$, being $166.\dot{6}$ and $111.\dot{1}$ percent of R and M values respectively. Thus a 10 percent reduction of the Guideline rate is equivalent to the M rate proposed.

Pb. Maximum annual average application rate recommended by the Guidelines is 33.3 $kg.ha^{-1}y^{-1}$ being $333.\dot{3}$ and 222.2 percent of R and M values respectively, the highest difference with stated M constraints of any metal.

Cr. Maximum annual average application rate recommended by the Guidelines is also $33.\dot{3}$ $kg.ha^{-1}y^{-1}$, and as for Pb is $333.\dot{3}$ per cent of R value.

As. Maximum annual average application rate recommended by the Guidelines is 0.3 $kg.ha.^{-1}y^{-1}$ being 95.24 percent of the R value.

Hg. Maximum annual average application rate recommended by the Guidelines is 0.06 $kg.ha^{-1}y^{-1}$, only $16.\dot{6}$% of the R value.

No M values are stated for Cr, As and Hg.

Comment

On the basis of the annual average application rates, shown in table 6.2, the proposed M and R values would reduce annual application rates of some Cd and Pb-rich sludges but would allow an increase of rate for many sludges which in the UK are limited by the overriding Zn ≡ rates recommended in the Guidelines. The significance of this conclusion is reinforced by the finding, in a study reported by Sterritt and Lester that sludges from 40 works, chosen "to provide a cross section of urban and rural areas with various proportions of industrial flow,"heavy metal concentrations limiting application to agricultural land were, of 40 sludges, 33 by Zn≡, 4 by Cd, 2 by Mo and 1 by Pb.[15] Although carried out in 1979 to examine the effects of the 1977 Interim Guidelines, the 30 year maximum values for Zn≡, Cd and Pb were the same as those in the Guidelines from which the annual average application rates shown in table 6.2 are derived.

It is therefore concluded that, unless otherwise limited, many sludges will be allowed a higher annual average application rate by limits in the proposal for a directive than those recommended in the UK Guidelines.

Maximum single application rate of metal elements

The interpretation of Article 5, of which Annex 1B is a part, is not clear but might be taken to allow up to ten times the annual average application rate, providing no further sludge was applied until it complied with the running annual average rate. On that basis ten times the average annual rate stipulated in the EC proposal is compared to 1/5 of the 30 year maximum recommended in the Guidelines, as shown in table 6.3.

Zn, Cu, Ni and Zn≡.

Individual single application limits recommended in the Guidelines are shown to be less than those assumed to be M values in the EC proposal. But again UK limits are subject to an overall Zn≡ limit; when Zn≡ is calculated for EC proposed values it is found that UK limits are 18.4 or 14.1 percent of R or M values on arable soils of pH 6.5 and 36.7 or 28.3 percent of R or M values on calcareous soils $>$ pH 7 or p. pasture $\geq$ pH 6. See table 6.3. On this basis it may be seen that both R and M values would allow a much higher single application than that allowed by the Zn≡ value recommended in the Guidelines. In practice however, application rate will probably be limited by N_2 requirement of the following crop before the above rates are reached.

Maximum single application rates of Cd, Pb, Cr, As and Hg.

Cd. Guideline recommended limit is 1 $kg.ha^{-1}$, the same as the R limit and 66.6 percent of the proposed M limit.

Pb. Guideline recommended limit of 200 $kg.ha^{-1}$ is 200 and 133.3 percent of R and M values respectively. The only metal for which Guideline value is greater than M limit.

Cr, As and Hg. Guideline recommended limits 200, 2 and 0.4 $kg.ha^{-1}$ for Cr, As and Hg are 200, 57.1 and 10 percent respectively of proposed R limits. No M values are stated.

Comment

It is concluded that the interpretation of Article 5 is not clear, but if a 10 year maximum single application rate is allowed, on the basis of R and M values shown in Annex 1B then providing other factors are not limiting:

The maximum single application rate recommended for sludge metals in the Guidelines is unlikely to be reduced as a direct result of M values stated in Annex 1B, except in the case of some Pb rich sludges;

For many sludges the maximum single application rate may increase as mandatory levels of Zn, Cu and Ni are not subject to an overriding zinc equivalent constraint and the mandatory 10 year limit for Cd is 50 percent higher than the Guideline recommendation of 1 $kg.ha^{-1}$ per 6 years maximum.

A comparison of limit values of 'trace elements' in soils

The fourth method of constraining metals in sludges used in agriculture is by specifying upper concentration limits in soils. This approach is in keeping with the environmental quality objectives approach to which the UK government seems now to be committed.[16]

The EC proposal prohibits the spreading of sewage sludge on soil in which metal concentrations exceed 1 or more M values.[17] R and M values, specified in Annex 1C of the proposal and Guideline recommended soil concentration limits are compared in table 6.4.

The limit concentrations specified in the proposals are in $mg.kg^{-1}$, whereas those in the Guidelines are in $mg.l^{-1}$. For the purpose of this comparison a soil density of 1 is assumed on the basis of the statement that "most mineral soils in the dried, ground and sieved state have a density of approximately 1 and there is no significant difference between concentrations of contaminants expressed in mg/l and mg/kg." as stated in the 1981 Guidelines. Subject to the above statement the comparison below is then for mineral soils. See table 6.4 note d.

Zn, Cu, Ni and Zn≡.

A further difficulty in comparing Guideline with EC proposal limit values is that 'Extractable' Zn, Cu, Ni and Zn≡ concentrations are recommended in the former and 'total' concentrations in the latter, making direct comparison difficult. To overcome this difficulty it is now assumed that 'extractable' values are 50 percent of 'total' concentration, as assumed by P. J. Matthews,[18] the following comparisons can be made.

Although total equivalents of recommended guideline limits for Zn, Cu and Ni are higher than R and M values, Guideline recommendations are subject to the overriding Zn≡ limit value. When Zn≡ of R and M limit values of Zn, Cu and Ni are calculated it is found that 'total' equivalents of Guideline 'extractable' concentrations in noncalcareous arable soils ≥pH 6.5, are 114.3 and 62.2 percent of R and M values respectively, therefore M value would allow more than 50 percent extra sludge to be applied. On calcareous soils > pH 7 Guideline Zn≡ values are 228.6 and 124.4 percent of R and M values respectively, therefore the proposed M value would require a reduction in sludge Zn≡ applied to calcareous soils of approximately 1/5th.

Cd, Pb, Cr, As and Hg concentrations in soils

As soil concentration limits of Cd, Pb, Cr, As and Hg are based on 'total' values and are the same for both calcareous and noncalcareous soils in Guideline and in the EC proposal for a directive comparison is more straightforward, but still subject to the assumption that $mg.kg^{-1}$ = $mg.l^{-1}$ in mineral soils.

Cd. Maximum soil Cd concentration of 3.5 $mg.l^{-1}$ recommended in the Guidelines is equivalent to 350 and 116.6 percent of R and M values respectively. The M value being 85.7 percent of that allowed by the Guidelines.

Pb. Maximum soil Pb concentration of 550 $mg.l^{-1}$ is equivalent to 1100 and 550 percent of R and M values respectively. M value being only 18 percent of Guideline value.

Cr, As and Hg. Maximum soil Cr, As and Hg concentrations recommended in the Guidelines are 600, 10 and 1 $mg.l^{-1}$ being 1200, 50 and 50 percent of R value respectively. No M values are specified for Cr, As and Hg.

Comment

It is difficult to make valid and meaningful comparisons between the maximum concentrations of metals in soils, to which sludge is applied, recommended in the Guidelines and M and R values stated in the EC proposal for a directive.

The Guidelines do not specify soil concentrations in permanent pasture land but the EC proposals apply to arable and grassland. The Guidelines recommend different values for pH ranges and soil type, whereas the EC proposal specifies one minimum pH.

The above comparisons are also limited by the necessary assumptions that a) in the laboratory, where soil concentrations are determined, $mg.l^{-1} = mg.kg^{-1}$; and b) the generalisation that 'extractable' concentrations of Zn, Cu and Ni and hence Zn≡ are 50 percent of 'total' concentrations.

Subject to these provisos it is concluded that on most mineral soils proposed Mandatory limits would:-

a) Allow 50 percent higher Zn≡ concentration in noncalcareous arable soils of pH 6.5 and over than recommended in the Guidelines;

b) Allow 4/5 of the Zn≡ concentration currently allowed in calcareous arable soils > pH 7 than allowed by the Guidelines;

c) Allow 85.7 percent and 18.2 percent of Cd and Pb concentrations in arable soils recommended by the Guidelines.

The restrictions on Pb and to a lesser extent Cd concentrations in soil will particularly affect spreading of sludges from industrial areas. If and when brought into effect M concentration values will immediately eliminate from further spreading on land in some areas which have received Pb and Cd rich sludges in previous years.

EC recommended concentrations are likely to be met in many rural areas and provide useful targets to be worked for on 'clean' land which may receive sludge in the future.

Proposed M values allow higher Zn≡ concentrations than implied by the most recent MAFF advice to farmers. Further comparisons of EC proposal values with Guideline or MAFF recommendations will be possible when sampling depths required by the EC directive are known.[19, 20]

Other limiting factors

Nitrogen

Nitrogen requirement of the crop following sludge application has often been the first limiting factor when liquid sludges have been applied to agricultural land.

Neither the 1981 Guidelines nor the EC proposal stipulate limit values. The EC proposal does state a 'rule' that "The sludge shall be spread in a manner which fulfils the needs of the plants and preserves the quality of the soil and of surface and ground water."[21] A requirement in keeping with recommendations made in the Guidelines.[22]

pH of receiving soils

Recommended limits given in the Guidelines are for arable soils of pH 6.5 and above and for grassland of pH 6 and above, but then recommend "Advice should be sought from agricultural advisers regarding the application to sewage sludge to soil with pH lower than these values."[23] By this means controlled utilisation/disposal of suitable sludges is allowed in areas where, because of soil origin, topography,rainfall, leaching or other factors, soils are frequently below pH 6.5 or 6.0.

By contrast to this facilitating and permissive approach the proposal for a directive simply directs that "Member States shall ensure that pH values of soil does not fall below six after spreading."[24] An administratively convenient but restrictive control which could lead to serious curtailment of sludge use, changes of treatment or subsidised liming in some RWA areas.[25]

Pathogen Control

It is now necessary to compare the pathogen control practices recommended in the 1981 Guidelines with the corresponding requirements in the proposal for a directive.

Again it should be noticed that whereas the Guideline recommendations apply to all sludge used on agricultural land the proposal for a directive does not apply to sludge from communities with a year-round population of less than 5000 persons.

In contrast to the 13 types of treatment and raw sludge listed with 7 categories of after use in table 7 of the 1981 Guidelines, shown in table 5.4, the proposal for a directive makes provision for 2 types of sludge - stabilised and non-stabilised and three classes of after use, one of which requires special authorisation, as shown in table 6.5.[26]

Points of importance to this study are as follows:

1. Unstabilised sludge may only be used "...if it is immediately injected or worked into the soil."[27] Except in areas suitable for sludge injection, this requirement will increase pressure on RWAs to stabilise sludges used in agriculture.

2. Considerable ambiguity is found in the EC requirement that "Member States shall prohibit the spreading of sludge <u>on crops</u> which would be in <u>direct</u> contact with the sludge and/or are <u>supplied</u> raw to consumers."[28] (my underlining).

Ambiguities: does this requirement apply to:

a) Sludge spread on crops rather than on fields before the crops are sown?

b) If so, does direct mean on the surface of the crop rather than in the soil surrounding the growing crop?

c) Whereas a trichotomy between crops not eaten, eaten cooked, and eaten raw by man seem to have been implied in earlier drafts, the requirement of "...or supplied raw to consumers" may include many vegetable crops e.g. potatoes which require cooking before eating.[29]

Interpretation requires clarification, but if excluding sludge from use on arable land where these vegetable crops requiring cooking are to be grown, this could considerably affect use in some areas.

<u>Grazing delay period</u>

The requirement that "Grassland shall not be grazed and forage crops shall not be harvested for at least six weeks after the application of stabilised sludge,"[30] is considerably longer than the 3 week or 5 week (if milk produced is not pasteurised) delay periods for pathogen control recommended and defended in the 1981 Guidelines.[31]

If adopted the EC harmonised 6 week delay period before grazing will seriously interfere with good husbandry practices in the UK and may lead to serious curtailment of summer use of sludge on grassland and fodder crops.

Use with special authorisation in parks, playgrounds and woodlands is likely to be slight, but does provide a channel for future growth, e.g. in use of woodland and forest areas not open to the public.[32,33]

6.2. Conclusions

Controls stated in the EC proposal for a directive of 8.10.1982 are simpler, more clear-cut but more restrictive than the recommendations contained in the 1981 DOE/NWC Guidelines. An amendment to the proposal for a directive was published on 14th June 1984. Where relevant conclusions are modified to take account of amendments published.

Comparing controls particularly in relation to metal concentrations in sludges disposed by use in agriculture the following conclusions emerge:

1. The omission of sludges from townships of 5,000 persons or less from control by the proposal for a directive will make little difference to current UK practice.[34] Particularly so as Article 2 has now been amended to apply to townships of limited treatment capacity treating throughout the year only domestic effluent.[35]

2. The EC proposal, if and when implemented, will impose via UK legislation mandatory as well as recommended controls on sewage sludge disposal by use in agriculture.

3. Use of sludges will be limited to land maintained at pH 6 or above after application has taken place, whereas the Guidelines make provision for use on land with lower soil pH values. However, article 9 has now been amended to propose, "Sludge shall not be spread on soil with a pH value which will allow excessive mobility of the trace elements."[36] This provision removes the mandatory lower pH limit and is now in keeping with recommendations made in the Guidelines.[37]

4. Mandatory limit values of metal concentrations in sludges used would prohibit the use of some sludges currently applied to UK agricultural land. Particularly Cd and Pb rich sludges derived from industrial towns, cities or conurbations.

5. The limits, if adopted, will however provide RWAs with strong incentives, justification and clear base line concentrations to carry out the necessary changes in trade effluent control.

6. Maximum annual average application rates proposed will allow higher rates of application of Zn, Cu, Ni in sludges than recommended in the Guidelines, allowing up to 4.2, 2.1 or 2.1 times more Zn≡ to be applied to non-calcareous, calcareous or pasture land respectively in an average year.
While application of Cd and Pb in sludges will be limited to 90, and 45 percent, respectively, of Guideline values, reducing application of important but relatively few Cd or Pb rich sludges.

7. Maximum single application rate. If article 5 of the proposal can be interpreted as allowing a single application equivalent to ten times the annual average rate, it is concluded that:
a) Up to 9, 4.5 and 4.5 times as much Zn≡ will be allowed to be applied to non calcareous, calcareous and pasture land by the

proposed mandatory limits than recommended by the Guidelines.

b) 50 percent more Cd but 25 percent less Pb may also be applied.

8. Maximum concentrations of metal elements in agricultural soils. As Mandatory limits apply to all soils of pH 6 or over, or as amended see conclusion 3, whereas Guideline values are for arable soils of >pH 6.5 or >pH 7, M values would appear to allow:

a) Up to 50 percent more Zn≡ on arable soils up to pH 7 and 20 percent less on calcareous arable soils >pH 7, than the Guideline recommendations.

b) The same M soil concentrations would be applicable to pasture soils.

9. Soil concentration conclusions 8a, b and c are, however, limited by the following assumptions:

a) That laboratory soil density is 1, and thus $mg.kg^{-1}$ used in the EC proposal is equivalent to $mg.l^{-1}$ used in the Guidelines and is likely to apply to mineral but not high organic matter soils.

b) That 'extractable' Zn, Cu, Ni and Zn≡ concentrations are equivalent to 50 percent of 'total' concentrations.

c) That soil sampling depths required by the EC directive if adopted will be the same as those recommended by MAFF and the Guidelines.

It is further concluded that:

10. If adopted the Mandatory limit values on concentrations of Zn, Cu, Ni, Cd and Pb in sludges will provide the major constraints on present sludge disposal practice.

11. But where these constraints can be met the EC proposal will in most cases allow more sludge to be applied to agricultural land than previously, particularly where currently limited by the Zn≡ recommendations of the UK Guidelines.

12. Reductions of metals entering sewers will be required particularly of Cd and Pb. The mandatory limits on Pb concentrations in the four controls reviewed being relatively the most severe. But this finding must be seen against the comment of the RCEP who in their report 'Lead in the Environment' were able to "... welcome the intention behind this proposed directive and note that it is consistent with recommendations 63 and 64 of our Seventh Report."[38]

13. Reductions of Cd and Pb inputs may bring about long term benefits.

14. In the short term one of the more serious effects of the Mandatory limits on concentrations in soils, if and when implemented, will be to prevent further applications on land which, though eligible to receive sludge under Guideline recommendations, will have Cd and/or Pb soil concentrations at or above stipulated EC values. Use of less or non contaminated land probably adding to transport costs.

15. Sludge applications are also likely to be curtailed or practices changed in some areas by the proposed constraints on pH and by pathogen control. The pH constraint having now been amended to be less prohibitive, see conclusion 3. Similarly Article 8 has been amended so that the spreading of sludge on 'Woodland' areas is no longer prohibited, but is still subject to special authorisation. Spreading of sewage on parks and playgrounds is now completely prohibited.[39]

16. The minimum grazing delay period of 6 weeks after sludge application being quite unacceptable on good husbandry grounds virtually eliminates the valuable opportunities provided for late spring and summer applications of stabilised sludges to grassland.

17. Providing this last difficulty can be overcome the proposed EC

directive, along with the monitoring and information collation required could, because found acceptable in other European countries, increase the confidence of farmers receiving sludge in the control framework within which operations are carried out.

18. In view of the foregoing comparison of controls on sewage sludge disposal by use on agricultural land, as recommended in the DOE/NWC 1981 Guidelines and those in the EC 1982 proposal for a directive, and as now amended in June 1984, it is now necessary and urgent to examine the potential for reduction of metal concentrations, particularly of Cd and Pb, but also of Zn, Cu, and Ni to which mandatory controls apply, and where opportune Cr.

19. In view of the finding that except in areas suitable for sludge injection, Article 7 of the proposal will increase pressure on RWAs to stabilise sludges used in agriculture it is now necessary to examine what effect stabilisation of sewage sludges may have on sludge metal concentrations and the implications of these findings for economic disposal of sewage sludges, and for trade effluent control.

TABLE 6.1

Comparison of limit values specified in an EC proposal for a directive on the use of sewage sludge in agriculture and those recommended in the DOE/NWC 1981 Guidelines (a, b)

Max. values of metal-element concentrations in sludge for use in agriculture. (mg.kg.$^{-1}$ Dry Matter)

Column	A	B	C	D	E
1982 Proposed element	Directive (Annex 1A)		1981 Guide-lines	Comparison of Conc.	
	R	M	G	G/R %	G/M %
Zn	2500	3000			
Cu	1000	1500			
Ni	300	400			
Cd	20	40	20(a)	100(a)	50(a)
Pb	750	1000	2000(b)	266.6(b)	200(b)
Cr	750	-			
As	-	-			
Hg	16	-			
F	-	-	3500(b)		

Notes:

a. OJC.264 pps 3-7, 8th October 1982.
b. DOE/NWC.STC.20 June 1981.

G. 1981 Guideline values (as shown on pps. 55-56 of STC.20 1981).

R. Recommended in Annex 1A of OJC.264, 8.10.82.

M. Mandatory in Annex 1A of OJC. 264, 8.10.82.

a When supplied to general public (Garden and Allotment Use)

b When sludge is applied to grassland.

TABLE 6.2

Comparison of limit values specified in an EC proposal for a directive on the use of sewage sludge in agriculture and those recommended in the DOE/NWC 1981 Guidelines

Maximum average annual application rate

Proposed Directive Annex 1B Annual average of 10yrs. (c)			1981 Guideline(G) equivalent (d)		Comparison of Rates			
			30 yr. Max. ÷ 30		G/R		G/M	
Constraint Element	R	M	Ra	(Rb)	a	(b)	a	(b)
Unit	$kg.ha^{-1}yr.$				%		%	
Zn	25	30	18.6	(37.3)	74.4	(148.8)	62.2	(124.4)
Cu	10	12	9.3	(18.6)	93.3	(186.6)	77.7	(155.5)
Ni	2	3	2.3	(4.6)	116.6	(233.3)	76.6	(153.3)
Cd	0.10	0.15	0.16	(e)	116.6		111.1	
Pb	10	15	33.3	(e)	333.3		222.2	
Cr	10		33.3	(e)	333.3			
As	0.35		0.3	(e)	95.24			
Hg	0.40		0.06	(e)	16.6			
			(f)					
Zn≡ (g)	61	78	18.6	(37.3)	30.6	(61.2)	23.9	(46.9)

Notes:

- G Guideline equivalent 30 yr. Max.application ÷ 30.STC20, 1981 p.52.
- R Recommended.
- M Mandatory
- a When applied to non calcareous arable soils
- b When applied to calcareous arable soils > pH7 and permanent pasture ≥pH6.
- c OJC. 264/6 8.10.82 (h).
- d Assuming 'uncontaminated' background levels are as stated in DOE/NWC STC.20 Table 8.
- e As for non calcareous arable soils.
- f Guidelines also include limits on B, Mo, Se and F.
- g Zinc equivalent calculated on the basis of 1 x Zn + 2 x Cu + 8 x Ni as in STC.20 para. 6.32.
- h Amended by OJC 154/11.14.6.84. See also conclusion 3.

TABLE 6.3

Comparison of limit values specified in an EC proposal for a directive on the use of sewage sludge in agriculture and those recommended in the DOE/NWC 1981 Guidelines

Maximum single application rate

Proposed directive Max. single application rate Annual average x 10 (c)			Guideline(G) equivalent 30 yrs. Max ÷ 5 (d)		Comparison of rates			
					G/R		G/M	
Constraint Element Unit	R kg.ha^{-1}	M year	Ra	(Rb)	a %	(b)	a %	(b)
Zn	250	300	112	(224)	44.8	(89.6)	37.$\dot{3}$	(74.$\dot{6}$)
Cu	100	120	56	(112)	56	(112)	46.$\dot{6}$	(93.3)
Ni	20	30	14	(28)	70	(140)	46.$\dot{6}$	(93.$\dot{3}$)
Cd	1	1.5	1	e	100		66.$\dot{6}$	
Pb	100	150	200	e	200		133.$\dot{3}$	
Cr	100		200	e	200			
As	3.5		2	e	57.1			
Hg	4.0		0.4	e	10			
			f					
Zn ≡ (g)	610	780	112	224	18.4	(36.7)	14.1	(28.3)

Notes:

- G Guideline equivalent 30 year max. application ÷ 5. STC20, 1981 para. 6.21.
- R Recommended
- M Mandatory
- a When applied to non calcareous arable soils
- b When applied to calcareous arable soils >pH 7 and permanent pasture ≥pH 6. (h)
- c OJC 264/4 Article 5 and Annex 1B. 8.10.82.
- d Assuming uncontaminated background levels are as stated in STC 20, table 8.
- e As for non calcareous arable soils.
- f Guidelines also include limits on B, Mo, Se and F.
- g Zinc equivalent calculated on the basis of Zn x 1 + Cu x 2 + Ni x 8.
- h Amended by OJC 154/11 14.6.84. See also Conclusion 3.

TABLE 6.4

Comparison of limit values specified in an EC proposal for a directive on the use of sewage sludge in agriculture and those recommended in the DOE/NWC 1981 Guidelines

Max. concentrations of metal elements in agricultural soil to which sewage sludge is applied

Constraint Element Unit	Proposed Directive. R(c) mg.kg^{-1}	M(c)	1981 Guidelines G. Ra mg.l^{-1}	(Rb)	Comparison when mgl^{-1}=mg.kg^{-1} (d) G/R	G/M
Zn	150	300	280^{x}	(560)^{x}	NC	NC
Cu	50	100	140^{x}	(280)^{x}	NC	NC
Ni	30	50	35^{x}	(70)^{x}	NC	NC
Cd	1	3	3.5	c	350	116.$\dot{6}$
Pb	50	100	550	e	1100	550
Cr	50		600	e	1200	
As	20		10	e	50	
Hg	2		1	e	50	
Zn≡	490	900	280^{x}	(560)^{x}	NC	NC
Zn≡	If 'extractable' = 50% of 'total'		560	(1120)	114.3(228.6)	62.2(124.4)

Notes:

G Guideline recommended values for arable soils only. STC.20.1981 p.53.
R Recommended.
M Mandatory.
a When applied to non calcareous arable soils.
b When applied to calcareous arable soils>pH 7.
c Values apply to all soils pH 6 and over. OJC.264 Annex 1c.1982 (h).
d "Most mineral soils...have a density of approximately 1.0 ..." STC.20 1981 p.50.
e As for non calcareous arable soils.
f Guidelines also include limits on B, Mo, Se and F.
g Zn≡ calculated on the basis Zn x 1 + Cu x 2 + Ni x 8. STC.20. 1981 para. 6.32.
x 'Extractable' concentrations.
NC Not directly comparable.
h Amended by OJC.154/11 14.6.84. See also conclusion 3.

TABLE 6.5.

Opportunities and constraints on the use of sewage sludge in agriculture, with respect to pathogen control, as allowed by E.C. proposal for a Directive published 8.10.82, as interpreted from articles 1, 2, 7 & 8.

Category	Sludge type	Crops not in direct contact with sludge and/or not supplied raw to consumers	Grassland and forage crops	Parks, Play-grounds and Woodlands	Crops in direct contact with sludge and/or supplied raw to consumers
1	Stabilised (a)	+	+ R	x S	x
2	Non-stabilised (b)	+ T	+ T	x S	x
3	Urban or similar (c) treated effluents from communities 5000p. throughout the year	Not controlled by the proposal for a directive			

Notes:

a "Stabilized sludge means sludge which has undergone biological or chemical treatment or long term storage." OJC.264 p.4 Article 1.

b Sludge not in category 1 or 3.

c OJC.264. 8.10.82 p.4 Article 2.

R "Grassland shall not be grazed and forage crops shall not be harvested for at least 6 weeks after the application of stabilized sludge." Article 8.2.

XS "Member states shall prohibit the application of sludge in parks, playgrounds and woodlands save where special reasons." Article 8.1. Amended to complete prohibition in parks and playgrounds. OJC.154/10 14.6.84.

X "Member states shall prohibit the spreading of sludge on crops which would be in direct contact with the sludge and/or are supplied raw to consumers." Article 8.3.

\+ Use not prohibited. Article 7.

+T "Non-stabilized sludge may be used only if it is immediately injected or worked into the soil." Article 7.