RESEARCH ARTICLE OPEN ACCESS

Effect Of Sewage Farming On Ground Water

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ABSTRACT
This chapter provides background information on treated effluent discharges and the associated risks to groundwater. The emphasis is on discharges to constructed sub-surface drainage fields, but the general principles can also be applied to discharges to the land surface (for example, infiltration sustainable drainage systems). A classification of the effluent types (domestic or trade) covered by this guidance is given.EPR has allowed us to look again at our definition of 'domestic sewage' and change to the one based on the Urban Waste Water Treatment Directive (UWWTD) definition and in the case of the Water Industry Act 1991 (WIA), case law. Domestic sewage includes wastes arising from normal domestic activities wherever these are carried out. Therefore, sewage from schools, restaurants, takeaways, holiday parks and nursing homes is domestic. Determining whether a discharge contains trade effluent should not involve a detailed audit of the substances used by an applicant on a particular site. If the effluent is broadly of a domestic nature it is domestic sewage. If a significant proportion of the waste generated by a commercial enterprise is different from that found in a normal home then it becomes a mixture of domestic sewage and trade effluent.
KEYWORDS: Effect, Sewage Farming, Ground Water, Septic-Tank Effluent , Ground-Water ,Quality

I. INTRODUCTION

1.1 Liquid effluent disposal

The main components of a liquid effluent disposal system to the sub-surface are shown on Figure 1.1 and are summarised below:

- Collection and treatment of raw effluent. Examples of systems for domestic sewage can include septic tanks (Primary treatment) and additional treatment via a package treatment plants (Secondary treatment). In some cases, the effluent may also be routed through a reed bed and undergo Tertiary treatment before discharge;
- Collection and distribution of treated effluent to the infiltration system.
- Discharge to ground via the infiltration system or drainage field.

The drainage field is an important component of the system, as significant attenuation processes can take place there and in the underlying unsaturated strata.

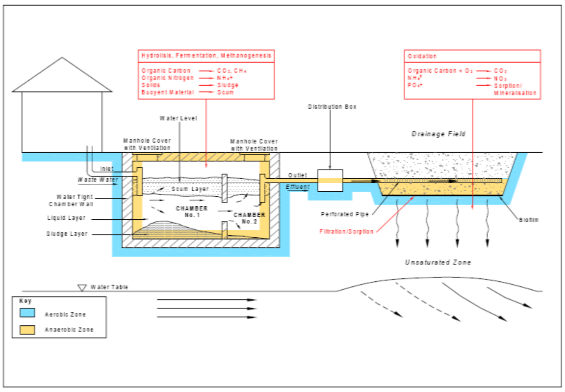

Figure 1.1 Septic tank system and discharge to an infiltration system

1.2 Effluent treatment

Liquid effluent discharges to infiltration systems occur largely from septic tank systems, package treatment plants, and sewage treatment works. Non-sewage related effluents (for example, from the treatment of industrial wastewaters), may come from a variety of other treatment plants. Further information on sewage treatment systems is provided. A description of the range of treatment processes and systems for other wastewaters is beyond the scope of this guidance.

1.3Liquid effluent composition

The chemical composition of liquid effluent will depend on the effluent source (for example, domestic or trade), the type of treatment system and the state/condition of the treatment system. Sewage effluent is likely to be more consistent than the potentially large range in compositions from the treatment of other wastewaters (such as trade effluent). Most of the following subsection is focussed on treated sewage effluent.

1.4.1 Sewage effluent

A summary of the main chemical and biological substances of concern is given. The chemical composition of a typical septic tank and package treatment plant is given in Table 2.3. Non-domestic sources of sewage effluent may have distinct characteristics that produce higher or lower strength effluent. The effluent from a sewage treatment works will usually be of a higher quality as a result of a higher standard of treatment.

1.4.2 Trade effluent

The chemical composition of trade effluent will be dependent on the activities which produce waste water and the type of treatment process. Some trade effluents may also vary though the year. Therefore its chemical composition will need to be characterised (for example, minimum, average, maximum or 90 / 95%-ile concentrations) by chemical analysis to determine the absence or presence of hazardous substances and non-hazardous pollutants. In our guidance notes for the application form for a permit, a list is provided of the substances for analysis that should be considered, but this list is not exhaustive and the analysis should be based on knowledge of the activities feeding the waste water stream.

1.5 Infiltration systems

Requirements for the design and installation of drainage fields and infiltration systems for domestic properties are set out in BS6297:2007 (+ A1:2008). Further guidance is contained in Part H of the Building Regulations (2002 edition)8 on drainage and waste disposal. Infiltration systems typically comprise a network of below surface perforated pipes which sit in gravel filled trenches. Unless properly designed and operated, infiltration systems can cause excess hydraulic loading.

This may mean:

- The underlying ground is unable to accept the rate of discharge, resulting in surface breakouts;
- Rapid travel times through the unsaturated zone or by-pass flow resulting in limited attenuation of the effluent;
- Groundwater mounding below the drainage field, resulting in a reduced unsaturated zone thickness.

To minimize the risk to groundwater you should ensure that the size of the drainage field is appropriate to the rate of discharge and the infiltration capacity of the ground. In addition, you should ascertain that there is a sufficient depth to the water table (minimum of 1.2 m) to ensure attenuation of the effluent. You should also consider the proximity to receptors such as water supplies and surface water courses. Good practice for the location of drainage fields is set out in BS 6297:2007 (+ A1:2008) Code of practice for the design and installation of drainage fields for use in wastewater treatment - Amended 2008 and Pollution Prevention Guidelines Note 4 (PPG4 Environment Agency/SEPA/EHS 2001 update 2006). The Building Regulations (Part H 2002) also prescribe certain criteria. Key requirements to protect water arising from these standards are summarised.

Both BS6297:2007 (+ A1:2008) and the Building Regulations (Part H 2002; 2010) require you to carry out a percolation test to determine whether the rate of percolation is suitable. If it is too low the effluent will not infiltrate, if it is too high infiltration will be too rapid and important attenuation mechanisms will not occur.

Drainage fields are frequently located at a lower level than the building/treatment plant that they serve so that drainage is gravity driven. However, surface or groundwater flooding of drainage fields and tanks is a potential problem and generally, you should not locate them in areas that are known to suffer from flooding. Flooding of the tank and/or drainage field (but not the property it serves) will mean that the contents will result in environmental pollution and human health issues. The drainage field may also need occasional maintenance to remove any clogging as a result of biofouling and in the long-term may need to be replaced when performance falls. Drainage fields with subsoil infiltration systems are typically maintained as grassed areas to prevent penetration of the distribution pipes by the roots of larger plants (shrubs and trees).

II. THE ACTIVITY AND ITS SETTING

This chapter outlines the information that you will need to provide as part of a detailed quantitative risk assessment. In summary you will need to:

- Characterize the discharge in terms of quantity and quality based on adequate understanding of the discharge mechanisms and infrastructure (for example, infiltration system layout), the volumes, concentrations and chemical nature of the discharge.

- Demonstrate a conceptual understanding of the relationship of the discharge, pathways and receptors within their wider hydrogeological setting including the likely fate and transport processes, particularly within the unsaturated zone.
- Describe the local soil conditions and hydrogeology, where necessary supported by site investigations; and in particular describe the strata (soils, rock) below the
- drainage field, the depth to water table and the permeability of the strata (for example, from percolation tests).

You should refer to our H1 Environmental Risk Assessment Annex (j) Groundwater (Environment Agency, 2011a) for the key principles in describing an activity and its potential impact on groundwater. This section provides further details on the information that will be needed to support a groundwater risk assessment(Table 3.2).

If we are not confident in the description of the activity, its site setting and the conceptual model, we will need to be conservative in how we review your environmental permit application. This could lead us to ask you to undertake further work or refuse your application. The amount of work and the sophistication of the risk assessment will depend on the nature of the discharge and the environmental sensitivity of the site.

Table 3.1 Guidance on data requirements

Discharge	Volume m^3/d	Data requirements for assessment (refer also to Table D1 (Appendix D) for a description of basic, extended and comprehensive data needs)
Sewage effluent	0 - 15	Basic information. For discharges that do not comply with the exemption criteria or those that fail our in-house risk assessment, you may need to supply an extended set of information
	>15 - <50	Extended or comprehensive set of information may be needed
	>50	Comprehensive set of information needed
Trade Effluent	0 - 25	Extended or comprehensive set of information may be needed
	>25	Comprehensive set of information needed
Combined sewage overflows (CSO) and Emergency overflows (EO)		Extended or comprehensive set of information may be needed

3.1 Construction, operation and management

We will need you to provide the following information in support of your application and to demonstrate that the necessary construction or engineering will be or has been put in place to control the discharge:

- Details of the type and source of effluent (for example, domestic sewage);
- Details of the discharge rate, frequency and duration;
- Details of the treatment process;
- Details (plans and cross sections) of the infiltration system;
- Results of the percolation tests;
- A description of how the quality of the construction or engineering has been or is to be controlled. Examples of quality controls include Building Regulations certificates;
- A detail of proposed operation and maintenance, to ensure the system continues to perform to design (for example, de-sludging of septic tanks, servicing of package sewage treatment plants, etc.).

III. RISK ASSESSMENT APPROACH

This chapter provides guidance on the steps in the evaluation of the risks posed by the proposed discharge to groundwater (and the wider water environment). The objective of the risk assessment is to ensure that the proposed discharge meets the requirements of EPR to prevent inputs of hazardous substances to groundwater and to avoid pollution from nonhazardous pollutants.

Definitions of the main terms used in this section are given. Before using this section you should consult the guidance provided in Chapter 4 of our main groundwater risk assessment guidance (Annex (j) Groundwater, Environment Agency 2011a).

This main guidance also describes how a conceptual model should be formulated and its importance in any risk assessment. It is assumed in the following paragraphs that basic requirements for water protection as set out in GP3 (Environment Agency 2006-2008.

4.1 Risk assessment approach

In undertaking the risk assessment we advise the following tiered approach as this will avoid unnecessary effort:

- Risk screening
- Generic quantitative risk assessment
- Detailed quantitative risk assessment.

The outcome from each stage will be one of the following:

a) There is sufficient information to determine that the discharge does not present an unacceptable risk.

b) Further assessment is required (by moving to the next assessment tier with additional information) or alternatively, modifications need to be made to the activity such as improved treatment of the effluent or changes to the drainage field or its location.
c) The activity presents an unacceptable risk and a permit will not be granted.

This tiered approach to risk assessment should ensure that the effort required is consistent with the complexity of the activity and its setting. The assessment should be as simple as these factors allow and summarised in the conceptual model. As part of the risk assessment process you will need to set one or more compliance points and to derive an appropriate compliance value.

Compliance points and compliance values are defined and are described. Exceedance of the compliance value would indicate that the discharge is not acceptable and that additional treatment or modifications to the drainage system will be required before we would grant a permit.

The objectives of risk assessment, in terms of regulatory requirements, are noted. For non-hazardous pollutants the requirement is to assess whether pollution will take place. This is described in the rest of this chapter and follows our standard approach to the assessment of groundwater pollution (see also the Introduction text on hazardous substances and non-hazardous pollutants).

4.2 Risk screening

Risk screening (RS) may identify that the proposed discharge is acceptable and a permit can be granted or that the activity needs more detailed assessment (for example, taking it to the next stage – a generic quantitative risk assessment). Risk screening should not be confused with an assessment as to whether an activity may be excluded from the definition of 'groundwater activity' under the EPR.

You will have reached the stage of risk screening because such exclusions cannot be applied and some level of assessment is needed. For treated sewage effluent discharges up to 15 m3/day we will already have undertaken a screening assessment for you based on the information supplied with your application. From this we will identify whether we require you to undertake any further assessment. For all other discharges (see Introduction) we will want you to include a risk screening section in your own risk assessment which considers factors such as those set out below:

4.2.1 Examples of factors as basis of risk screening

From an initial risk screening of the site, can the discharge be shown to be acceptable based on one or more of the following:

• The discharge has concentrations of hazardous substances sufficiently close to our relevant ‘minimum reporting value’ (MRV: usually a detection level or agreed
minimum practical analytical value) or the natural background level in groundwater (whichever is the higher concentration) for an assessment to be made at a qualitative level that their input will be prevented by virtue of available attenuation processes in the unsaturated zone and/or immediate dilution at the water table13.

- The discharge has concentrations of non-hazardous pollutants less than the relevant environmental standard or natural background level applicable to the receiving groundwater.
- The presence of unproductive drift or unproductive bedrock strata (there are no aquifers beneath or near the activity – Unproductive Strata) and remoteness from surface waters means that risk to any identified groundwater dependent receptor is very low.
- The volume or hydraulic loading rate of the discharge is very small such that only minimal dilution in underlying groundwater will be required to avoid pollution by nonhazardous pollutants.

The basic information required for a screening assessment would include: the size of discharge; the results of percolation tests; depth to water table; geology (soils and strata descriptions and thicknesses from logs from excavations) and details of/proximity to receptors. For existing disposal activities then groundwater monitoring data may be used to support the assessment.

This will involve comparison of groundwater quality data in down-gradient boreholes with the relevant environmental standard or MRV. If there are no exceedances then provided the monitoring data are representative then it would be reasonable to conclude that attenuation and dilution is sufficient to reduce the concentrations of hazardous substances and/or non-hazardous pollutants to acceptable levels.

More detailed quantitative risk assessment will involve an assessment of whether attenuation and dilution will reduce the concentrations of hazardous substances and non-hazardous pollutants to acceptable levels.

4.3 Generic quantitative risk assessment

A generic quantitative risk assessment (GQRA) is used when the source, pathway and receptor terms are sufficiently well understood that they can be confidently represented by conservative assumptions. This includes activities where the source can be well defined and the known properties of the soil are easily sufficient to reduce risks to underlying groundwater to low regardless of uncertainties in the thicknesses and properties of underlying strata.

Basic quantitative risk assessments will typically use these conservative assumptions as input values to relatively simple scoping calculations of for example, dilution, unretarded and retarded travel time, and attenuation factor. Some basic equations and examples are presented.

4.4 Detailed quantitative risk assessment

Detailed quantitative risk assessments (DQRA) should be carried out where a potential risk has been identified from the generic risk assessment based on simple calculations and conservative assumptions. A detailed quantitative risk assessment will require more detailed site specific information supported by investigations and typically use a probabilistic modelling approach to assess the impact of uncertainties in input data. They may also be needed where the quantity and quality of the activity's discharge may change significantly through time (as potentially the case for trade effluent discharges).

4.5 Compliance points and compliance values

As part of the risk assessment process you will need to set one or more compliance points and to derive an appropriate compliance value. Compliance points and compliance values are defined. For discharges to the ground, the following compliance points should be considered and shown in Figure 4.1.

For **hazardous substances**:

- Groundwater at the point of entry into the saturated zone immediately below the infiltration field. Or, where borehole monitoring is necessary to validate the assessment:
- As near as practically possible to the point of entry into the saturated zone, if necessary further down-gradient at, or as near as possible to, the boundary of the infiltration field.

The aim is to account only for the instant dilution that occurs as the discharge comes into contact with the groundwater but not attenuation in the saturated zone or dilution by groundwater flow below or outside the mixing zone.

For **non-hazardous pollutants**:

- An existing water use (for example, abstraction borehole, spring, wetland, stream or river) or a suitable point between this receptor and the discharge along the contaminant pathway. Or, where it is the groundwater resource rather than defined receptors at risk:
- The distance to the compliance point will need to take account the environmental sensitivity of the aquifer. The receptor in this case would be a theoretical abstraction borehole at a point not exceeding 50 metres from the boundary of the discharge (in a Principal or strategically important Secondary Aquifer) or a point up to 250 metres from the boundary of the discharge (in a Secondary Aquifer of local importance).

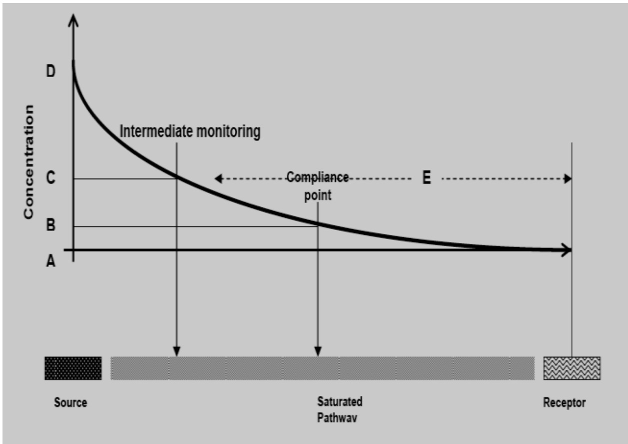

Figure 4.1 Compliance points

A = Environmental standard necessary to protect the **receptor**.

B = Compliance value at a **compliance point**, set to ensure the environmental standard at the receptor is/will be met (may be physical, such as the actual **monitoring point** or a virtual point used for model prediction).

C = Quality measurement at **intermediate monitoring points** to provide advance information.

D = Discharge source concentration.

E = Possible range of compliance point locations according to site specific conditions – could be at the receptor itself, or some other point along the pathway.

Exceedance of the compliance value indicates that the discharge is not acceptable and that additional treatment or modifications to the drainage system will be required before we can grant a permit. For further guidance on compliance points please refer to our H1 Environmental Risk Assessment *Annex (j) Groundwater* (Environment Agency, 2011a)

IV. MONITORING

This chapter describes specific elements of monitoring related to discharges of treated effluent for a newly granted or existing environmental permit. Investigative monitoring may be required during the permit application and risk assessment process.

Please refer to 'Investigative Monitoring' for more details.
For more information on monitoring in general please refer to our H1 Environmental Risk Assessment *Annex (j) Groundwater* (Environment Agency 2011a) where we describe the need and benefits of monitoring and the required approach, with links to relevant guidance. The decision for whether or not you will need to install investigative and/or post-permit monitoring will be assessed on a site specific basis.

5.1 Ongoing monitoring of the activity

We need to make sure that, if permitted, the activity is carried out within any limits assumed in the risk assessment. Monitoring may comprise one or more of the following:

- Checks and records;
- Measurement of the discharge rate and effluent quality;
- Measurement of groundwater levels and groundwater quality in boreholes located around the infiltration system;
- Measurement of water quality in related receptors.

Under the current environmental permitting 'charging for discharges' scheme we will normally undertake essential monitoring of the effluent and groundwater (where and if existing boreholes are available) for the purposes of checking compliance with the permit – unless you have entered into an Operator Self Monitoring arrangement whereby you take over some of this responsibility. However, in all cases we will require you to provide the necessary infrastructure and access arrangements. You will normally be responsible for conducting measurements of discharge flow rate if this is required by the permit.

You should check our EP charging scheme pages for further information. The extent of monitoring required will be site specific and depend on the size and type of discharge and the sensitivity of the environmental setting.

For smaller discharges, monitoring may be limited to checks and records; for larger discharges (typically greater than 50 m3/day) or where the site is in a particularly sensitive location then we may require monitoring of groundwater levels and quality. We would advise you to discuss this with us at an early stage as this will influence the scope of the risk assessment.

5.1.1 Effluent monitoring

For treated sewage effluent the parameter suite should typically include ammonium and total inorganic nitrogen. For larger discharges, you should set out the recommendations for monitoring of effluent discharge rate and quality including the frequency of measurement and which parameters will be measured.

5.1.2 Recommendations

The proposals should include recommendations for essential monitoring of groundwater. This requires careful planning, usually on a case-by-case basis, to determine parameters to be measured or sampled and analysed, frequency of measurement / sampling and location of monitoring points.

Reference should be made to the conceptual model when designing the monitoring system. For more detail on the sampling of groundwater please refer to: British Standard BS ISO 5667-11:2009 (Guidance on Sampling of Groundwaters). In line with, European Guidance (EC, 2007 – CIS No 17), we recommend that you consider the following points when proposing a groundwater monitoring programme:

- Up-gradient and / or background monitoring: It may be necessary to report on the unaffected / background situation in the subsurface either before a new activity is set up or up-gradient of an existing source of contamination. For the larger discharges, upgradient or compliance monitoring should be outside the zone of influence (that is away from any potential groundwater mounding).
- Monitoring intervals (frequency) should take into account the behaviour (for example, travel times) of the known pollutants and their degradation products.
- Construction (technical) characteristics of the monitoring wells and the depth of monitoring within each observation well should be dependent on the nature of the input and on the seasonal water level fluctuation.
- Sampling methods, sample preservation and analysis methods will be dependent on the nature of the input and its expected pollutant concentration. Commercial analytical laboratories can advise on sample preservation and analysis.

V. METHODOLOGY FOR GROUNDWATER QUALITY SURVEY

6.1 Criteria for selection of Bore Wells/Tube Wells/Hand pumps

For selection of groundwater quality survey location the following criteria were kept in mind:

- Drinking water wells;

- Wells closer to polluting sources like industries, urban wastewater drains, garbage dumpsites etc.;
- Wells suspected for natural contaminants like fluoride, iron, arsenic or such pollutants.

6.2 Sample collection, transport, preservation and analysis

Samples were collected from one of the following three types of wells:

i) Open dug wells

In use for domestic or irrigation water supply, ii) *Tube wells* fitted with a hand pump or a power-driven pump for domestic water supply or irrigation; iii) *Hand Pumps*, used for drinking. Open dug wells, which are not in use or have been abandoned, were not used for sampling.

For collection of samples a weighted sample bottle or sampler was used to collect sample from an open well. Samples from the production tube were collected after running the well for about 5 minutes. For bacteriological samples, when collected from tube wells/hand pump, the spout/outlet of the source was sterilized under flame by spirit lamp before collection of sample in the container. From open wells the samples were collected directly in to the pre-sterilized glass bottles.

The samples were transported to the laboratory. The samples were analyzed immediately for the parameters like Coliform, BOD, COD and nutrients. Other parameters were analyzed within a week time. Total twenty five ground water samples from each metropolitan cities were collected each during pre-monsoon (June 2003) and post-monsoon (December 2003) seasons from various abstraction sources at various depths covering extensively populated area, commercial, industrial, agricultural and residential colonies so as to obtain a good aerial and vertical representation and preserved by adding an appropriate reagents as and when required.

6.3 Sampling Locations

The groundwater quality survey locations were chosen (dug/open wells, tube well, bore well etc.) so that they depict the influence (if any) of the prevailing anthropogenic activity as well as industrial activity of the Metro city limit area. The groundwater survey covers mainly 18 dug wells, 42 tube wells, 34 bore wells, 109 hand pumps and others one well totaling to 204 groundwater sampling locations as presented in Table 6.1

Table.6.1 Groundwater monitoring in Metropolitan cities

S. No.	Name of Metro cities	State	DW/ OW	TW	HP	BW	Others	Total
1.	Agra	Uttar Pradesh	-	-	25	-	-	25
2.	Meerut	Uttar Pradesh	-	04	21	-	-	25
3.	Chennai	Tamilnadu	01 (Open Well)	-	24	-	-	25
4.	Coimbatore	Tamilnadu	09 (Open well)	-	-	16	-	25
5.	Ludhiana	Punjab	-	29	-	-	-	29
6.	Lucknow	Uttar Pradesh	-	09	15	-	01	25
7.	Madurai	Tamilnadu	07	-	-	18	-	25
8.	Vijaiwada	Andhra Pradesh	01	-	24	-	-	25
Sub total			**18**	**42**	**109**	**34**	**01**	-
Grand total			**204**					

6.4 Sampling Period in Metropolitan Cities

The sampling was done in pre-monsoon (June) and post-monsoon (December) at all the twenty-five locations of each metropolitan city.

6.4.1 Parameters selection in Metro-cities

The physico-chemical analysis was performed following standard methods. The brief details of analytical methods and equipment used in the study are given in the Table.6.2

Table.6.2 Analytical methods and equipment used in the study

Sl. No.	Parameter	Method	Instruments/Equipment
A.	Physico-chemical		
1.	pH	Electrometric	pH Meter
2.	Conductivity	Electrometric	Conductivity Meter
3.	TDS	Electrometric	Conductivity/TDS Meter
4.	Alkalinity	Titration by H_2SO_4	-
5.	Hardness	Titration by EDTA	-
6.	Chloride	Titration by $AgNO_3$	-
7.	Sulphate	Turbidimetric	Turbidity Meter
8.	Nitrate	Ultraviolet screening	UV-VIS Spectrophotometer
9.	Phosphate	Molybdophosphoric acid	UV-VIS Spectrophotometer
10.	Fluoride	SPADNS	UV-VIS Spectrophotometer
11.	Sodium	Flame emission	Flame Photometer
12.	Potassium	Flame emission	Flame Photometer
13.	Calcium	Titration by EDTA	-
14.	Magnesium	Titration by EDTA	-
15.	Boron	Carmine	UV-VIS Spectrophotometer
16.	BOD	5 days incubation at 20°C followed by titration	BOD Incubator
17.	COD	Digestion followed by titration	COD Digestor
B	Bacteriological		
18.	Total coliform	Multiple tube fermentation technique	Bacteriological Incubator
19.	Faecal coliform		
C.	Heavy Metals		
20.	Iron	Digestion followed by Atomic spectrometry	Atomic Absorption Spectrometer
21.	Manganese		
22.	Copper		
23.	Nickel		
24.	Chromium		
25.	Lead		
26.	Cadmium		
27.	Zinc		
D.	Pesticides and Polynuclear Aromatic Hydrocarbons		
28.	Aldrin	Gas chromatography	Gas Chromatograph with ECD, NPD and FID
29.	DDT		
30.	DDE		
31.	DDD		
32.	A-BHC		
33.	B-BHC		
34.	γ-BHC		
35.	δ-BHC		
36.	Methoxychlor		
37.	Endosulphan		

Indian Standards& WHO Guideline for Drinking Water are given in Table.6.3

Table.6.3 Indian Standards& WHO Guideline for Drinking Water

S. No.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organization (WHO Guideline)
		Desirable Limit	Permissible Limit	Maximum allowable concentration
1	Colour	5 Hazen Units	25 Hazen Units	15 True Colour Units
2	Turbidity	5.0 NTU	10 NTU	5.0 NTU
3	PH	6.5-8.5	No relaxation	6.5-8.5
4	Total Hardness (as $CaCO_3$)	300 mg/L	600 mg/L	500 mg/L
5	Chlorides (as Cl)	250 mg/L	1000 mg/L	250 mg/L
6	Residual Free Chlorine (When Protection against viral infection is required it should be Min 0.5 mg/L)	0.2 mg/L	-	-
7	Dissolved Solids	500 mg/L	2000 mg/L	1000 mg/L
8	Calcium (as Ca)	75 mg/L	200 mg/L	-
9	Sulphate (as SO_4^{2-})	200 mg/L	400 mg/L	400 mg/L
10	Nitrate (as NO_3^-)	45 mg/L	100 mg/L	10 mg/L
11	Fluoride (as F^-)	1.0 mg/L	1.5 mg/L	1.5 mg/L
12	Phenolic Compounds (as C_6H_5OH)	0.001mg/L	0.002 mg/L	-
13	Anionic Detergent (as MBAS)	0.2 mg/L	1.0 mg/L	-
14	Mineral Oil	0. 01 mg/L	0.03 mg/L	-
15	Alkalinity	200 mg/L	600 mg/L	-
16	Boron	1.0 mg/L	5.0 mg/L	-
Micro Pollutants (Heavy Metals & Pesticides)				
17	Zinc (as Zn)	5.0 mg/L	15 mg/L	5.0 mg/L
18	Iron (as Fe)	0.3 mg/L	1.0 mg/L	0.3 mg/L
19	Manganese (as Mn)	0.1 mg/L	0.3 mg/L	0.1 mg/L
20	Copper (as Cu)	0.05 mg/L	1.5 mg/L	1.0 mg/L
21	Arsenic (as As)	0.05 mg/L	No relaxation	0.05 mg/L
22	Cyanide (as CN)	0.05 mg/L	No relaxation	0.1 mg/L
23	Lead (as Pb)	0.05 mg/L	No relaxation	0.05 mg/L
24	Chromium (as Cr^{6+})	0.05 mg/L	No relaxation	0.05 mg/L
25	Aluminium (as Al)	0.03 mg/L	0.2 mg/L	0.2 mg/L
26	Cadmium (as Cd)	0.01 mg/L	No relaxation	0.005 mg/L
27	Selenium (as Se)	0.01 mg/L	No relaxation	0.01 mg/L
28	Mercury (as Hg)	0.001 mg/L	No relaxation	0.001 mg/L
29	Total Pesticides	Absent	0.001 mg/L	-

S. No.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organization, (WHO Guideline)
		Desirable Limit	Permissible Limit	Maximum allowable concentration
1	Sodium	-	-	200 mg/L
2	Aldrin &dieldrin	-	-	0.03 μg/L
3	DDT	-	-	1.0 μg/L
4	Lindane	-	-	3.0 μg/L
5	Methoxychlor	-	-	30.0 μg/L
6	Benzene	-	-	10.0 μg/L
7	Hexachlorobenzene	-	-	0.01 μg/L
8	Pentachlorophenol	-	-	10.0 μg/L

VI. EFFECTS OF SEPTIC-TANK EFFLUENT ON GROUND-WATER QUALITY

Wells and springs were sampled on three occasions to determine if septic-tank effluent has affected ground-water quality. The sites sampled varied from one sampling event to the next, depending on the results of previous analyses.

7.1 Major Inorganic Constituents

Samples collected during the study did not exhibit concentrations of any water-quality constituents that decisively indicated effects of septic-tank effluent. Concentrations of ions such as sulfate, calcium, chloride, and sodium, which are commonly used as indicators of sewage contamination, were typical of uncontaminated ground water.

7.2 Nutrients

The principal nutrients, nitrogen and phosphorus, are potential indicators of
ground-water, septic-tank contamination by effluents (Miller, 1980; p. 190 and table 23). Most of the sampling in the study was focused to determine concentrations of the principal species of nitrogen (organic, ammonia, nitrite, and nitrate) and phosphorus (organic and orthophosphate).

The results of the analyses indicated higher than background concentrations of these nutrients in several of the samples (table 2). Elevated nitrite plus nitrate (1.5 mg/L as N), ammonia (1.3 mg/L as N), and ammonia plus organic nitrogen (1.8 mg/L as N) concentrations were measured in water from spring Wm:O-9. Concentrations of these water-quality constituents were not noticeably elevated in samples from the domestic wells, the other springs, and the surface-water sites sampled in May 1988.

Some of the samples collected in November 1988, however, did indicate a possible effect of nutrients from septic-tank effluent upon ground-water quality. Samples from springs Wm:O-9 and Wm:O-11, and from well Wm:O-12 had slightly elevated concentrations of nitrite plus nitrate (2.7, 2.2, and 1.4 mg/L, as nitrogen, respectively) that may have been due to field-line effluent.

Analyses of May 1989, however, indicated no discernable effect from septic-tank effluent. Although in May 1989, spring Wm:O-9 did have a nitrite plus nitrate concentration of 1.4 mg/L as nitrogen, the data are inconclusive as to whether the slightly elevated concentration of nitrite plus nitrate was due to septic-tank effluent.

The November 1988 analyses of water from well Wm:O-13 revealed somewhat elevated concentrations of ammonia plus organic nitrogen (2.8 mg/L), total phosphorus (1.4 mg/L, as P), and sulfate (150 mg/L, as SO,). These were the highest concentrations of these constituents measured in any of the samples from any of the sites.

7.3 Optical Brighteners

To demonstrate whether or not a hydraulic connection exists between field lines and the springs in the study area, a qualitative dye test for optical brighteners was conducted. Sampling devices consisting of surgical white cotton swabs attached to wire secured to a concrete base were placed in the discharge of the springs.

These swabs were later tested for fluorescence under ultraviolet light (a characteristic of optical brighteners) using methods described by Mull and others (1988). Four optical-brightener sampling devices were placed in the three springs (Wm:O-9, Wm:O-10, and Wm:O-11) at the Williamson County site, and in the spring at the Davidson County site (Dv:F-2) in April 1989.

These devices were retrieved after 3 days. Of the four devices, only the one from spring Wm:O-9 fluoresced under ultraviolet light, indicating the presence of optical brighteners in the discharge. Another device was placed in spring Wm:O-9, and left for 14 days. The second swab also fluoresced, confirming the presence of optical brighteners which are commonly found in septic-tank effluent. Based on the results of this test, a hydraulic connection between field lines and spring Wm:O-9 was shown to exist. Hydraulic connection between field lines and the other springs could not be demonstrated.

7.4 Bacteria

Both fecal coliform and fecal streptococci bacteria are present in the gastrointestinal tract of humans and other warm-blooded animals. The presence of these bacteria in natural water indicates degradation by human or animal waste and may be related to septictank waste. Samples collected in May 1988 from domestic wells Wm:O-7 and Wm:O-8, four surface-water sites, and three springs were analyzed for fecal streptococci and fecal coliform.

Samples collected in May 1989 from the four observation wells, spring Wm:O-9, and domestic well Dv:F-1 also were analyzed for these bacteria. Sample collection and analyses were in accordance with the methods of Britton and Greeson (1987). Results are included in table. Water from the four surface-water sites had fecal streptococci counts ranging from 670 to 3,900 colonies per 100 milliliters (mL) of sample.
Spring Wm:O-11 is located in a cow pasture and is used by cows as a source of drinking water; consequently, its water quality may be influenced not only by septic-tank effluent but also by animal excreta. None of the samples from the three domestic wells contained fecal coliform or fecal streptococci bacteria. Bacterial concentrations in water from the four observation wells ranged from less than 1 to 65 colonies of fecal coliform per 100 mL and from less than 1 to 380 colonies of fecal streptococci per 100 mL. The sample from observation well Wm:O-15 did not contain either fecal coliform or fecal streptococcus bacteria

VII. CONCLUSION

The issues raised in this report urgently need to be The results of analyses for major chemical constituents and nutrients in water from domestic wells, observation wells, and springs do not conclusively show the presence or absence of septic-tank effluent in ground. Concentrations of constituents commonly thought to be a product of effluent from field lines did not greatly exceed concentrations common in natural ground water in the area.

Slightly elevated concentrations of nitrite plus nitrate and total ammonia in spring Wm:O-9 could be the result of septic-tank effluent. Organic substances were not detected, but the absence of such substances in ground water does not demonstrate nor eliminate a possible direct hydraulic connection between the field lines and ground water. Results from these analyses are inconclusive as to whether or not septic-tank effluent is affecting ground-water quality. Bacteria were not detected in any of the three domestic wells sampled for this study.

The highest concentrations of fecal coliform colonies were in water from springs Wm:O-9 and Wm:O-11. Only the results of sampling for optical brighteners gave conclusive evidence that septic-tank effluent is affecting ground-water quality. One of the four springs tested in the study areas contained optical brighteners. This indicated that this spring (Wm:O-9) is hydraulically connected to the septic-tank field lines.

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