Effects of Land Disposal of Solid Wastes on Water Quality

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FOREWORD

This Technical Services information pamphlet is a review and interpretation of current literature on water quality as related to solid waste disposal. It does not in all instances represent the policy of the Solid Wastes Program of the U.S. Public Health Service, but it does attempt a comprehensive review of the literature.

Readers should consider the data and material discussed in the light of their own particular problems. They are urged to seek further advice and assistance from the appropriate local or state agency or from the technical services activity of the Solid Wastes Program in Cincinnati.

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I. INTRODUCTION

Water has always been essential to the growth and development of society. Early man was not concerned about the quality of his water. Today, with a highly developed urban society, we are acutely aware that water supplies are continuously polluted and that action to prevent pollution must be continuous.

The accumulation and disposal of solid waste is another growing problem of urbanization. Solid waste consists of garbage, refuse, and other discarded solid materials including solid waste materials resulting from industrial, commercial, agricultural, and domestic operations. Over 800 million pounds of urban solid wastes,[1] and untold millions of pounds of agricultural and industrial solid wastes, must be disposed of daily. Most of the waste disposed of will be in contact with the ground and, hence, accessible to both ground and surface water. The possible impairment of the water quality by processes associated with solid waste disposal should be considered in the selection of a disposal site.

Background

A few investigations[2-6] have dealt with pollution of water by solid waste disposal. In general, it has been concluded that solid wastes can pollute water, but the interrelationships and factors that determine the extent and degree of pollution are not well defined. More research is needed. In fact, documented instances of such pollution are rare. Thus, we need to summarize our present knowledge in order to develop information relating to water quality from a waste disposal standpoint.

Ground and Surface Water Related to Solid Waste Disposal

Solid wastes consist of putrescible and nonputrescible material, including garbage, rubbish (trash), ashes, incinerator residue, street cleanings, and industrial and agricultural wastes. The majority of solid wastes in untreated or in residual forms, ultimately come in contact with the land in dumps or in sanitary landfills. By simply placing the wastes on or in the ground, we are faced with the possibility of contaminated water. Although documented occurrences of water contamination from refuse disposal sites are few in number,[2,5] controlled studies have documented that such contamination may occur,[2,4-6] and it is probable that many instances go unrecognized.

Enough contamination has occurred so that in some states current regulations prevent the dumping of solid wastes in water, such as lakes, rivers, and gravel pits, or placing it in direct contact with the groundwater table. Under certain conditions, solid wastes can pollute both ground and surface water. That these wastes should never be dumped into water has become a sanitary engineering axiom.

Purpose

The purpose of this report is to provide information relative to water pollution that may be caused by solid waste disposal. Definitions, site descriptions, water quality criteria, potential hazards, case histories, recommendations, and tentative guides are included. This information is designed to give some insight into the problems that may occur and the methods for solving them.

Definitions

Aerobic: Capable of oxidation (organic compounds) by oxygen.

Anaerobic: In the absence of molecular oxygen, capable of oxidizing with an inorganic oxidant (NO_3, SO_4).

Incineration: The process of reducing solid, semi-solid, or gaseous combustible wastes to an inert residue containing little or no combustible material.

Putrescible: Capable of being decomposed by microorganisms with sufficient rapidity to cause nuisances from odors and gases.

Refuse: Putrescible and nonputrescible solid wastes, including garbage, rubbish, ashes, incinerator residue, and street cleanings.

Sanitary Landfill: Disposal of solid wastes on land without creating a nuisance or safety hazard, by utilizing engineering principles in order to confine the wastes to the smallest practical volume and to cover it with a prescribed layer of earth at the conclusion of each day's operation, or more frequently if necessary.

Saturated: Having absorbed all liquid that can be taken up.

Solid Wastes: Garbage, refuse, and other discarded solid materials, including solid wastes materials resulting from industrial, commercial, agricultural, and domestic operations.

II. METHODS OF DISPOSAL

Impairment of water quality by solid wastes may occur when improper land disposal practices are followed. Good judgment and sound engineering practices are essential in site selection. Knowledge of the physical environment of the site is also required.[7,8] It is desirable to minimize the effects of processes that may cause the water to become polluted from refuse. Sanitary landfills by definition minimize these processes.

Land Disposal Methods

The following disposal methods place the burned or unburned solid wastes in contact with the ground, thus making them susceptible to any process by which contaminants can be added to water.

The Open Dump. An open dump is the consolidation of wastes from one or more sources at a central disposal site with little or no management. Some of the problems associated with open dumps are: breeding of disease vectors, air pollution, water pollution, land pollution, land blight, and accident potential.

The Sanitary Landfill. A sanitary landfill is designed and operated to dispose of solid wastes on land without creating a nuisance or a hazard to public health or safety. This kind of landfill utilizes the principles of engineering in order to confine the solid wastes to the smallest practical area, to reduce them to the smallest practical volume, and to cover them with a prescribed layer of earth at the conclusion of each day's operation, or more frequently if necessary. This is the most desirable land disposal method.

Means of Potential Surface and Groundwater Pollution

It has been demonstrated that solid wastes disposal can directly and indirectly contaminate surface water and groundwater supplies.[2, 4, 5, 9, 10] Surface sources of water for leaching in a finished fill include rainfall, runoff, and irrigation. Subsurface sources are high groundwater levels and breaks in water mains and sewers.

Major factors involved in the introduction of contaminants through the use of land disposal sites are[2]: infiltration and percolation, solid wastes decomposition processes, gas production and movement, leaching, groundwater travel and direct runoff.

These factors may also be examined from the standpoint of three basic mechanisms for the contamination of groundwater[2]: direct, horizontal leaching of refuse by groundwater; vertical leaching by percolating water; and transfer by diffusion and convection of gases produced during decomposition.

These mechanisms and factors may be combined at random and work together. Each of the factors is important and may have an effect upon water quality. The retention or spread of any products from these factors and mechanisms is determined by the particular meteorologic, geologic, and hydrologic conditions at the landfill site.[7,8]

Infiltration and percolation. Infiltration and percolation of rainfall and runoff can produce leachates that may cause groundwater contamination.[2] Flooding of surface water and saturation of the solid wastes by this process are also factors that must be considered.

To produce contamination,[2] possible pollutants must have a means of access to an aquifer.

Solid waste decomposition processes. Many factors, such as time, composition, availability of oxygen, temperature, moisture, and salinity, will affect decomposition of solid wastes. Decomposition of the organic constituents by bacterial action results in a broad array of chemical and biochemical products available for potential distribution in a water system.[5]

Gas production and movement. Gas production is closely related to solid wastes decomposition.[2] Aerobic action produces a rise in temperature, water (H_2O), ammonia (NH_3), and carbon dioxide (CO_2), which is heavier than air and remains in the fill. Carbon dioxide and water combine to make carbonic acid (H_2CO_3), which is a very weak acid. The ammonia, which is oxidized from nitrates and from nitrites and water, is always present.

Anaerobic action, through a deficiency in oxygen, produces a rise in temperature and creates ammonia and methane gas.

Leaching and groundwater movement. Three conditions must exist in order to have contamination by the process of leaching and groundwater travel: the site must be over, adjacent to, or in an aquifer; there must be saturation within the fill; leached fluids must be produced, and the leachate must be capable of entering an aquifer.

When leaching does occur, the groundwater in the immediate vicinity of the fill, approximately 1,000 feet downstream,[7] can become polluted and unfit for human and animal consumption, or for industrial and irrigational uses.[7]

Direct runoff. The direct surface runoff of water from a solid waste disposal site may affect water quality. The effect of the runoff will vary according to the source of the water, its quality, the quantity of solid wastes, the site, and the operational conditions.

III. INFLUENCE OF SOLID WASTE DISPOSAL ON WATER QUALITY

Evidence that physical characteristics, biological quality, and chemical composition of surrounding waters are affected by quality and quantity of solid wastes conditions is well known.[2,4,5,7] These factors that govern water quality will be discussed, presuming that the disposed solid wastes are not in direct contact with water.

Physical Characteristics

Physical characteristics of water include turbidity, odor, taste, and color. Turbidity would be initially present in both surface runoff and leachate, but usually would be a problem only in the immediate vicinity of the disposal site. The taste and odor of water contaminated by solid wastes may be impaired under anaerobic conditions where hydrogen sulfide is produced.[7] Color may be present because of the heterogeneous nature of solid wastes, and, in most cases, it would be removed by natural purification processes.

Biological Quality

Biological water quality refers to bacteria present in the water, usually by leaching. Bacteria normally do not persist in underground water in the direction of flow for more than 50 yards, and seemingly important bacteria are seldom found below 4-foot depths, and never below 7 feet, even in highly permeable soil.[7] The pumped recharge of polluted water to underground aquifers has been shown to result in travel of bacteria for less than 1,000 feet.[7]

In a study by Weaver[3] an average of 740,000 coliform bacteria per gram of solid wastes was reported. Leaching from solid wastes may have a high biochemical oxygen demand (BOD). A British study showed the BOD of Leachate in a wet fill to be 5,150 ppm.[2]

Chemical Composition

Solid wastes contain mineral and organic substances in quantities capable of causing gross pollution of underground water supplies.[2] The finer the composition, or grain, and the greater the surface area of the waste material, the heavier will be the potential concentration of chemicals in the leachate.

Chlorides and other inorganics do persist in water and are only reduced in concentration by dilution with unaffected water. Free and saline ammonia also show appreciable increase in water traveling underground, and are slowly oxidized and diluted.[11]

Organic matter in wastes undergoes both aerobic and anaerobic decomposition, thereby producing large volumes of carbon dioxide (CO_2) and methane (CH_4), with small amounts of ammonia (NH_3) and hydrogen sulfide (H_2S).

Hydrogen sulfide has an offensive taste and odor, but, by dilution with water containing oxygen and/or by diffusing atmospheric oxygen, the sulfide is oxidized to tasteless and odorless sulfur and sulfates.

The effect of carbon dioxide, which increases water hardness, and the effects of ammonia, which on oxidation increases the nitrate content, are among the most significant chemical characteristics of decomposing organic matter in a landfill operation. The nitrate-nitrogen thus produced can exceed by 10 to 20 times the safe level for consumption by infants.[7]

The methane has a low solubility and diffuses out of the refuse site, presenting little or no contamination potential to water.[7]

Carbon dioxide has a high solubility and combines with water to form carbonic acid with an associated increase in hardness. The acid formed will dissolve magnesium, iron from tin cans, lime from calcareous materials and deposits, and other substances,[2,7] all of which are undesirable at high concentrations in water resources.

In considering all three phases of decomposition that affect water quality, it is of prime importance to know the Federal, State, regional, and local regulations that deal with the chosen disposal site. Any sampling for contamination must be of a frequency and method approved by the regulating authority, such as the Federal drinking water standards[12] or the standards of the New England Interstate Water Pollution Control Commission.[13]

IV. CASE STUDIES OF WATER QUALITY INVESTIGATIONS RELATED TO SOLID WASTE DISPOSAL OPERATIONS

Samples of past investigations and some present research efforts are presented to clarify the potential pollution problem associated with refuse disposal sites.

The distance that contaminants may travel was reported in an occurrence of pollution near the southern Indiana-Ohio state line many years ago.[9] Fifteen wells in a limestone strata formation were being used. One well became contaminated. After a 3-month investigation, it was reported that a solid wastes dump 18 miles away was found to be the source of the pollutants.

Andersen and Dornbush

Andersen and Dornbush[4] reported that groundwater leaving a 160-acre disposal site was not seriously impaired. They drew the following preliminary conclusions.

1. Groundwater in the immediate vicinity of and in direct contact with a refuse landfill exhibited a significant increase (three times) in the concentration of dissolved minerals as determined by specific conductance measurements.

2. During the summer, groundwater from the fill helped to reduce the hardness and alkalinity of the water in an algae-laden pond located downstream.

3. In this study, the three most significant parameters of those utilized to show variations in groundwater quality were chloride, sodium, and specific conductance.

4. There was need to determine the extent of travel of the leached ions, the aging of the deposited refuse, and the climatic variation.

University of Southern California

A University of Southern California investigation[5] showed that 15 inches of water applied at the rate of 1 inch a day was necessary to saturate the fill material and produce free water or leachate. These studies were done with deep (10-ft) bins, rubbish-garbage mixtures, and about 50 percent moisture. A landfill could absorb large quantities of water without becoming supersaturated (approximately 65 gallons per ton).

San Diego, using water for compaction in a landfill, required 385 gallons per ton of solid wastes.[7] The addition of this much water was not recommended where there was a possibility of groundwater contamination.

The complex problem of deciding whether a given landfill can cause contamination requires investigation and the judgment of competent sanitary engineers.

University of Illinois

The purpose of this project[6] was to determine the influence of the geological structure on groundwater and its relationship to potential groundwater pollution by a sanitary landfill.

Geologists have said that there are no such things as "perfect seals" that might prevent leachate from a landfill from reaching the groundwater.[14]

If a landfill is in the zone of saturation, which is usually known to engineers as the water table, the fill eventually becomes saturated, and water movement through the fill takes place.[14] Initial results of the University of Illinois study showed the following conditions:

1. A groundwater mound had formed beneath the landfill with gradients away from the landfill in all directions. The intersection of this groundwater mound with the land surface produced seepage, along one edge.

2. Construction of the landfill had caused a rise in groundwater levels of 3 to 5 feet beneath the landfill, the lower part of the refuse becoming saturated. A brownish-black, rather oily liquid (leachate) with an obnoxious odor was encountered.

The following preliminary conclusions were made:

1. A groundwater mound had formed beneath the landfill, saturating the lower part.

2. Chloride concentration decreased rapidly away from the fill.

3. Beneath the central portion of the landfill and in the clay till below the surficial sand, groundwater gradients were downward to the underlying bedrock. Near the margins of the landfill in the surficial sand, gradients had a lateral component.

British Studies

British experiments,[11] in which percolates from solid wastes fills had access to groundwater, or were directly placed into water to which groundwater had access, showed, respectively, that in 2.5 years the water contained little polluting matter, and that in 1.5 years pollution was measurable.

In Britain, tipping into water is a recent method, which is not yet fully accepted. Dry areas are becoming scarce. The study used a 6-acre pit and a 36-acre pit, both with 12- to 15-foot depths and utilizing 100,000 tons of solid wastes per year. When refuse was disposed of in water, the dissolved oxygen was used up rapidly and anaerobic organisms began to develop. Typical concentrations of substances in water before and after the polluting effect of solid wastes are highly variable (Table I).

TABLE I

Polluting Effect of Solid Waste

Analyzed component	Before	After
	(ppm)	(ppm)
Total solids	450	5000
Chloride ion	30	500
Aklalinity	180	800
Sulphate	120	1300 (no reduction) 0 (reduction)
P. V.	neg	230
BOD	neg	2500
Nitrogen (fs)	neg	70
Albumin-nitrogen	neg	16
pH	7.5	5

California State Conclusions

Extensive studies have led to the following conclusions by the California State Water Pollution Control Board[5]:

1. "A sanitary landfill, if so located that no portion of it intercepts ground water, will not cause impairment of the ground water for either domestic or irrigational use.

2. "A sanitary landfill, if so located as to be in intermittent or continuous contact with ground water, will cause the ground water in the immediate vicinity of the landfill to become grossly polluted and unfit for domestic or irrigational use. Local increase of mineral elements to concentrations varying from 20 times those found in the unpolluted ground water of the area in the case of common minerals up to 10, 000 times, in the case of ammonia, nitrogen, are possible.

3. "It may be expected that continuous leaching of an acre-foot of sanitary landfill will result in a minimum extraction of approximately 1. 5 tons of sodium plus potassium, 1. 0 tons of calcium plus magnesium, 0. 91 tons of chloride, 0. 23 tons of sulfate, and 3. 9 tons of bicarbonate. Removals of these quantities would take place in less than one year. Removals would continue with subsequent years, but at a very slow rate. It is unlikely that all ions ever would be removed.

4. "Dissolved mineral matter, entering a ground water as a result of intermittent and partial contact of a sanitary landfill with the underlying ground water will

a. have its greatest travel in the direction of flow,

b. undergo a vertical diffusion to a limited extent and, where the aquifer is of appreciable thickness (100 feet or more), the bottom water will probably remain unimpaired;

c. be subject to dilution, the result of which will be a minimizing of the effect of the entering pollutant ions.

5. "Where the pollutional load on a ground water is light by reason of a sanitary landfill being in intermittent and partial contact with the underlying ground water, the most serious impairment of the ground water as little as a half-mile downstream from the landfill will be an increase in hardness, and then only in the upper portions of the aquifer.

6. "Rainfall alone in this area will not penetrate a 7.5-foot thick landfill sufficiently to cause entry of leach into the underlying ground water.

7. "Compared to the hardness entering the ground water with leach from a sanitary landfill, the additional hardness which might

result from the dissolution of calcium carbonate by carbon dioxide produced within the fill is negligible, unless the aquifer is of a calcareous nature.

8. "Anaerobic conditions with production of combustible gas will exist within a sanitary landfill in approximately one month following deposition of the fill. The composition of the gas at that time will be approximately 70 percent methane and 30 percent carbon dioxide.

9. "The production of methane and carbon dioxide from solid fill materials results in increased pressure, and gas diffuses out of the fill. Low content of limestone in an aquifer will limit the diffusion of carbon dioxide into the water, and all but a negligible amount of the gas formed will escape into the atmosphere."

V. REQUIREMENTS FOR PROPER LAND DISPOSAL

Various requirements and guides have been compiled relating solid waste disposal to water.[2, 3, 5, 7, 8, 15] By understanding these, the relationship between solid wastes and groundwater is defined, and potentially dangerous situations may be avoided.

One suggested guideline is to designate different classes of disposal sites, with associated limitations as to the type of solid wastes to be placed in each class. Possible surface and groundwater areas as they relate to solid waste disposal are discussed, together with methods of making the problem areas safe. Some of the state regulations[2,7,13] for control are listed.

Surface Water Wet Areas

In general, these areas should not be used for the disposal of solid wastes, but, in cases of necessity and with proper precautions, they may be considered.

Swamps and Marshes. These need an adequate drainage system to handle both groundwater runoff from adjoining uplands and surface runoff from newly filled areas. The discharge end of drainage ditches should have readily cleanable screens. Flap gates should be used to control backflows in tidal areas. Solid wastes should never be disposed of in or near shellfish grounds.

Tidal Areas. The site should be divided into several lagoons by means of dikes. For better control of operations and to prevent nuisances, these are filled one at a time.

Ponds, Quarries, and Similar Depression-Type Areas. Dumping solid wastes directly into water causes nuisances, biochemical activity, and odors, and should not be done. Although a shallow pond could be filled by dumping only in cold weather, this is not good practice.

Groundwater

No type of solid waste disposal site should be placed in direct contact with the groundwater supply. At least 2 feet between the lowest point in the fill and the highest recorded water table level should be maintained. Even this may not be sufficient distance since the water table may rise directly below the refuse fill. In some areas, less distance, and even intermittent contact is allowed when only certain types of inert solid wastes are placed in the fill.

General Information

The use of ravines for disposal sites is possible where water courses are involved, but something must be done to get the water through the fill. Storm sewers may be built before the fill is constructed.[7] This adds to the cost, but it has been done successfully with corrugated metal pipe and also with concrete pipe. This is not done too often, but it is possible.

Two ways have been used to minimize pollution at a disposal site: sealing the site before starting the fill; and making the fill so dense that, by actual measurement, the resistance to the passage of water is higher through the fill than it is through the undisturbed soil.

Los Angeles Requirements

Two of the basic requirements for a satisfactory sanitary landfill in Los Angeles County[15] follow:

1. "The site should be located at or near the upstream boundary of the watershed on which it is located to avoid storm flow hazards."

2. "The geology and hydrology of the formation underlying the site should be such that the cuts or fills would never penetrate a useable ground water supply."

A California Water Pollution Control Region

The Water Pollution Control Region, that has jurisdiction in the Los Angeles and Ventura watershed areas has established three classes of disposal sites.[7]

1. "Sites located on non-water-bearing rocks, or underlain by isolated bodies of unuseable ground water, which are protected from surface runoff and where surface drainage can be restricted to the site or discharged to a suitable wasteway, and where safe limitations exist with respect to the potential radius of percolation."

2. "Sites underlain by useable, confined, or free ground water, when the minimum elevation of the dump can be maintained above anticipated high ground water elevation, and which are protected

from surface runoff and where surface drainage can be restricted to the site or discharged to a suitable wasteway."

3. "Sites so located as to afford little or no protection to useable waters of the State."

The following is an indication of the nature of wastes acceptable at each class of disposal sites.

1. "No limitation as to either solid or liquid wastes."

2. "Limited to ordinary household and commercial refuse and/or rubbish, garbage, other decomposable organic refuse, and scrap metal . . . . at safe elevations above the anticipated high ground water elevation in the vicinity of the site."

3. "Limited to non-water soluble, nondecomposable inert solids . . . ."

Illinois and Idaho Recommendations

Illinois and Idaho[7] have similar recommendations to minimize the possibility of underground pollution.

1. "Do not build on exposed rock strata. Keep a minimum of 30 feet clay-till overburden between strata and refuse, unless studies indicate that a lesser depth is satisfactory.

2. "Locate fill at least 500 feet from drift wells, unless studies indicate subsurface seepage is not imminent.

3. "Do not place garbage and refuse in mines or other areas where resulting seepage or leachate may carry waste to water-bearing strata or wells. Remember that chemical pollution may emanate from a fill and probably will travel for long distances as compared to organic and bacterial pollution travel.

4. "Do not locate sanitary fills on or near springs.

5. "Consult the state department of reclamation, state geologist, and the state department of public health regarding any problems of possible underground pollution."

VI. GUIDELINES

Suggested Management Guides

Guides to enable management to judge the acceptability of a waste disposal site[8] are listed:

1. "Where the waste release is in the zone of unsaturated rock materials above the water table, information should be available on the composition and thickness of the materials in this zone, on the kind and degree of porosity and permeability in this zone, and on the position of waste release within the zone.

2. "General knowledge of the natural direction and rate of flow of groundwater between waste-disposal sites and places of natural groundwater discharge.

3. "Knowledge of the

a. particular waste,

b. its relative degree of attenuation in clay, sand, or rock environment, and

c. its approximate rate of movement in comparison to that of groundwater.

4. "Knowledge of the extent of hydraulic connection between waste in the ground and places of withdrawal of groundwater.

5. "Historical knowledge of the use of the ground for water supply and waste disposal in the area of concern. . . ."

6. "Knowledge of the risks to health from specific types of wastes if the wastes get into a surface stream, into vegetation, or into a groundwater supply.

7. "Full consideration of all possible courses of action concerning waste practices in relation to a specific situation. . . ."

Guides to Good Practices

1. Never place solid wastes in direct contact with a groundwater supply. Since a groundwater mound may be formed, a minimum of 7 feet of separation is desirable.
2. Do not locate solid wastes on or near water-bearing strata, springs, wells, or where seepage or leachate may cause contamination.

3. Minimize surface water passing over or through a disposal site by instituting proper drainage. Cover and grade a finished site so that runoff does not flow across the fill area.
4. Follow recommended procedure for the operation and maintenance of a sanitary landfill, utilizing sound engineering practices and judgment.
5. Do not intentionally add water to a solid waste disposal site.
6. Consult with local, State and Federal agencies in the fields of public health, water pollution, reclamation, geology, and hydrology regarding any problem of possible water pollution.
7. To aid in preventing many problems before they occur, carefully select site and evaluate its entire physical environment.
8. Do not depend on ventilation to relieve produced gases; do not depend on coatings to decrease the permeability of the disposal pit surfaces.
9. Avoid leaching at the disposal site itself, and do not depend on dilution.
10. Because solid wastes absorb water, do not mix them with water.

VII. SUMMARY

Water pollution caused by improper solid waste disposal is a serious problem. The first step in solving it should be to select an appropriate site and to acquire a thorough knowledge of its physical environment, including, geologic, hydrologic, and meteorologic parameters. These conditions should be considered in order to minimize potential contamina'ion of ground or surface water by the refuse. Areas where problems exist, or are thought to be present, should be avoided. Care should be taken to forsee problems that may occur and, to avoid them by selecting if possible, another site. In operating the disposal site, proper practices and maintenance, as well as the use of sound engineering judgment should be continuous.

The sanitary landfill, by definition, disposes of solid wastes on land without creating any nuisances or hazards to public health. If every landfill operated were truly sanitary, there would be no problems. It would, therefore, be advantageous to require that all solid wastes disposal sites be operated as, or converted to, sanitary landfills.

The possibility of pollution will exist as long as we dispose of solid wastes in or on the land. Every attempt should be made to minimize the possibility of contamination. Each site should be selected and considered individually.

Polluting substances can leave the solid wastes fill as dissolved solids or as gases. Dissolved solids occur only through the development of leachate, but gases may move because of gravity or pressure differential. Some solids become leachable only upon decomposition, and gas is produced as a result of the decomposition.

Physical and biological contamination can occur, but the most serious problem is that of chemical pollution. Solid wastes contain minerals and organic substances in quantities capable of seriously damaging water supplies.

State agencies may have made recommendations and conclusions to be followed in order to minimize the possibility of groundwater pollution. Local regulations that may affect a given situation should be evaluated.

A properly located and operated sanitary landfill, one that is properly covered and graded, will minimize potential water pollution problems.

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