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# IS IT FEASIBLE TO CLEAN THE AQUIFER ONCE IT IS CONTAMINATED BY LANDFILL LEACHATE?

B.T. LAKSHMAN, P.E., CHIEF ENGINEER
Artesian Water Company, Newark, Delaware, U.S.A.

ABSTRACT

In this paper an attempt is made to critically examine the implications and experiences of ground water contamination due to landfill leachate in the State of Delaware in particular and the United States of America in general. The feasibility of cleaning such contaminated aquifers through abatement programs has also been weighed and analyzed. Also discussed in general are other sources of contamination contributing to the impairment of aquifers used for potable water supplies.

## INTRODUCTION

Among other things, one of the least recognized pollution hazards is the hidden deterioration of the quality of ground water. Ground water is of vital importance for the people, industries and agricultural enterprises all over the United States and the entire world. The problems of ground water contamination are highly complex. All factors such as the geological, hydrological, hydraulics, physical, chemical, and biological nature of the pollutants involved in an individual case must be considered.

There are hundreds of streams, thousands of landfill sites and millions of septic tanks where a great variety of domestic and industrial wastes are disposed of in the United States. Although dumping of solid and liquid wastes into the ground has been going on continually for a long time, we have started looking at and realizing the possible damage to the quality of ground water only in recent times.

Contamination or pollution of the aquifer basically denotes impairment of the quality of ground water to a degree considered hazardous to the public health.

## THE IMPORTANCE AND THE NEEDS FOR GROUND WATER

Ground water is an important world resource which has received insufficient attention until recent times. Ground water represents the largest source (95%) of fresh water available to mankind. The potential of ground water to satisfy the prodigious water demands of the world is boundless. Today half of the American population (95% of its rural residents) take their drinking water from underground aquifers. According to one estimate, the usable portion of ground water in the entire U.S.A. is 150 times greater than the amount of water used in the country in

1965. According to another projection before the end of this century the water use in the United States will triple and the demand on ground water sources will be seven times greater than today. Besides, in the U.S.A. the average cost of developing underground water per 1,000 gallons is between 6¢ and 20¢ compared with the national average of 25¢ to 40¢ for treated surface water and about $2 for desalinated sea water.

## COMMON SOURCES OF AQUIFER CONTAMINATION

The major sources of aquifer contamination are (a) sanitary landfills, (b) industrial landfills and the discharge of liquid wastes, (c) cesspools and septic tanks, (d) leaky sanitary and storm sewers, (e) leaks from petroleum and oil storage tanks and pipelines, (f) infiltration from contaminated rivers, lakes and ponds, (g) accidental or deliberate spills of acids or other dangerous chemicals, (h) salt water intrusion, (i) insecticides, herbicides and fertilizers; and (j) thermal pollution.

## CONTAMINATION THROUGH LANDFILLS

Among other threats, the newly recognized serious threat to ground water quality is contributed by improperly designed landfills. According to the latest estimate, about 150 million tons of municipal solid waste and another 240 million tons of industrial waste is generated in the U.S.A. for disposal every year. Industries also pour an estimated 10 trillion gallons of liquid waste into pits, ponds and lagoons annually. Most of this refuse has to be disposed of by dumping on the land as a landfill. According to one estimate in 1977, there were about 18,500 municipal landfills in the U.S.A. Under a well-designed, well-controlled landfill operation water pollution may not result. Unfortunately, these conditions rarely occur. Seventy-five percent of the solid waste generated in the United States is deposited on the land in open dumps as contrasted with only eight percent in sanitary landfills. E.P.A. estimates that there are 30,000 to 50,000 existing disposal sites in the U.S.A. that are contaminated to some degree by hazardous wastes. Of these, 1,200 to 2,000 existing sites present imminent hazards to public health. Much of the hazard associated with these sites is ground water contamination. According to E.P.A., 90% of all hazardous wastes in the U.S.A. are discarded in environmentally unsound or dangerous ways.

## COMPOSITION OF URBAN SOLID WASTE, PRODUCTION AND QUALITY OF LEACHATE

According to one analysis, urban solid waste in the U.S.A. normally consists of about 50% paper products, 15% food wastes, 8% metal, 8% glass and ceramics, 5% garden wastes, 5% plastics, leather, rubber, and cloth, 2% wood and the remaining 7% miscellaneous products.

Decomposition of refuse is initially aerobic. After the top layer of soil is placed, anerobic reactions predominate. Carbon dioxide, nitrogen and other gases produced from decomposing refuse dissolve in water and form a weak acid known as "leachate" with some potential contamination. During wet seasons, as precipitation exceeds evaporation, surplus water infiltrates through the refuse and moves down to the top of the zone of saturation and then in the direction of potential gradient. Generally in new fills rapid biodegradation occurs with consequent production of acidic leachate. This lowers pH of water and tends to increase the solvent capability of water passing through.

The quality of leachate from any landfill refuse is a function of such factors as the composition, sorting, degree of compaction, moisture content, temperature and age of disposal. The production of the amount of leachate is a function of air temperature, composition of refuse, depth of refuse, rate of decomposition, chemical and hydrological quality of the soil and the amount of water passing through the landfill material. Approximately 3% to 5% of the dry weight of refuse is leachable. A considerable portion of the leachate strength may be attributable to textiles, rubber, leather, wood and paper present in refuse. The leachate from a landfill is generally characterized by very high concentrations of dissolved organic and inorganic substances and other dissolved chemicals. Besides, it might carry bacterial pollutants. Therefore, the leachate is usually high in chemical and biological oxygen demand. The total per capita $BOD_5$ load is about a third to a half that of raw sewage $BOD_5$. The quality of leachate is improved as it moves from the landfill by such processes as dilution, biological assimilation, bio or chemical oxidation, adsorption, and ion exchange. Clay minerals have very large charged surface areas per unit volume of material and thus are good adsorbents or ion exchangers, while quartz, gravel and sand have low adsorption capacity.

## LANDFILL CONTAMINATION AT LLANGOLLEN, DELAWARE, U.S.A.

History. About two miles southwest of the City of New Castle, Delaware, U.S.A., the so-called "Llangollen Landfill" was operated as an all-purpose solid waste disposal site from 1960 through 1968 in a sand-and-gravel pit (see figure). The area of fill is about 60 acres; the average refuse thickness is about 25 feet; and the fill contains more than two million cubic yards of municipal and industrial refuse, about 30% of which was beneath the seasonal water table. During the gravel pit operation, excavation appeared to have been continued below the water table and penetrated the potomac artesian aquifer through a thin layer of clay.

During 1970 the landfill was covered with approximately two feet of soil, mostly sand. Percolating rain water seeped through the landfill to produce leachate that contained high concentrations of iron, chlorides, dissolved organics, heavy metals and a putrid odor.

An investor-owned public utility, Artesian Water Company has been operating a large potable water wellfield approximately 3,000 feet south of the landfill since 1952. At the initial stage of investigation in 1972 the leachate plume appeared to have advanced about 2,000 feet towards the Company wellfield. Some of the private wells in the area were contaminated by this leachate, and they had to be abandoned. In view of the potential contamination problem and in order to maintain the hydrological balance, the State and New Castle County asked Artesian to curtail the amount of pumping from 5 mgd to a maximum of 2 mgd at its Llangollen wellfield, which is known to be the biggest potable water wellfield in Delaware.

Abatement Program and Current Status. Under its abatement program New Castle County installed several leachate recovery wells near the landfill site which are initially being pumped up to a maximum of 3 mgd to a nearby stream without any treatment. Incineration ($25-40 million), excavation transportation and reconstruction of refuse at another landfill site ($15-20 million), as well as hastening decomposition by recirculation or annelidic consumption (about $20 million) were some of the other alternate corrective measures considered.

Since it is a substantial investment, the County is looking for federal aid; and so far the federal government has allocated only $650,000 towards a Llangollen landfill leachate control program. Since 1972 the County government has spent several million dollars towards this abatement program and has not accomplished any tangible solution except containing the leachate front. The annual cost of the present leachate recovery and control program alone costs its tax payers over $1,000,000 every year.

The Llangollen landfill has become Delaware's most costly pollution problem to date. Complete return of the aquifer for water supply purposes is still in doubt and is at least a decade away even if a successful leachate control strategy were to be initiated and implemented immediately.

Since Artesian Water Company has curtailed the amount of pumping from the Llangollen wellfield, the County started reimbursing Artesian towards purchased water in hundreds of thousands of dollars until recent times. Artesian has already spent over one million dollars and is contemplating a multimillion-dollar project to replace the lost water and to assure an adequate water supply to its customers.

Under the circumstances Artesian has already filed a suit against New Castle County seeking damages in the amount of $6 million.

## IMPACT OF SOME OF THE IDENTIFIED LANDFILL LEACHATE CONTAMINATION PROBLEMS IN THE U.S.A.

Love Canal Landfill. The Love Canal landfill is the U.S.A.'s first notorious episode of land pollution. Love Canal is located in New York near Niagara Falls. Hooker Chemicals deposited about 21,000 tons of chemical waste in a 3,000-foot length (16 acres) of abandoned canal during the years 1942-1953. Twenty-five years later leachate emanating from the fill reached the back yards and basements of homes nearby. E.P.A. has identified 82 chemicals in the air, water and soil, of which 11 are suspected human carcinogens. Some 239 families in the first two rings of homes bordering the canal were evacuated, and their homes were purchased by the state. A school built over the landfill was closed. Further evacuation of an additional 710 families is contemplated by the federal government. Reclamation of the Love Canal environment is estimated to cost about $36 million, and this amount does not include any compensation to residents of the Love Canal for their suffering. Compensatory and damage suits brought against the company by New York, E.P.A. and 1,300 private individuals amount to as high as $11 billion.

Jackson Township Landfill. This municipal landfill is located near Trenton, New Jersey. Among other wastes, the landfill consists of sewage sludge and septic tank wastes. Because of organic chemical contamination, more than 100 domestic wells surrounding the landfill have been closed since 1978. Water samples carried chloroform, methylene chloride, benzene, trichloroethylene and acetone. New Jersey is now taking legal action against the concerned parties, and the landfill was recently closed. A $1.2 million water system is planned for the affected residents. No action is being taken to restore ground water quality. None may even be feasible.

Atlantic City Landfill. E.P.A. recently detected a toxic plume consisting of nine hazardous wastes emanating from an abandoned landfill towards the main wellfield supplying water for Atlantic City, New Jersey. This wellfield supplies 90% of the city's water supply. The landfill appeared to have received 8.3 million gallons of industrial waste, mostly during 1972. Suspecting potential contamination in the near future, the city has shut down five of the field's 13 wells. The city is contemplating a suit against the owner of the landfill.

Rocky Mountain Arsenal. Near Denver, Colorado, almost 30 square miles of shallow aquifer were contaminated by aldrin, dieldrin and other toxic substances. During the 1950's these substances seeped from an unlined holding pond at the Rocky Mountain Arsenal where pesticides and other chemical wastes were deposited. Some 64 wells used for domestic supply, livestock and irrigation had to be shutdown.

ORGANIC POLLUTION INCIDENTS ON GROUND WATER SUPPLIES

Thanks are due to modern analytical tools which help detect organic compounds such as pesticides, PCE, TCE, THM, etc. In one notable case of ground water pollution, agricultural runoff containing the pesticide DBCP contaminated 193 domestic wells. DBCP use was banned in California in 1977 because of its association with sterility in workers. Recently synthetic organics in ground water have generated public concern in the U.S.A. and have resulted in numerous well closures. Many of them are industrial compounds. So far out of 700 organic chemicals found in drinking water, 21 of them have been identified as known or suspected carcinogens. These 21 include vinyl chloride, benzene, carbon tetrachloride, PCB, TCE and kepone. In 25 states many private and public water supply wells have been capped as a result of organic contamination (TCE, PCB, etc.). During 1979 alone more than 300 organic contamination incidents were reported. So far E.P.A. has promulgated standards for six pesticides and trihalomethanes.

## MEASURES TO PROTECT GROUND WATER FROM CONTAMINATION IN USA

The advent of new water testing technologies and research have helped the regulatory agencies enact certain standards and regulations to protect the quality of ground water. In recent years the U.S.A. has enacted several acts and regulations such as the Clean Water Act, the Resource Conservation and Recovery Act, the Safe Drinking Water Act, the Surface Mining Control and Reclamation Act, the Toxic Substances Control Act, the Federal Insecticide, Fungicide and Rodenticide Act, the Underground Injection Control Regulations and $1.6 billion Superfund Legislation, etc., to control and protect ground water from contamination.

## CONCLUSIONS

Ground water is one of the most precious renewable resources in the USA as well as in the whole world. It is renewable only when we take care of protecting it. We create the future and set the odds ourselves. In most ground water contamination incidents on record locating the source of pollution has been relatively easy. Shutting off the source and eliminating the pollution from the ground water has always been time-consuming, costly and many times economically unfeasible.

According to one estimate, the cleaning up project of all the abandoned potentially dangerous sites nationwide in the U.S.A. is estimated to cost between $28 and $58 billion. Even if such an expensive project were to be envisaged, the anticipated results are questionable and uncertain.

We have not acquired enough experience in cleaning the contaminated aquifer. I have no knowledge of any fully recovered aquifer which was contaminated by landfill leachate. Even when theoretically feasible, it might take several decades and substantial capital to clean the contaminated aquifer to its original status. Furthermore, it is presently unknown whether contaminated ground water can be treated to drinking water standards. In many cases, the practical solution to cleaning up such "potential time bombs" is unknown, unsure or questionable. Therefore, until better methods of waste disposal can be devised, perfected and used, it is absolutely necessary to impose rigorous control for the selection of a disposal site, operation and maintenance to prevent the possible contamination of aquifers.

In light of the aforementioned discussion, to answer the question, "Is it feasible to clean the aquifer once it is contaminated by landfill leachate?", I would say theoretically, "yes," but practically and sensibly, "no."

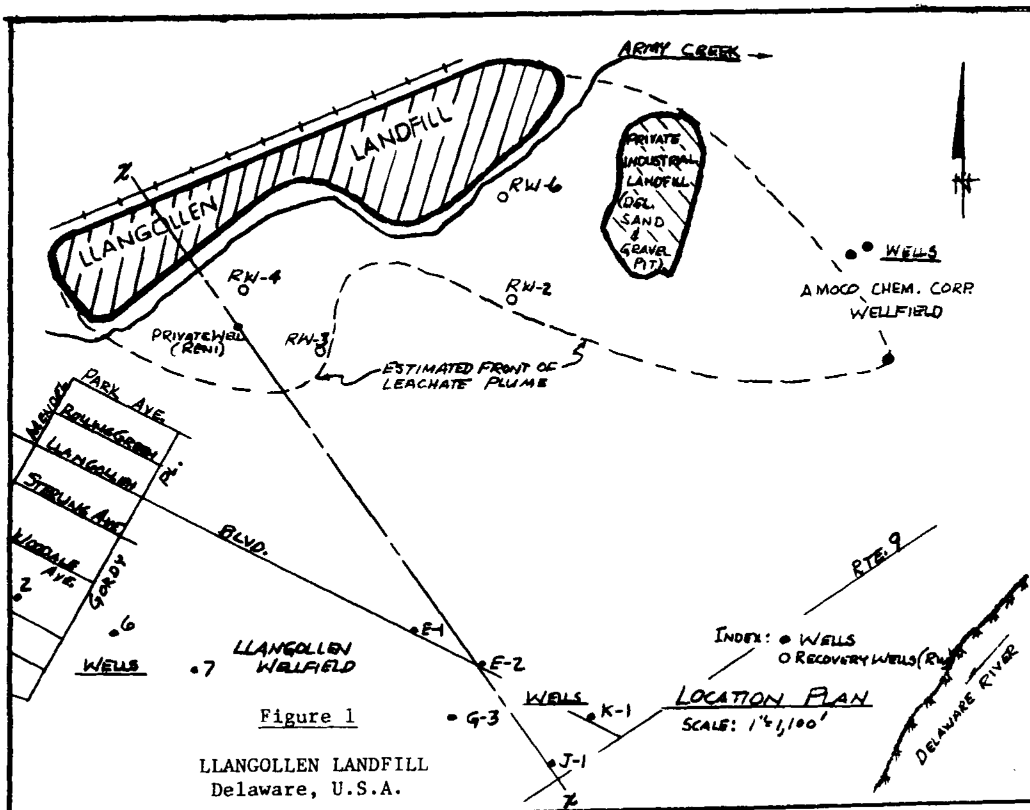


Figure 1

LLANGOLLEN LANDFILL
Delaware, U.S.A.

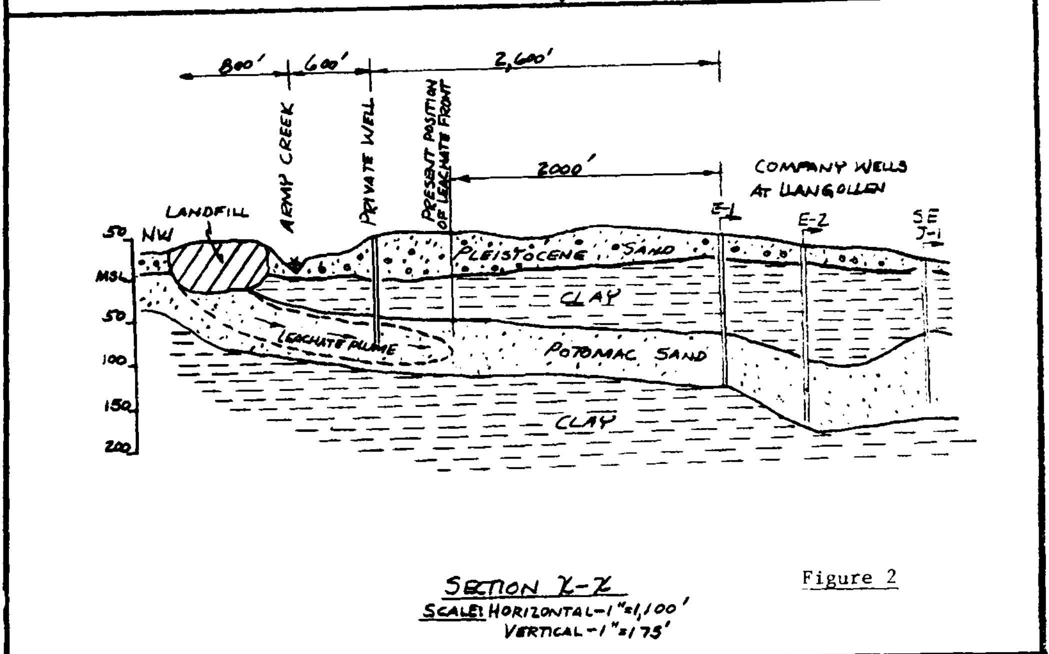


Figure 2

REFERENCES


1 EPA, November 1980, 'Groundwater Protection - A Water Quality Management Report', U.S. Environmental Protection Agency Publication.
2 Cameron, R.D., March 1978, 'The Effects of Solid Waste Landfill Leachates on Receiving Waters', Journal, American Water Works Association.
3 Lakshman, B.T., 1977, 'Grounwater Contamination Viewed in the Light of New Safe Drinking Water Standards,' paper presented at the 15th Annual Resources Conference of WRA of Delaware River Basin, Pocono Manor, Pennsylvania.
4 National Academy of Sciences, 1977, Drinking Water and Health, A Summary Report on the Safe Drinking Water Committee.
5 Dunlap, W.J., et al, 1976, Organic Pollutants Contributed to Groundwater by a Landfill, Research Symposium, Rutgers University, New Jersey.
6 Lakshman, B.T. 1973, 'Aquifer Contamination', AWWA Annual Conference (Chesapeake Section), Ocean City, Maryland.
7 Roy F. Weston, Inc., 1972 - 1977, Reports connected with the investigation of Groundwater Contamination of Llangollen Landfill, Delaware.