

2005-2008 Perfluorochemical Evaluation at Solid Waste Facilities in Minnesota
Technical Evaluation and Regulatory Management Approach
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Background

Many products containing perfluorochemicals (PFCs) are widely used and disposed of through commercial, residential, and industrial settings. The final disposal location for many of these products is solid waste landfills in Minnesota. The type of landfill in which these products are disposed of often depends on their source. For most commercial, industrial, and residential settings, waste is disposed of in either municipal solid waste (MSW-Combustor Ash) or Industrial landfills, which are designed as lined landfills. Wastes generated from demolition or construction often ends up at Demolition landfills, which are commonly unlined.

In 2005, the Minnesota Pollution Control Agency (MPCA) Solid Waste Section began an evaluation of the impacts that PFC-containing wastes have on solid waste landfills in Minnesota. The evaluation was broken down into two main categories: waste generated from the disposal of products in commercial, residential, and industrial settings ending up in MSW-Combustor Ash and Industrial landfills (lined landfills), and waste generated from the demolition and construction of commercial, residential, and industrial settings ending up in Demolition landfills (unlined landfills).

The PFC evaluation was phased between 2005 and 2008. Principal activities included:

2005

- Leachate and gas condensate was sampled from landfills known to have taken PFC sludges from 3M.

2006

- Leachate and gas condensate was sampled from ten lined landfills (MSW-Combustor Ash and Industrial landfills).
- Landfill gas samples were collected from two landfills which converted gas to energy.

2007-2008

- Treated leachate was sampled from seven MSWs which spray irrigate their leachate as a form of leachate management.
- Groundwater samples were collected both upgradient and downgradient of all the landfills evaluated in 2006.
- Groundwater samples were collected from 20 unlined Demolition landfills around the state.
- Following pilot testing, landfill gas was resampled from two landfills in 2007 using a more refined sampling technique and lower detection limits.
- A second round of sampling was performed at each landfill in 2008 for every media of concern to confirm the results generated from the initial sampling events.

Based on the results of the evaluation, the MPCA Solid Waste Section developed the following management approach to control and/or monitor PFCs at solid waste landfills in Minnesota. Because of the limitations in information existing on the toxicology and associated risk of PFCs, the current management approach is based on the presence of perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanoic acid (PFBA) in the media of concern. As new information is developed on the toxicology for other PFCs, and as the Minnesota Department of Health develops new drinking water standards, other PFC parameters will be re-evaluated to determine if additional action will be required to mitigate human and environmental impacts.

Results and Management Approach

Leachate and Gas Condensate

PFCs were detected in leachate and gas condensate at every MSW-Combustor Ash and Industrial landfill (lined landfills). The PFC management approach for leachate is broken down into two approaches: the first for landfills that spray irrigate their leachate as a form of leachate management, and the second for landfills that dispose of leachate and gas condensate at wastewater treatment plants (WWTP) as a form of leachate management.

- I. Leachate Spray Irrigation Sites (landfills that spray irrigate leachate rather than dispose at a WWTP):
 - a. Require routine monitoring of leachate for PFCs prior to spray irrigation. Sampling will take place in the spring and fall of each year.
 - b. All landfills that spray irrigate their leachate will be required to sample their leachate at least twice per spray season for PFCs and keep track of cumulative PFC loading(s) rates. Cumulative loading limits of 0.384 pounds per acre for PFOS will be applied to be consistent with current MPCA policy. If the cumulative loading limit of 0.384 pounds per acre of PFOS is exceeded, then the landfill must stop spray irrigation of leachate.
 - c. Dependent upon current and long-term leachate analytical results, baseline groundwater monitoring shall be conducted at monitoring wells to evaluate the nature of PFC impacts in groundwater and to determine the nature of long-term monitoring which may be required at the site. Groundwater sampling will be required if PFC concentrations in leachate exceed associated intervention limits for groundwater during any one sampling event.
 - d. If PFCs exceed intervention limits (ILs) in site monitoring wells, landfills shall follow the steps outlined in the solid waste rules (Minn. R. 7035.2815, subp. 4G) as they relate to exceedances of ILs.
 - e. Soil samples for PFCs will be required from within the spray irrigation field in accordance with the other soil sampling described in the approved sampling plan to evaluate the nature and extent of PFC contamination in soil. Soil sampling plans will need to be developed where they do not exist to accomplish this task.
 - f. The cover crop in the spray irrigation field may need to be evaluated for the presence of PFCs if the cover crop is being utilized in some other application, such as animal bedding or feed stock. Any further utilization of the cover crop, if found to have impacts, shall be re-evaluated.
 - g. If spray irrigation continues to be problematic relative to environmental impacts from PFCs, alternative methods of leachate management must be evaluated.
- II. Landfills that dispose of leachate and gas condensate at WWTPs:
 - a. The MPCA will share current information with appropriate MPCA water programs to aid in identifying any potential PFC management needs at pertinent WWTPs.

- b. Because the MPCA does not regulate leachate/gas condensate characteristics or criteria for disposal, any long-term PFC sampling or characterization requirements will be managed by the party accepting the leachate and/or gas condensate for disposal/treatment. This will likely be driven by any regulations MPCA water programs impose on WWTPs.
- c. No additional action or requirements shall be implemented to evaluate PFCs in leachate at landfills that dispose of leachate at WWTPs at this point in time.

Landfill Gas

Landfill gas samples analyzed in 2006 indicated that PFCs were not present in landfill gas. However, due to the relatively high detection limits and problems associated with the sampling matrix, MPCA staff decided that more rigorous sampling techniques would need to be developed to limit the effect of matrix interference and thereby enhance relative detection limits to generate a more accurate assessment of PFCs in landfill gas. Therefore, new sampling techniques were developed and field tested prior to the landfill gas sampling conducted at the landfills in September 2007. Consequently, landfill gas analytical data generated during the 2007 sampling event indicated that landfill gas is being impacted by PFCs. The nature of PFC contamination present in gas was not a reflection of what is being discharged to the atmosphere from the system, because the samples were taken from within the extraction system before the gas was either flared or utilized as fuel for energy conversion. The following recommendations will be implemented:

- a. The information has been shared with pertinent MPCA air programs.
- b. Considering the cost of analysis (four to five times that of PFC leachate or groundwater samples), the lack of a sampling method for sampling PFCs in the gas stream after the flare, and the lack of knowledge about risks associated with air exposure, no further action is recommended at this time until more information is obtained regarding relative risk through the air exposure pathway.
- c. Once relative risk from air exposure is identified, the MPCA Solid Waste Section shall seek guidance from MPCA air programs to identify any permit needs to characterize and manage PFC air discharges at permitted landfills.

Groundwater

Groundwater sampling results were compiled from two rounds of sampling from select MSW-Combustor Ash and Industrial landfills, and unlined Demolition landfills, which took place in 2007 and 2008. The results were statistically evaluated by staff from the MPCA Water Monitoring Section, segregating the data by lined (MSW-Combustor Ash and Industrial Landfills) and unlined (Demolition) landfills. The objective of the evaluation was to compare upgradient concentrations in groundwater to downgradient concentrations to see if there was a significant difference between upgradient and downgradient results.

Data from unlined landfills was evaluated by:

- Comparing upgradient and side gradient results to downgradient results.
- Comparing results to regulatory risk levels as defined by the associated Health Risk Limits (HRLs), Health Based Values (HBVs), and surface water criteria depending upon site-specific permit requirements.
- Comparing results to ambient groundwater concentrations generated by sampling conducted by the MPCA Environmental Assessment and Outcomes Division (EAO).

Data from lined landfills was evaluated in the same manner with one exception: some of the older lined landfills have unlined components, so samples were taken downgradient of the lined and unlined components to distinguish between impacts from the unlined component versus the lined component of each landfill where applicable. This information was taken into consideration when drawing conclusions relative to the role liners have in preventing the release of PFC contamination from landfills.

Groundwater Results

There were significant differences in PFBA and PFOA concentrations between the lined and unlined landfills. Median PFBA concentrations were significantly higher at lined landfills (33.2 ng/l: nanograms per liter or parts per trillion (ppt)) compared to the unlined landfills (7.29 ppt). Similarly, PFOA concentrations were significantly higher at the lined landfills (median 2.39 ppt) compared to the unlined ones (median 0.36 ppt). The PFOS data set from the unlined landfills contained over 90 percent censored values (nondetects), which resulted in a tenuous estimation of the descriptive statistics. As a result, median PFOS concentrations from the lined and unlined landfills were not compared.

There also were significant differences in PFBA and PFOA concentrations between the upgradient and downgradient wells. At the unlined landfills, PFBA concentrations were significantly greater at the downgradient wells compared to the upgradient wells. Similarly, PFOA concentrations at the unlined landfills were significantly greater at the downgradient wells compared to the upgradient ones. There was no significant difference between the PFBA concentrations in the upgradient and downgradient wells at the lined landfills; however, PFOA concentrations were significantly greater at wells downgradient of these landfills compared to upgradient wells. There was no significant difference in PFOS concentrations between the upgradient and downgradient wells at the lined ($p=0.0987$) or unlined landfills.

Groundwater Conclusions

PFOS

Over 90% of the data came back with no detections for PFOS. Where there were detections, there was no significant difference in PFOS concentrations between upgradient and downgradient wells at lined or unlined landfills.

PFOA

There were significant differences between upgradient and downgradient concentrations of PFOA at lined and unlined landfills. For the majority of lined landfills with unlined components, the significant differences appeared to be present at wells downgradient of the unlined component. The median PFOA concentrations at lined and unlined landfills (2.39 ppt and 0.36 ppt, respectively) were significantly lower than the HRL for PFOA of 300 ppt. The MPCA EAO Division generated ambient groundwater results from eleven counties for PFOA where concentrations ranged from 1.1 ppt to 24.8 ppt.

PFBA

There were no significant differences in PFBA concentrations between upgradient and downgradient wells at lined landfills. There were significant differences between upgradient and downgradient concentrations of PFBA at unlined landfills. The median PFBA concentration of 7.29 ppt at unlined landfills was significantly lower than the HBV for PFBA of 7,000 ppt. The MPCA EAO Division generated ambient groundwater results from eleven counties for PFBA where concentrations ranged from 1.34 ppt to 61.3 ppt with the exception of Ramsey and Washington Counties, where concentrations ranged from 266 ppt to 922 ppt.

Considering the concentrations of PFOS, PFOA, and PFBA in groundwater relative to their respective HRLs/HBVs and associated surface water criteria, and considering what is being observed in a limited ambient groundwater evaluation performed by the MPCA EAO Division, the following conclusions are provided:

- Landfills which did not receive PFC waste from 3M are not acting as a source of PFOS contamination to groundwater.
- Landfills which did not receive PFC waste from 3M do not appear to be acting as a significant source of PFOA or PFBA contamination to groundwater.
- One MSW landfill (Pine Bend) which disposed of PFC waste from 3M in an unlined portion of the landfill is impacting groundwater at concentrations above ILs and, in some cases, above respective HRLs and HBVs, for PFOA, PFOS, and PFBA.
- One unlined landfill (Summit Ave Demo) which took water treatment lime sludge is impacting groundwater for PFOA above the potential intervention limit for this parameter.
- One unlined landfill (SKB Dawnway) exceeded an IL value for PFOA in a monitoring well. An analysis of groundwater flow direction indicates this well is located side gradient of the landfill. Therefore, groundwater quality data generated from this well is not indicative of groundwater quality migrating downgradient of the landfill.
- One lined landfill (Spruce Ridge MSW) exhibited PFOA concentration above potential drinking water ILs. However, the site-specific ILs are based on surface water criteria and results were well below the potential surface water IL (25% of 2680 ppt).

Groundwater Recommendations

Considering the concentrations of PFOS, PFOA, and PFBA in groundwater relative to their respective HRLs, surface water criteria, and what is being observed in the ambient groundwater evaluation performed by the MPCA EAO Division to date, the following recommendations are provided:

- The nature and extent of PFC contamination should be evaluated at the MSW and unlined landfills noted above.
- Further evaluation of PFCs in groundwater at solid waste landfills in Minnesota is not warranted at this time.

Regulatory Authority to Implement

- Minnesota Statute Chapter 103H, Groundwater Protection
- Minnesota Rules Chapter 7035, Minnesota Pollution Control Agency Solid Waste

Limitations Associated with Groundwater Data

Observations were weighted towards downgradient wells. Eighty-one of the 121 observations from unlined landfills were located downgradient of the landfill, and 47 of the 67 observations from lined landfills were from wells located downgradient of the landfill.

NOTE:

Since establishing this management approach, the Minnesota Department of Health has developed a HBV for perfluorobutane sulfonate (PFBS). Therefore, the decision to manage PFC at solid waste landfills will include an evaluation of the nature and extent of PFBS in the media of concern.