PCC Termination Determination and the Concept of Equilibrium

by Carl E. Burkhead (9-26-12)

Equilibrium is defined in the Merriam-Webster dictionary as a state of balance between opposing forces or actions that is either static (as in a body acted on by forces whose resultant is zero) or dynamic (as in a reversible chemical reaction when the rates of reaction in both directions are equal. The **Le Chatelier-Braun principle** states that when a system in equilibrium is subject to stress, i.e. to a change in its conditions, the system will adjust itself to annul, as far as possible, the effect of the stress. The combination of these two statements is descriptive of what happens in a MSWLF in terms of leachate and LFG generation, i.e., leachate and gas generation depends upon the resultant impact of moisture, temperature, compaction, etc. on the stored MSW. In fact, recognition of this fact is important in establishing a methodology for the determination of PCC termination since these "outside forces" will define/determine the leachate and LFG quality and quantity.

The two operational extremes which determine the ultimate fate of MSW stabilization in MSWLFs are the dry tomb and bioreactor (or a system where optimum moisture levels exist for MSW stabilization) approaches. Each of these systems will come to their respective equilibriums **only** after a successful closure protocol which prevents or controls future perturbations from the outside that will affect the equilibrium of the stored MSW mass. However, it should be noted that after closure neither operation is at equilibrium because internal disturbances caused by physical, chemical and biological changes will continue to occur. These include phenomena such as physical settling and microbial degradation that are dependent on time and internal factors which don't need outside influences to continue. The magnitude of these changes, especially in an arid landfill, should be small compared to those prior to closure when MSW is still being accumulated; thus contributing to the production of leachate and LFG.

The other aspect of this comparison is the fact that the closure plan for the two operational extremes can be diametrically opposite each other. The dry tomb approach would typically have a impermeable cover which should insure that the MSW mass does not receive any outside disturbances (except for earthquakes or other possible "Acts of God"). The bioreactor cover may be designed to allow precipitation infiltration so that microbial degradation can continue at a rate comparable to that right before closure. The only difference is that no new MSW is being added (as said before) which can contribute to leachate and LFG generation above that produced by the existing MSW mass. Also, in this case the leachate and LFG quality and quantity changes are still occurring. The **potential** for significant changes in this approach is much, much less than in a dry tomb operation since the relative amount of the unstabilized mass is much greater in the dry tomb.

It can be concluded that the quickest way to reach leachate and LFG equilibrium (or a clearly defined trend in their production) is with a dry tomb MSWLF. This means that closure and PCC plans can be prepared which can justify a shorter PCC period than the statutory 30 year period. However, with a bioreactor type MSWLF, where MSW stabilization approaches completion, similar closure and PCC plans can be prepared that are more certain because future outside factors will have less chance for producing leachate and LFG changes, i.e., the trends should be more stable and indicative that an ultimate equilibrium has been reached. This fact will provide a greater degree of certainty in terms of the financial assurance aspect of the closure plans.

In closing, it is recognized that the percentage of biodegradable material in MSW is decreasing because of recycling and reuse efforts. This means that the time to reach the two equilibriums mentioned in the previous paragraph will approach each other as this trend continues. In fact, as the biodegradable fraction of MSW approaches zero, the time to reach equilibrium will become less and less for both systems until there are not bioidegradables.