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Dear Roger:

Thank you for your enlightening meetings on water quality regulation of composting sites. This letter represents my first attempt to formally parse the groundwater pollution potential of compost operations. I offer a possible option for establishing a statewide rule that that takes into account local conditions. Without composting as an option, California will have great difficulty meeting its landfill diversion needs. Above all, I would like to see composting survive as an affordable option for cities and businesses working to find beneficial uses for what would otherwise be waste. Chip and grind operations, currently exempt from this rule, contain the same contaminants (salts, metals, nutrients, pathogens) as compost, but do not reduce pathogens or stabilize material. The possibility of transmitting plant pathogens, possibly risking entire industries, should be considered prior to any actions creating market pressure toward less sanitary options.

Composting operations can be broken down into sequential activities. The most important are:

1. Receiving
2. Size reduction
3. Blending
4. Active composting
5. Curing
6. Screening
7. Stockpiling
8. Discharge
9. Washing

Each of these should have different considerations as the pollutants present can differ potentials for water transport exist from activity to activity. Pollutants of greatest concern as identified by your agency include:

- Salinity
- Nitrate
- Pathogens
- Metals

The current regulatory draft emphasizes impermeable pads. Such pads can be very expensive and will make many operations economically uncompetitive. I think that a more a flexible approach might be considered that focuses on protecting areas where leaching is most likely. Leaching is not just a function of soil conductivity; it is also controlled by the duration and amount of ponded water present. If water can be removed from operations quickly, leaching will be greatly reduced.

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Here is my appraisal of the significance of the activities listed above:

1. Receiving

Receiving areas accommodate truck movement and feedstock storage. Feedstock contain various amounts of salts, nitrate, pathogens, and metals, depending on their origins. Biosolids, foodwastes, and manures are usually not stored for long because of odor concerns. A key point is that metals at this point are organically bound and will not leach significantly. Heavy metals, if present, should be associated with solid particulates and would be detected in ponds capturing solids. Bacteria and helminthes are relatively large and unlikely to leach significantly unless water drains directly, as through an abandoned well. Viruses tend to sorb to clay particles and are also unlikely to move to groundwater. While there is some potential for viruses to move, the real threat is minimal. Stockpiled materials are not likely to contain significant nitrate. They may contain ammonium, however, which can be nitrified in the soil. Ammonium will not leach readily, except in sandy soils. Nitrate can leach quickly, but because the leachate will also contain dissolved organic matter and organic salts, I also expect significant denitrification to reduce overall nitrate fluxes. The salt content of these materials will depend on their origin. Salts will leach if given the opportunity.

2. Size reduction

Size reduction is a rapid process and I would not expect groundwater to be impacted. Size reduction applies to greenwastes and possibly foodwastes. Metals are not a significant concern here. The threat of pathogens movement into groundwater from foodwastes is small unless the site is used extensively as a means of intentionally disposing infected raw meat. Cooked, but spoiled foods may contain pathogens sufficient to infect someone who eats them, but seldom pose an environmental concern. Salts and inorganic nitrogen may be present. Ammonium will outweigh nitrate. If foodwastes are size-reduced care should be taken to avoid moisture emissions.

3. Blending

Blending is occasionally done indoors to avoid odors. Outside, it may be carried out on a concrete pad to facilitate working with heavy equipment. Usually it occurs during pile construction in the active processing area, however. Contaminants present in feedstock will be present during blending, but blending operations take place in a matter of hours or minutes, however, and for this reason do not normally pose a significant leaching concern. Water may be added during blending, and this should be done conservatively so that no runoff or leaching occurs.

4. Active Composting

During active composting conditions are maintained so that pathogens are rapidly inactivated. Once piles reach temperature, human pathogens, if present, are effectively reduced within 3 days. Repeated turning of windrows assures that all parts of the pile are exposed to heat, by moving exterior material to the hotter core. Because storm events carry particles from the outside of the pile, a single turning should be sufficient to reduce pathogen concerns. Heavy metals are associated with solid particles and are therefore not going to leach significantly. A bit of added mobility may occur as piles pass through an acid phase during active composting, but the effect should be small, transitory, and mainly in the interior of the pile where water movement should be minimal. The weak acids are organic, and the pH will be restored within the soil when the dissolved organic matter decomposes. In the event that metals do enter the soil, they will very likely be retained near the soil surface as most metals sorb to clay surfaces. Movement of metals, whether free or complexed together with dissolved organic matter, is associated with preferential flow patterns below unlined ponds or cultivated soils. It is not normally associated with the packed homogenized soils typical of compost production sites. Compost piles have an enormous capacity to capture and maintain water so movement out of a well managed pile through its interior should not occur. If there are questions about this, tests of the composts water holding capacity can be made and compared to the compost water content. Surface runoff during storm events can happen. Surface runoff can contain metals, pathogens, ammonium, and salts. Runoff water should be removed promptly by appropriate grading and diversion. Small puddles can be removed. Note that active compost is often covered with cured material to control odors and assure uniform heating, particularly in static pile systems. In some cases cured compost covers may be applied to reduce VOC emissions. Water is often, but not always, added to piles during active composting. If water is added, care should be taken to avoid significant surface runoff.

5. Curing

During curing little water is added yet compost maintains its absorbency. Pathogen levels are low. There is much less dissolved organic matter present and pH values will approach neutral. The potential for metal migration is therefore small. Some nitrate may be present, but most inorganic nitrogen will remain in the ammonium form. Nitrate is an indicator of a very mature compost. Cured compost does contain salts. Based on column studies conducted at UC Riverside, under normal conditions water is unlikely to leach from the bottom of cured compost, though care should be taken if curing piles are used as a means of disposing collected runoff water. The material can be tested for moisture content in the field to assure proper conditioning. Surface runoff from piles can occur and should be removed promptly. Curing piles are usually substantially larger than active piles and therefore present less surface area per unit of material.

6. Screening

Screening is a rapid process and significant leaching is unlikely because no water is added. During screening material is removed from the curing pile, quickly processed and delivered to stockpiles.

7. Stockpiles

Stockpiles are similar to curing piles except that piles of different particle sizes may be present. All absorb moisture. Most composters avoid large stockpiles of finished material, but market conditions sometimes make them necessary.

8. Washing

Equipment should be washed to avoid the possibility of cross contamination. Washwater may contain nutrients, salts, metals, and pathogens. Concentrations will depend on the amount of material removed, the amount of water used, feedstock properties, and the stage of processing.

In our research we have found that it is possible to estimate the water holding capacity of compost. There is considerable capacity to retain water following precipitation events. Percolation through pile should not normally occur. An exception might be for sodden food wastes or other inherently wet materials if they are stored for excessive time periods. Biosolids, wet manures, and food wastes are not normally stored in piles for any length of time however, due to the risk of odors and local regulations. It may be feasible to ask large composters to monitor precipitation and the moisture of their piles so that percolation is controlled. Composters actively avoid overly wet compost conditions because this interferes with the compost process, cooling piles, slowing the process, and generating significant odor concerns. In many parts of the state, composters must battle to maintain enough moisture in their piles. If, due to repeated precipitation events, compost becomes overly wet, it may be necessary to add fresh dry material and reinitiate compost operations. If you would like, I could work with you to develop a method for assessing the potential for rainfall to saturate piles to an extent that significant leaching occurs. Acceptable practices for drying saturated material might also be promulgated.

Compost surfaces are most likely to contact runoff water. Runoff can be collected by orienting piles parallel to graded surfaces. Diversions can be constructed as appropriate to reduce the concentration times of flows so that they can be removed promptly. Prompt removal will greatly reduce the leaching potential on compost sites. One enforcement approach might be to determine a leaching reduction ratio. The agency might, for example, determine a baseline infiltration value associated with no management practices (very long narrow piles on flat terrain, for example) for a region and then require some fraction of infiltration control. Composters could elect to grade, add diversions, modify their pile geometries, or treat their soils to reduce infiltration (and therefore the downward movement of pollutants). The Rational Method in this simple case would probably be sufficient to estimate improvements, though other methods would also serve.

I have also had an interesting thought recently. Composters commonly report dry conditions under their piles yet collect significant runoff during storm events. It should be noted that hydrophobicity may be a factor in some locations. Hydrophobicity occurs when organic acids enter soils and dry forming a waxy coating. Even sandy soils can strongly resist downward water movement under such conditions. Worldwide, this is a very significant problem for growers in semi-arid regions trying to water affected soils and there has been 50 years of active research on the topic. It is possible that in some locations the processing of compost may lead to impermeable conditions that would greatly facilitate water removal through surface flow rather than leaching. Time would be required for this condition to develop however, and not all organic acids contribute to this condition. It would be very simple to test for this condition and if it is manifested, regulatory targets could be adjusted accordingly. Organic acids are richest in the dark “compost tea” puddles that can form ephemerally when water is added to compost piles. One obvious management practice would be to have composters promptly remove these puddles. It would be an interesting if these puddles turned out to promote hydrophobicity and were protective of groundwater quality. I am far from any conclusions, but the fact that such puddles form and persist, rather than rapidly infiltrating, may lend credence to the possibility of this effect.

Composters can also police their operations and promptly remove any water standing as a result of their management techniques, such as water additions for dust or VOC control. Credit should also be given to composters who configure their piles so that water is captured within them. Piles that are wider and taller contain more material per unit area and will have significantly less exposed soil areas. These configurations normally require active aeration which can be costly, however. Aeration tends to dry piles from the bottom which will further discourage downward movement of leachate.

There is a precedent for regulating according to a pre-determined reduction in losses from an unmanaged system in proposed South Coast and Central Valley AQMD rules for reducing VOC emissions. Since different hydrologic zones in California have different baselines, one way to draft a statewide order would be regulate in terms of improvement over unimproved leaching depths. An average value should be used since infiltration potential will vary across a site. Site can be broken into sectors where the Rational Method, or another approach, can be applied.

I have looked at draft Leachate and Runoff Analysis Synopsis you linked within your September 29 email. Salinity (specific conductivity) and dissolved solids (TDS) appear to be the constituents identified as of greatest concern, although in all but one of the California cases levels were in the vicinity of, though above, acceptable drinking water standards as described here: http://www.swrcb.ca.gov/water_issues/programs/gama/docs/coc_salinity.pdf. Note that the units for conductivity in the document are puzzling. Units for this are usually in dS/m, though µmho/cm is also common. I am not familiar with µmho/cm^2. I assume it is not simply a typographical error as it appears throughout the document. Nevertheless, I will interpret these values as µmho/cm for the purpose of my discussion here.

The difference between the SMCL for salinity (1600 µmho/cm) and the noted measures seem within reach of regulatory goals in all but one case.

Demo project: 1050 – 1110 µmho/cm
Green waste analysis 1: 1200 – 2900 µmho/cm
Green waste analysis 2: 3300 – 12000 µmho/cm
Surface runoff: 2400 µmho/cm

Without knowing the specifics as to how these were collected, it is hard to evaluate these data. It is also not clear if these data represent hot spots or site averages. I would like to point out that salinity values for compost leachate are not as fixed as other sources. Much of the salt load in active compost is organic and likely transitory. As I mentioned above, organic salts decompose in water, serving as substrate for denitrifiers. Salinity may be reduced as organic salts decompose removing nitrate. Unfortunately, I do not believe that this has been specifically studied, and it will not completely resolve the problem. It would be interesting to pursue, however.

I have raised quite a number of points here. You may also be interested in supporting data. In some cases, the studies are available, while others represent extrapolations of data on my part. Please let me know if there are specific topics you would like me to support through literature citations, and I will be happy to do so. I am familiar with both composting and the scientific literature and will be happy to assist in making information available to you in any way you deem helpful. Obviously the industry knows the particulars of their practices better than I do and the opinions of the composters themselves should be respected for their ground-truthing experience. They will also have a better grasp of what is doable and what is not. As a University of California academic, I would not recommend a conclusion as to how compost operations should be regulated. Understand that this is simply offered as a starting place for considering the issues as a manageable scientific question.

Sincerely,

David M Crohn

David Crohn
Associate Professor and Extension Specialist