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SMALL SCALE WASTE MANAGEMENT PROJECT

Linear Loading Rates for On-Site Systems

by

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August, 1998

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In sizing on-site systems, the emphasis has been placed on sizing of the bottom area in either gpd/ft^2 or in ft^2/bedroom using either a bed or trench design. This approach has worked reasonably well for in-ground trenches and beds where the limiting condition has been at least 3 ft and the soil has been relatively permeable. However, with the introduction of mounds and at-grades, the site has become more restrictive due to smaller separation distances between the ground surface and limiting condition and more slowly permeable soils, especially on sites limited to the mound. To overcome deficiencies associated with the soil loading rate, the linear loading rate concept was introduced in the 1980s.

The linear loading rate is defined as the amount of wastewater applied daily along the landscape contour. It is expressed in gallons per day per linear foot along the contour.

The linear loading rate concept is a rather simple concept but one that can be hard to understand and interpret on a site by site basis. Where soil loading rates are based on soil texture, structure and consistence, linear loading rates are not as easily assigned for a given soil texture, structure and consistence as other factors such as distance from the ground surface to seasonal saturation or restrictive layers need to be considered. In essence linear loading rates have been used indirectly in the design of mound systems. Mounds in the State are not all the same length for a given daily design flow but vary in length depending on soil/site conditions. For example, in some parts of the state, the mound absorption area may be 100 ft long while in other parts of the state they may be 60 ft long. For a 3 bedroom home, the linear loading rate for the 100 ft long absorption area is 4.5 gpd/lf while for the 60 ft long absorption area it is 6.7 gpd/lf.

Assigning a linear loading rate is as much of an art as it is a science. In most situations, it has been based on judgement and experience. Thus, the following will serve as a guide for assigning linear loading rates and thus dictating the system length along the contour. Linear loading rates are not affected by effluent quality as is soil loading rates. The linear loading rate relates to getting the effluent away from the soil absorption unit and the soil loading rate is more related to clogging mat/soil interaction. Applying highly pretreated effluent (sand filter and aerobic unit effluent) will allow downsizing of the absorption area (increase soil loading rate in gpd/ft^2)but it will not affect the linear loading rate. Thus the length of the soil dispersal unit receiving highly pretreated effluent will be similar to a mound receiving septic tank effluent on similar soil profiles.

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Figure 1 illustrates the concept. The left diagram represents the soil treatment/dispersal bottom area (LxW) for septic tank effluent and the arrows on the bottom represent the linear loading rates. The middle and right diagrams represent the soil treatment/dispersal bottom area assuming the site will accept 50% downsizing (LXW)/2, resulting in soil loading rate (gpd/ft^2) twice that of the left diagram. The bottom area of the middle and right diagrams are equal but the linear loading rate on the right one is twice that for the middle one because it is half as long. The linear loading rate of the right one is 2 times the linear loading rate of the left diagram but the middle diagram has the same linear loading rate as the left diagram. The site might not be able to handle the linear loading rate assigned to the right diagram (2 times) and thus the design for the site may be inappropriate.

Figure 2 in the Wisconsin Mound Manual and the Wisconsin At-grade Manual provides excellent graphics of water movement away from mounds and at-grade units. It is similar for other soil dispersal units such as in-ground beds/trenches with restrictive layers (seasonal saturation, slowly permeable soils), especially if separation distance is only one to two feet which may be the case for highly pretreated effluent. The discussion presented in the manuals gives the designer a better understanding of what linear loading rate to assign to a given soil profile.

If the design is for a replacement system, the existing system length may be a good indicator of the linear loading rate for the site if the system failed because of longevity (clogging). If it surfaces only during high seasonal saturation, then failure may be due to the fact that the effluent can not move away from the distribution cell fast enough. Thus, the linear loading rate may need to be reduced for the new system, resulting in a longer system. However, the seasonal saturation may intrude into the system because seasonal saturation may be close to, at or above the bottom of the system. On some sites, where limiting conditions may not allow for the most appropriate linear loading rate, the designer must decide the degree of risk he/she is willing to take that 1) effluent will leak out the mound toe or 2) effluent will pond in shallow in-ground trench during stress periods.

The following examples will provide some guidelines in assigning linear loading rates.

Site 1.

Soil/Site Conditions

0- 6" Silt loam with moderate medium subangular blocky structure and friable consistence.

6-14" Clay loam with weak subangular blocky structure and friable consistence

14-24" Clay loam with massive structure and very firm consistence.

Seasonal saturation at 6" but may be higher as it is difficult to determine redoximorphic features in the top soil. Slope of 5%.

Summary

Highly pretreated effluent would enter the silt loam surface horizon relatively easy because of the structure and consistence. During the drier seasons, the effluent would move vertically downward to the clay loam horizon where it would be held up somewhat because of the texture and weaker structure. Since this profile has a slower permeability some of it would move horizontally and as it moves horizontally, gravity and capillary action would pull it downward. As it reaches the next lower horizon, the vertical flow is slowed up because of the massive structure and very firm consistence. Depending on the degree of massiveness, some will move vertically while the majority will move horizontally. During wet seasons (saturation at 6" or so), the situation is aggravated further because there is no vertical movement. A linear loading rate of 3 gpd/lin.foot is suggested for this site. Also, during the wet season, there is a good possibility of a spongy toe and toe leakage out of the modified mound especially if the surface horizon consists of slowly permeable soils such as clay loams. For a system serving a 3 bedroom home (450 gpd), the distribution cell (aggregate) length would be 150 ft along the contour.

Site 2

Soil/Site Conditions

0- 8" Silt loam with moderate medium subangular blocky structure and friable consistence.
8-17" Silt loam with weak, medium subangular blocky structure and firm consistence.
17-40" Clay loam with strong, medium angular blocky structure with firm consistence.
40-60" Clay loam with moderate, fine angular blocky structure with firm consistence.

Seasonal saturation at 17" and site slope of 8%.

Summary

Highly pretreated effluent would enter the silt loam surface horizon relatively easy because of the structure and consistence. As it approached the next horizon, it would be slowed up slightly because of the weak structure and firm consistence with some horizonal movement but mostly vertical movement. As it approaches the third horizon, it would be slowed some because of texture change but still have significant vertical flow. During the wet season there would be about 17" of vertical soil for the effluent to move horizontally away from the system. A linear loading rate of 5 gpd/lf may be appropriate for this site if the separation distance is at least 17". For a shallow in-ground trench with the bottom at 5" below the surface, a similar linear loading rate may be appropriate but the system will be somewhat stressed which may result in possible ponding occurring in the distribution cell (aggregate, chamber).

Thus the designer must be cognizant how the effluent moves away from the soil dispersal unit especially on the more restrictive sites which, for the most part, is the case when highly pretreated effluent is applied.

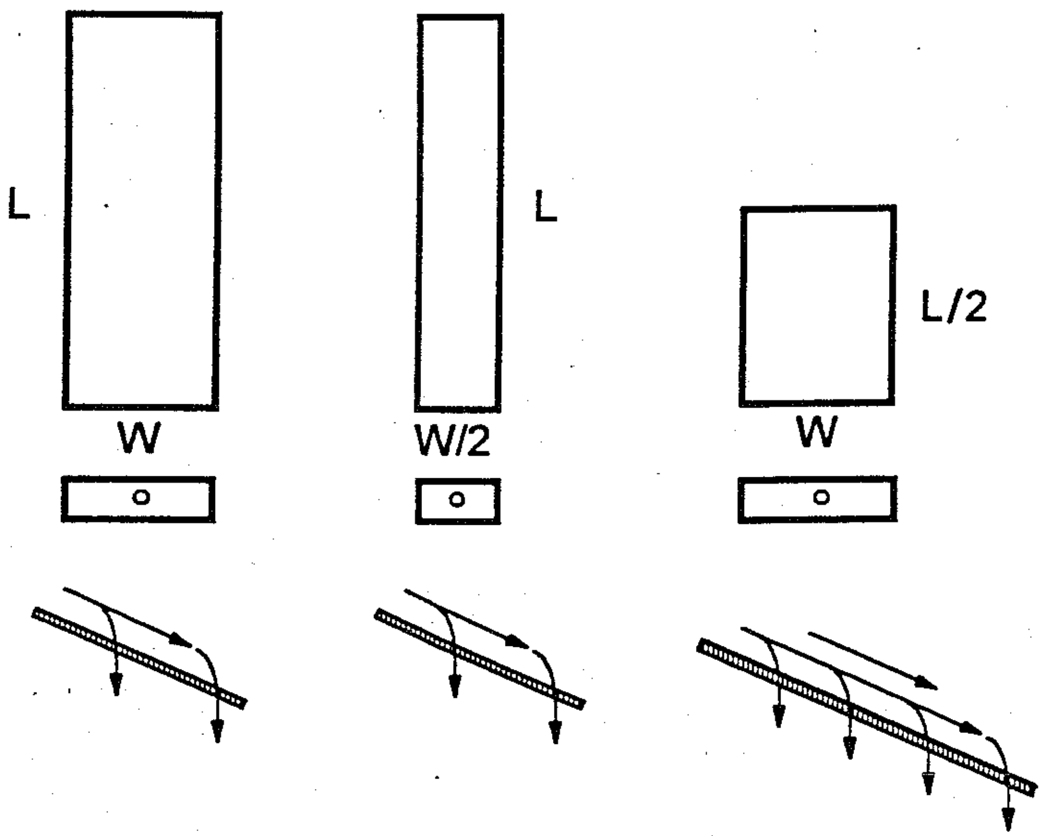

Fig. 1. These three diagrams illustrate how downsizing configuration affects linear loading rates. The left diagram represents the full size system. The middle one represents a half size system (bottom area) resulting in twice the soil loading rate and the same linear loading rate. The right one also represents a half size system (bottom area) resulting in twice the soil loading rate and but also twice the linear loading rate.

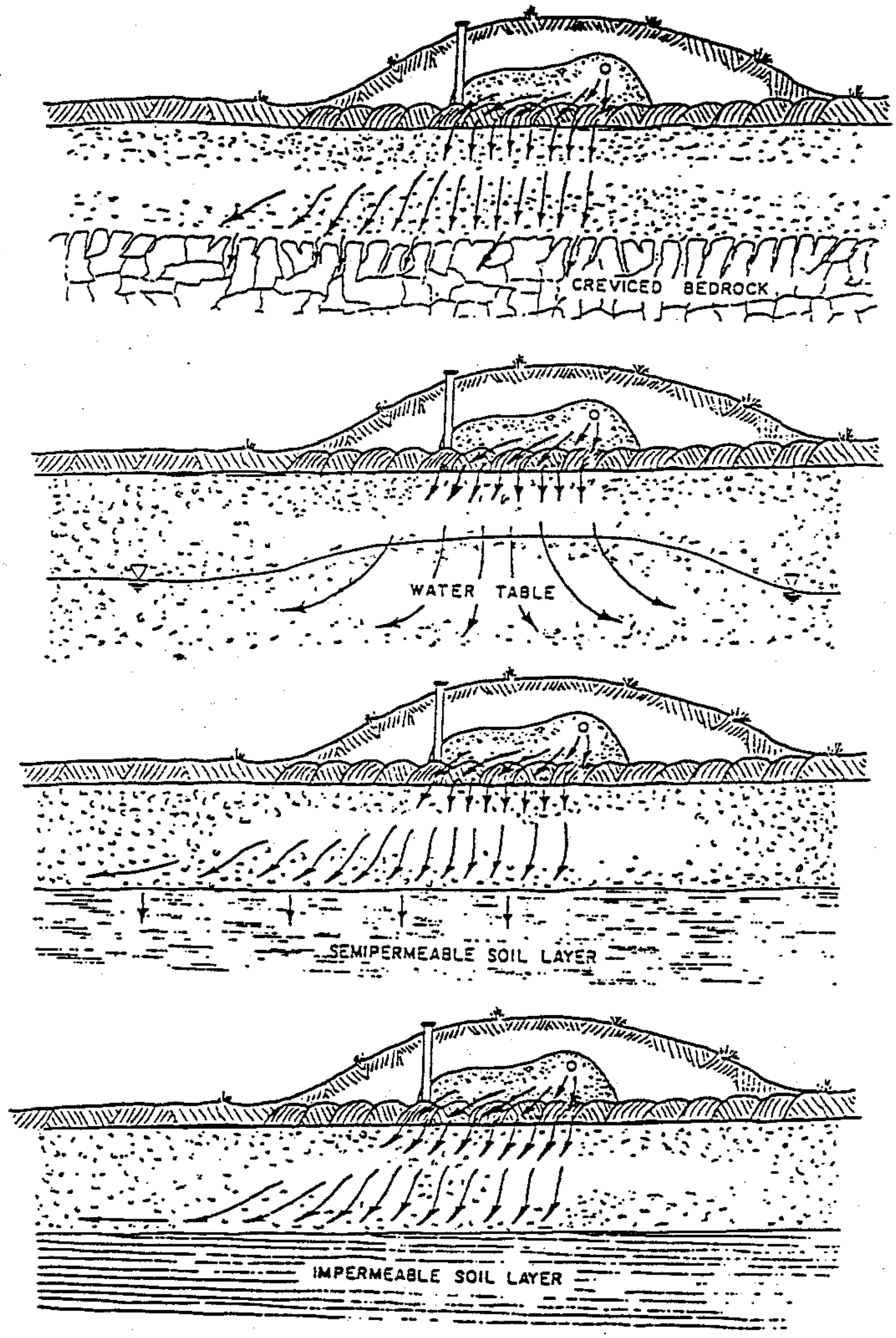

Fig. 2. This schematic represents flow away from a soil treatment unit under various soil/site conditions illustrating at-grades but suitable for mounds and other soil systems. The upper one represents permeable soil over creviced bedrock with mainly vertical flow. The other three represents more restrictive conditions resulting in lower linear loading rates.

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