3.9 Hydraulic application rate and scheduling

Hydraulic application rate can be interpreted as:

- the instantaneous application rate which allows infiltration without runoff
- the amount of water per application to fill the soil profile, or
- the seasonal or annual application needed to meet plant water requirements.

In the case of dairy effluent, nutrient loading usually governs the area of land required for spreading and the water demand by crops is usually satisfied by rainfall or irrigation. However, all of the above points are critical: the first two to avoid the loss of nutrients in runoff, the latter for its limitation on yield and nutrient uptake.

Typical values of hydraulic conductivity

The instantaneous application rate under irrigation must not exceed the soil's hydraulic conductivity (infiltration rate) or runoff will occur. Typical values for hydraulic conductivity are given by Hazelton and Murphy (2007) and are reproduced in Table 1 (these values are estimates only and should be used with caution). The acceptable range for effluent is generally 5 to 50 mm·h^{-1}.

Table 1. Typical hydraulic conductivities of various soil types (Hazelton and Murphy 2007).

Texture	Structure	Infiltration	Permeability (mm·h^{-1})
Sand	apedal	very rapid	>120 (can be >250)
Sandy loam	weakly pedal apedal	very rapid rapid	>120 60–120
Loam	peds evident weakly pedal apedal	rapid moderately rapid moderately rapid	60–120 20–60 20–60
Clay loam	peds evident weakly pedal apedal	moderately rapid moderate slow	20–70 5–20 2.5–5
Light clay	highly pedal peds evident weakly pedal	moderate slow very slow	5–50[a] 2.5–10 <2.5
Medium to heavy clay	highly pedal peds evident weakly pedal	low to moderate very slow very slow	2.5–50[a] <5 <2.5
Clay		moderate very slow extremely slow	8 <2.5 <1

a: Strongly structured polyhedral subsoils, e.g. Krasnozem or Dermosol.

The application rate should be governed by the steady-state hydraulic conductivity of the soil, which can be influenced by groundcover and previous soil management. Over time, the hydraulic conductivity of soil under effluent and solids application can change as a result of pore clogging (Magesan *et al.* 1999). Increasing soil sodicity associated with the application of salt can also reduce the hydraulic conductivity of clay soils.

Soil water-holding capacity

As most plants extract water directly from the soil, the physical characteristics of the soil influence the quantity and availability of water to plants. Soils capture and hold water within the air spaces and around the soil particles; the strength with which soils retain this water depends on soil structure and texture. This strength is expressed as pressure or suction, with higher values indicating less readily removed water. Water availability in soils is commonly expressed as mm water per metre of soil depth; this relates directly to volumetric soil moisture content.

Typical relationships between soil water tension (the holding strength) and available soil water are presented in Table 2. This information is commonly used to assist scheduling of effluent applications, as soil moisture meters frequently rely on parameters related to it. In conjunction with rooting depth for the crop or pasture to which effluent is applied, it also governs the maximum depth of water that can be applied without having water (and potentially any soluble nutrients) move beyond the root zone.

Table 2. Relation between soil water tension (in kPa) and available soil water (in mm·m^{-1} soil depth) (Doorenbos and Pruitt 1984)**.**

Soil water tension (kPa):	20.3	50.7	253	1520
Soil texture	Available soil water (mm·m^{-1})			
Heavy clay	180	150	80	0
Silty clay	190	170	100	0
Loam	200	150	70	0
Silty loam	250	190	50	0
Silty clay loam	160	120	70	0
Fine-textured soils	200	150	70	0
Sandy clay loam	140	110	60	0
Sandy loam	130	80	30	0
Loamy fine sand	140	110	50	0
Medium-textured soils	140	100	50	0
Medium fine sand	60	30	20	0
Coarse-textured soils	60	30	20	0

Seasonal water demand

Crop and pasture yield, and consequently nutrient uptake, depend on moisture availability. For dairy farms without irrigation, the size of the reuse area must therefore take into account the variation in yield with dry, average and wet years (10th percentile, mean and 90th percentile rainfall years).

Chapter 2.6 ‘Effluent storage requirement’ provides a model for assessing the hydraulic balance and determining seasonal or annual water demand. The following section provides further information on typical crop water use or evapotranspiration.

Crop evapotranspiration

Seasonal water use by crops and pastures (crop evapotranspiration, or ET_c) commonly falls within the ranges shown in Table 3 (see chapter 2.6 ‘Effluent storage requirement’ for calculating ET_c).

Table 3. Range of seasonal ET_c (Doorenbos and Pruitt 1984).

Crop	Seasonal ET_c (mm)	Crop	Seasonal ET_c (mm)
Deciduous trees	700–1050	Tomatoes	300–600
Maize	300–600	Vegetables	250–500
Onions	350–800	Lucerne	700–1100
Oranges	600–950	Perennial pasture	600–900
Potatoes	350–625		

3.9 Hydraulic application rate and scheduling

Water requirements may be met by both irrigation and rainfall, although the latter is unpredictable. The selection of crops and pastures to be grown across the reuse area must take into account water availability, or their capacity to use the nutrients applied will be curtailed.

Crop coefficients

In assessing water use, it is important to take into account crop growth stage and cultural practices such as grazing or cutting. FAO (1988) provides further information on calculating ET_c under non-standard conditions.

Table 4 documents crop coefficients (k_c) for a range of crops. The hydraulic balance model (Table 2, chapter 2.4 'Effluent storage requirement') can be used to indicate the relative water use by a range of crops where the district evaporative rate is known. If reference crop data for the district is available, it will generally be more reliable than modelled data.

Table 4. Indicative crop coefficients (k_c) for water budget modelling (Doorenbos and Pruitt 1984).

Percentage of crop-growing season:	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Lucerne	0.55	0.60	0.70	0.80	0.90	0.95	0.95	0.95	0.90	0.80	0.65
Beans	0.20	0.30	0.40	0.65	0.85	0.90	0.90	0.80	0.60	0.35	0.20
Citrus and avocados	0.50	0.45	0.45	0.45	0.45	0.45	0.50	0.55	0.60	0.55	0.50
Maize	0.20	0.30	0.50	0.65	0.80	0.90	0.90	0.85	0.75	0.60	0.50
Cotton	0.10	0.20	0.40	0.55	0.75	0.90	0.90	0.85	0.75	0.55	0.35
Fruit, deciduous	0.20	0.30	0.50	0.60	0.70	0.75	0.70	0.60	0.50	0.40	0.20
Fruit with cover	Averages about 1.00 for periods of rapid growth of cover crop										
Grain sorghum	0.20	0.35	0.55	0.75	0.85	0.90	0.85	0.70	0.60	0.35	0.15
Grain, spring	0.15	0.20	0.25	0.30	0.40	0.55	0.75	0.85	0.90	0.90	0.30
Grain, winter	0.15	0.25	0.35	0.40	0.50	0.60	0.70	0.80	0.90	0.90	0.30
Grapes	0.15	0.15	0.20	0.35	0.45	0.55	0.55	0.45	0.35	0.25	0.20
Shaftal clover	Averages about 0.95 for maximum growth										
Walnuts	0.30	0.35	0.55	0.70	0.75	0.75	0.75	0.65	0.55	0.30	0.15
Pecan nuts	0.35	0.45	0.55	0.75	0.75	0.65	0.50	0.45	0.40	0.35	0.30
Peanuts	0.15	0.25	0.35	0.45	0.55	0.60	0.65	0.65	0.60	0.45	0.30
Potatoes	0.20	0.35	0.45	0.65	0.80	0.90	0.95	0.95	0.95	0.90	0.90
Rice	0.80	0.95	1.05	1.15	1.20	1.30	1.30	1.20	1.10	1.90	1.50
Sugar beets	0.25	0.45	0.60	0.70	0.80	0.85	0.90	0.90	0.90	0.90	0.90
Sugar cane	Varies from 0.55 to 1.00 depending upon rate and stage of growth										
Vegetables, deep rooted	0.20	0.20	0.25	0.35	0.50	0.65	0.70	0.60	0.45	0.35	0.20
Vegetables, shallow rooted	0.10	0.20	0.40	0.50	0.60	0.60	0.60	0.55	0.45	0.35	0.30

Scheduling irrigation frequency

Because water use will vary daily with weather conditions, the frequency with which irrigation water will be applied will vary substantially. Daily water use by some crops can exceed 10 mm on some summer days so much greater reliance is now placed on short-term weather forecasts and soil moisture monitoring

The following equation relates irrigation interval to ET_c and the available soil water from 'Soil water holding capacity' above:

$$\text{Irrigation interval (day)} = \text{available soil water in root zone (mm)} / ET_c \text{ (mm day}^{-1}\text{)}$$

3.9 Hydraulic application rate and scheduling

It is unlikely, and undesirable, that effluent be applied at every irrigation, as effluent storages are generally drawn down over the irrigation months. Effluent applications should be planned for periods of maximum crop growth and to allow a minimum exclusion period of 2 to 5 weeks before any grazing occurs (see chapter 3.11 ‘Microbial risks’).

When applying effluent, whether it be as part of an irrigation event or as the only source of applied water, check the short-term weather forecast to avoid applications before wet weather.

References

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