18.0 - fertilisers and the environment

- biological activity
- fertiliser and acidity
- contaminants in fertilisers
- nitrate leaching
- nutrient runoff
- stock poisoning by fertiliser
- nitrate poisoning
- effluent disposal
- elemental composition of phosphate rocks
- typical dry matter (%) and nutrient concentrations (%) in some common effluents

18.0 fertilisers and the environment

The Resource Management Act (1991) requires that the air, soil and water be managed according to the principles of sustainability. A Fertilisers Code of Practice has been developed which provides a framework for assessing and managing the potential environmental and social issues related to the use of fertilisers (see Chapter 3).

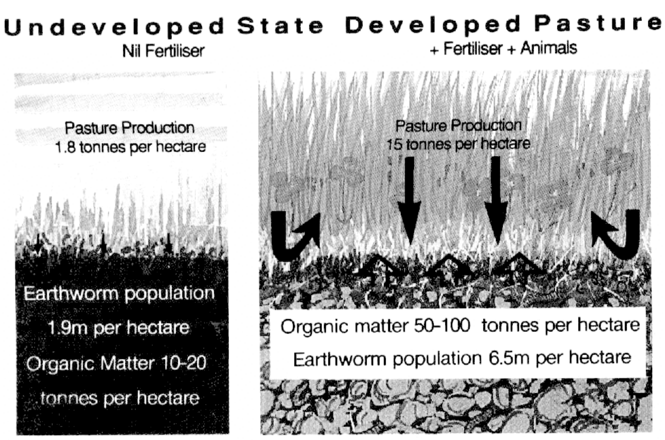
The Code of Fertiliser Practice is based on the Framework for Evaluating Sustainable Land Management (FESLM) which defines any practice as sustainable if it simultaneously:

1. increases or sustains production
2. decreases the risks of production
3. has minimal effect on resources
4. is economic
5. is socially acceptable

By this criteria the efficient and responsible use of fertilisers is a sustainable practice for there can be no doubt that fertiliser are required to sustain production, reduce the risks of achieving production and are economic. The future challenge is to develop the technologies and practices that ensure that the use of fertilisers is socially acceptable and has minimal effect on the resources, soil, water and air.

Some of the major issues are discussed below.

Figure 18.1 Earthworm Population in Developed and Undeveloped Pasture



SOIL QUALITY

The quality – chemical, physical and biological – of NZ soils is generally very good in an international context. This is because NZ soils are young and have not been greatly weathered and, importantly, the major land use is pastoral agriculture. The exceptions include soils that are over-cropped and those vulnerable to erosion. Note that these exceptions are related to land use and not to fertiliser use.

Biological Activity

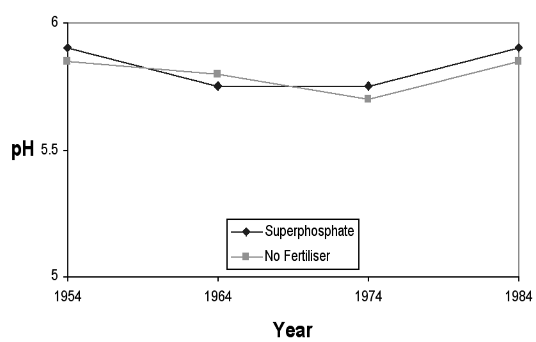
There is much evidence showing that all fertilisers have beneficial effects on soil biology and soil biological activity (Figure 18.1), providing their use is coupled with appropriate management systems that maximise the return of plant litter to the soils. This occurs because on nutrient deficient soils, fertilisers increase plant growth and consequently more plant litter is returned to the soil. In pastoral farming this is enhanced further by the return of dung and urine. This litter provides a healthy substrate for soil macro and microorganism. It is not surprising therefore that given fertiliser, time and, in the pastoral situation, the grazing animal, soil organic matter and biomass levels increase and can reach very high levels. (see Tables 9.4) The more "closed" the system, the faster the accumulation of organic matter.

Continuous cropping with stubble removal, for instance, will result in a decline in soil organic matter. Organic matter also influences many soil physical properties. Thus a consequence of higher organic matter levels is often an improvement in the tilth and friability of soils (see Chapter 8).

Fertiliser and Acidity

Some fertilisers, when they react in the soil, produce acids; others have a liming effect (Table 16.1). These effects are not related to whether the fertilisers are defined as organic or otherwise. For example, elemental S is defined as an organic fertiliser but decreases soil pH. Superphosphate and potash, two chemical fertilisers, have no long-term effect on soil pH (Figure 18.2). This highlights the danger of making generalisations. It is far better to understand the specific effects of the different fertiliser products and manage the consequences accordingly.

Figure 18.2 An Example of the Effect Of Superphosphate On Soil pH



The amounts of lime to counteract the acidity caused by different fertilisers are given in Table 16.1. Note that these effects are not large. It takes either excessive inputs, or continuous inputs over a long period of time, for significant practical effects on soil pH to occur. Generally the acidifying effects of fertiliser on soil pH can be readily managed with the normal liming program.

Fertilisers, with the exception of N fertilisers, stimulate legume symbiotic N fixation. This is most desirable. However, fixed N, which is subsequently leached as nitrate N, as occurs mainly from urine patches, causes acidification. So too does the removal of crops when they contain an excess of base elements, and the accumulation of organic matter. These, and other natural biological processes (see Chapter 10 and 16) have much larger acidifying effects than fertilisers.

It has been calculated that the net effect of all these acidifying processes in fertile pastoral soils is production of acidity equivalent to that which requires about 200-400kg limestone/ha/yr to neutralise. This accords well with the current general practice of applying 2.5 tonnes limestone/ha every 4-5 years to maintain soil acidity.

Contaminants in Fertilisers

The raw materials from which all P fertilisers are derived have either biological or geological origins. Thus, they contain most, if not all of the elements present, or which accumulate, in these systems. Some of these "contaminants" are beneficial (see Chapter 15). Others (Table 18.1) are potentially dangerous if they are allowed to accumulate in the environment.

Of particular concern is the element cadmium (Cd), which through normal geological and biological processes, accumulates in the food chain. It can be toxic to humans at high concentrations.

Fortunately, and despite many years of fertiliser use, New Zealand soils currently have low levels of Cd. Nevertheless, it is accepted that Cd does accumulate in some fertiliser deposits (Table 18.1) and that fertilisers do contribute to the accumulation of Cd in soils.

For this reason, the New Zealand fertiliser industry has taken the initiative and imposed limits on the Cd concentration in the raw materials it uses to manufacture fertilisers. The maximum permissible level is 280 mg Cd/kg of P in superphosphate.

In effect, this means that the Cd concentration in super must be less than 20-30 ppm.

A consequence is that the industry must select raw materials that are low in Cd (Table 18.1). These are very high standards and will mean that the agricultural industry is operating well within the safety guidelines that have been developed internationally.

NITRATE LEACHING

Nitrate can be leached from soils (see Chapter 10), thus elevating the nitrate N concentration in the ground water. The current international standard is that the nitrate N concentration in drinking water should be less than 10ppm. There is evidence that this level is exceeded in some groundwaters in the Pukekohe, Waikato and Taranaki regions.

The major point source of nitrate leaching in pastures is the urine patch and the reason for this is that the rate of application of N in the urine patch is much greater than what the plant can utilise (i.e. 1000kg N/ha for cows and 500 kg N/ha for sheep). Importantly, most of the N leaching from urine patches occurs in the autumn and winter periods when the soil is saturated with water. Direct loss of fertiliser N by leaching is small (about 10% of that applied at 400 kg N/ha/yr).

Increasing the amount of N in the N cycle (see Chapter 10), either by legume symbiotic N fixation or the addition of fertiliser N, enables more animals to be carried, increasing the number of urinations and therefore the amount of N leached. Thus nitrate leaching is a problem related to productive legume based pastures and is not due to fertiliser N use per se.

While the incorrect use of N fertiliser, including the use of the wrong form applied at the wrong time, may increase the leaching losses of N the problem of reducing leaching losses of N generally must be approached by finding management systems which limit the leaching of N from urine patches. Options that are currently being researched include:

- → Removing animals from pastures during the autumn and winter onto a feeding pad. Note that this will only have a net positive effect if the urine from the feeding pad is collected and distributed evenly back onto the land.
- → Decreasing the total N in the N cycle. This will reduce the total production and will require a decrease in stocking rate and hence in animal production. Note that reducing the stocking rate per se will not reduce N leaching if the remaining animals simple ingest the balance of the pasture.
- → Changing the feed balance of animals by decreasing the proportion of pasture (protein rich) and increasing the proportion of low protein feeds such as maize silage.

NUTRIENT RUN-OFF

Nutrient run-off is essentially a P problem. About 90% of the P entering fresh waters comes from diffuse sources (as run-off and sediment). The balance comes point sources (industrial and urban). The amounts lost from pastoral land range from 0.1 to 1.7 kg P/ha/yr.

Most (80%) is in the form of P attached to soil particles (particulate associated P (PAP)) and the balance as soluble P dissolved in run-off water).

Surface run-off of dissolved P and direct application of fertilisers to waterways are the major sources of dissolved P in water bodies while stream channels and hill slopes are the main sources of sediment P.

The application of fertilisers, whether soluble or slow release, increases the P status of the soil and hence increases the amount and concentration of P in both dissolved P and sediment P. Water soluble P fertilisers have a greater immediate (50-100 days) effect on dissolved P in run-off than less soluble P fertilisers, such as RPR. But in the longer-term slow release P fertilisers may pose a greater overall risk to P run-off because they remain on the soil surface for longer than soluble P fertilisers.

Options for reducing run-off of P, both dissolved P and PAP include:

→ Avoid direct application of P fertiliser to water ways.

→ Avoid applying P fertilisers in the late autumn and winter (ie prior to the period of greatest rainfall) and when extremely dry, such that the fertiliser will not become rapidly incorporated into the soil, particularly on hill soils.

→ Fencing of waterways to eliminate animals and hence reduce the input of topsoil excreta and plant material into waterways.

→ Reducing erosion generally and specifically steam bank erosion.

→ Developing riparian strips along stream banks.

STOCK POISONING BY FERTILISER

Fertiliser P, if ingested directly by livestock, can cause P and/or fluoride (F) toxicity. Accordingly, animals should not have direct access to fertiliser bins or other storage facilities. Also, it is important that pastures should not be grazed if there are fertiliser particles adhering to the leaves.

Ideally, grazing should not occur until sufficient rain (25mm) has washed the particles onto the soil. Where high rates of fertiliser (1000kg/ha) have been applied, special care is required. If phosphate poisoning is suspected, this can best be established by F analysis of blood levels.

NITRATE POISONING

High levels of Nitrate N can arise in plants, causing toxic conditions for animals. This can often occur in the autumn after a prolonged dry spell when soil N is released following rain. High Nitrate N can also occur when grazing fast growing winter forages and crops. Sometimes high levels can also be experienced in the spring period. Stock management practices e.g. feeding hay, at these times needs to be adopted to minimise any impact.

EFFLUENT DISPOSAL

The practice of land disposal of effluents and other organic waste streams is increasing. While this is to be encouraged, problems can arise. The most frequent problem, especially with dairy shed effluent and dairy factory whey, is that the area to which it is applied is too small. The consequence is that the rate of application of water and nutrients is too high and the soil becomes waterlogged and/or overloaded with nutrients. In effect, the site become a large point source for nutrient losses. This can be further complicated if the effluent is high in sodium (Na) as can be the case for some whey products. Excess Na can cause the clay particles to flocculate with a decrease in the soil physical quality.

The key steps to avoid these problems include:

→ Analyse the particular effluent or organic waste material for N, P, K, S. Include Na and heavy metals (Pb, Cd) if these are suspected to be present.

→ Determine the rate of application such that the amounts of nutrients applied per hectare will not overload the soil. This calculation will need to take into account the likely nutrient uptake and removal of the crop or pasture system.

→ Given the volume of product to be used or disposed of, calculate the area of land required.

A list of common waste products and their typical nutrient analysis is given in Table 18.2.

Note that some Regional Councils limit the rate of application of some waste products. For example, for dairy shed effluent the maximum permissible application rate is 150 kg N/ha. At this rate it would also apply 25 kg P/ha and 105 kg K/ha.

Table 18.1 Elemental Composition of Phosphate Rocks

Rock Source	Total P	Cu ppm	Cr ppm	As ppm	Cd ppm	U ppm	Ni ppm	Mo ppm	Pb ppm
Arad	14.4	9	116	6	11	148	12		< 5
Bucraa	16.0		73	9	36	75	7	12	< 5
China	16.0		18	14	2	15	12		60
Duchess	14.1	15	36	8	3				< 5
Egypt	13.2			9	5				
Florida	14.3		50	5	10	130	28	12	35
Gafsa	13.0		196	3	36				10
Jordan	14.8		55	11	8	45	8	5	< 5
Khouribga	14.4	36	200	18	17	85			10
Kola	17.0				4				
Mexico	14.8		89	3	24	126	25		10
Nauru	16.9	10	59	3	94	55			< 5
Nth Carolina	13.1		405	15	46	64	30	32	<5
Phalaborwa	17.4			11	2				
Sechura	12.8	17	108	26	30	70	10	32	5
Syria	12.90	36	137	5	5	85	33	6	< 5
Togo	15.9	22	78	24	61	115	38	6	16
BG4	12.5	25	216	7	6	107	13	5	< 4
Xmas	14.5	31	76		28	18	8		18
Zin	13.7	11	39	4	26	110	40	28	< 5

Note: 1. Levels, particularly of minor elements, will vary depending upon mine source and P source being excavated

Table 18.2 Typical Dry Matter (%) and Nutrient Concentrations (%) in Some Common Effluents

Effluent	DM	N	P	K	S
Dairy					
Shed Effluent Sludge		0.044	0.008	0.03	
Whey - Lactate		0.14	0.07	0.16	0.01
Whey - Permeate		0.05	0.03	0.13	0.01
Pig					
Effluent	2	0.1	0.06	0.05	0.01
Solids	25	0.6	0.3	0.1	0.1
Poultry					
Cage manure	40	1.4	1.4	0.7	0.3
Broiler litter	75	2.5	1.5	1.3	0.3
Feed waste	15	0.12	0.022	0.2	0.016

Note: 1. Whey normally spread at 43,000 l/ha supplies the equivalent of some 450 kg/ha, 30% Potash Super + 100 kg/ha Urea.
2. Broiler litter spread at 2 tonnes/ha supplies the equivalent of 400 kg/ha, 15% Potash Super + 100 kg/ha Urea.