# FACTORS INFLUENCING SOIL AND NUTRIENT LOSS IN STORMWATER FROM A MARKET GARDEN

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## Abstract

This paper refers to a subset of data from a nutrient monitoring project in the Hawkesbury-Nepean catchment. Surface water runoff sampling and measurement of flow were carried out at the boundary of an 8 ha market garden (with 6.3 ha of vegetable growing area) near Richmond (NSW) over two years. Land management on the farm was fairly typical of other market gardens on poorly drained, moderately to highly erodible loams, overlying Wianamatta shale. Erodibility was increased by regular cultivation and low soil cover. Runoff samples were analysed for concentrations of suspended solids and particulate and soluble forms of N and P. Losses of suspended solids, N and P in stormwater were calculated for each major runoff event. Over the two year period, 240 t of soil, 138 kg of P, and 1599 kg of N were transported off the farm. P was transported predominantly in particulate form. The results highlight the need for more efficient fertiliser application combined with erosion prevention and control measures.

*Key words: Stormwater, phosphorus, nitrogen, erosion, cultivation, soil cover, fertiliser.*

Market gardening is considered by many as detrimental to water quality. Land management practices include intensive and frequent fertiliser inputs, cultivation, irrigation and pesticide use. Management practices need to be improved to provide greater long-term profitability and decrease the deleterious impacts on water quality.

This paper concerns nutrient movement and soil erosion from a commercial market garden. By comparing land management practices to farm-scale soil erosion and nutrient loss, our understanding of how land management influences soil and nutrient loss can be improved. This paper refers to data from a farm draining to station 6 in a major nutrient runoff monitoring project (1).

## Methods

Runoff quality and quantity was monitored over two years. Samples taken by an automatic sampler were analysed for concentrations of suspended solids and particulate and soluble forms of N and P. The methods are described in further detail by Baginska et al. (1). ?Surface soil samples were analysed at the beginning and end of the monitoring period. Management practices were observed and documented and fertiliser inputs were quantified over the course of the study.

Land management was surveyed for seven runoff events that occurred after January, 1996. Soil cover and disturbance were assessed visually and mapped at the time of each runoff event. The following definitions were used. Soil Cover: the percentage of the site, including furrows, occupied by the vertical projection of foliage and other material (vegetable plant, weeds, plastic mulch, stubble and residue). This was estimated to the nearest 10 %. Soil Condition: qualitative estimate of the degree of disturbance to the soil surface, on a scale of 1-3, with 1 being low and 3 being high. Nutrient additions were carefully documented over the 2 year study

### *Description of the farm*

The soil on the case study farm near Richmond, NSW, is a Brown Podsolic (Db2.41, Db1.41) overlying Wianamatta shale. The soil on the vegetable growing beds is moderately to highly erodible, due to high silt and fine sand content (74%), poor structure, and low organic matter. The $A_1$ horizon is moderately dispersive, while the $A_2$ horizon is moderately to highly dispersive. Background concentration of plant available P in 0-10 cm of soil is low (5 mg/kg) but is very high on the vegetable beds (174-304 mg/kg). Organic C was well below that of an adjacent uncultivated soil (0.79-0.95 % and 3.0 % respectively).

Table 1: Total fertiliser inputs over 2 years

| Fertiliser | Weight [kg] | Timing | N [kg] | P [kg] |
|---|---|---|---|---|
| Ammonium nitrate | 4000 | side/base dressings | 1880 | 0 |
| Poultry manure | 112 000 | summer - autumn | 3584 | 2408 |
| | | TOTAL | 5464 | 2408 |
| | | kg/ha/yr | 433 | 182 |

Table 2: Losses of suspended solids (SS), nitrogen and phosphorus from the market garden over 2 years

| Runoff event | SS losses [kg] | N losses [kg] | P losses [kg] | Rain [mm] | Peak runoff [$m^3$/min] |
|---|---|---|---|---|---|
| 19 - 21/09/95 | 266 | 11.3 | 0.3 | 35.7 | 2.0 |
| 24 - 26/09/95 | 20 281 | 109.7 | 7.8 | 94.0 | 13.7 |
| 19 - 22/11/95 | 976 | 178.9 | 1.7 | 84.6 | 3.1 |
| 1 - 2/12/95 | 3 109 | 29.6 | 2.0 | 25.3 | 4.7 |
| 5 - 6/12/95 | 1 778 | 39.8 | 1.5 | 24.8 | 5.8 |
| 2 - 16/01/96 | 3 553 | 74.1 | 2.1 | 63.6 | 3.7 |
| 19 - 20/01/96 | 71 069 | 92.7 | 27.0 | 64.5 | 22.2 |
| 27 - 29/02/96 | 6 290 | 19.9 | 4.3 | 23.3 | 5.8 |
| 2 - 6/05/96 | 34 279 | 448.4 | 22.0 | 117.6 | 6.7 |
| 30 - 31/08/96 | 30 223 | 190.4 | 22.7 | 81.3 | 5.3 |
| 28 - 30/09/96 | 7 449 | 40.0 | 4.5 | 54.1 | 4.2 |
| 26 - 31/01/97 | 36 170 | 164.9 | 20.1 | 115.8 | 4.5 |
| 11 - 14/02/97 | 30 585 | 199.4 | 22.6 | 164.6 | 19.0 |
| TOTAL | 239 490 | 1599.1 | 138.6 | 917.2 | |

Lettuce was the major crop grown, along with spinach, capsicum, cabbage and cucumber. Poultry manure was the major form of fertiliser, supplemented with ammonium nitrate. All fertiliser was incorporated into the soil, but not always immediately. Like on other market gardens on poorly drained soils derived from Wianamatta shales, semi-permanent raised beds were used. The furrows measured approximately 1.5 m apart. ?The height from the top of the beds to the bottom of the furrow varied from 0.15 to 0.3 m. The slope of the furrows ranged from level to gently inclined, with an average gradient of 3%. The furrows sloped into a level to very gently inclined drainage channel (average gradient ~1%) with a slightly concave profile. Due its low gradient, the drain acted as a sediment trap, which the farmer excavated at the end of 1995. The excavated sediment was spread back onto the paddock.

## Results and discussion

### *Nutrient inputs*

Fertiliser inputs of N and P are given in Table 1. The rate of 182 kg/ha/yr for P, while high, is less than half that of the rate quoted for other market gardens in the region (2).

### *Runoff losses of suspended sediment, nitrogen and phosphorus*

Losses of suspended solids (SS), total N and total P from runoff events over a 2 year period from the farm are shown in Table 2. The total rainfall for the period was 1517 mm, of which 917 mm produced runoff events. Loss of suspended solids was equivalent to over 19 t/ha/yr.

N loss in runoff was equivalent to 30% of fertiliser inputs while P loss in runoff was equivalent to 5.8% of fertiliser inputs. Over 90% of P was transported in particulate form, as a result of soil erosion. N was transported predominantly as $NO_3$. However, in some events, particulate N was dominant (Fig. 1).

*Rainfall intensity and sediment loss*

The concentration of sediment in intense storm events was high with concentrations of up to 130 g/L. The concentration of suspended solids (SS) was highest for the January, 1996 event when the concentration of SS reached 130 g/L (Fig. 2). The event had the highest rainfall intensity (measured at 2 minute intervals $I_2$>25) and largest sum of rainfall at I225 (the sum of rainfall which occurred at greater than 25 mm/hr).

The event consisted of two almost identical peaks, during both of which, sediment concentration parallelled discharge. However, sediment concentration was disproportionately higher during the second peak. Rainfall intensity was very similar during both peaks (in both cases approximately 20 mm fell in 8 minutes). This suggests that the antecedent soil water strongly influenced aggregate strength (3).

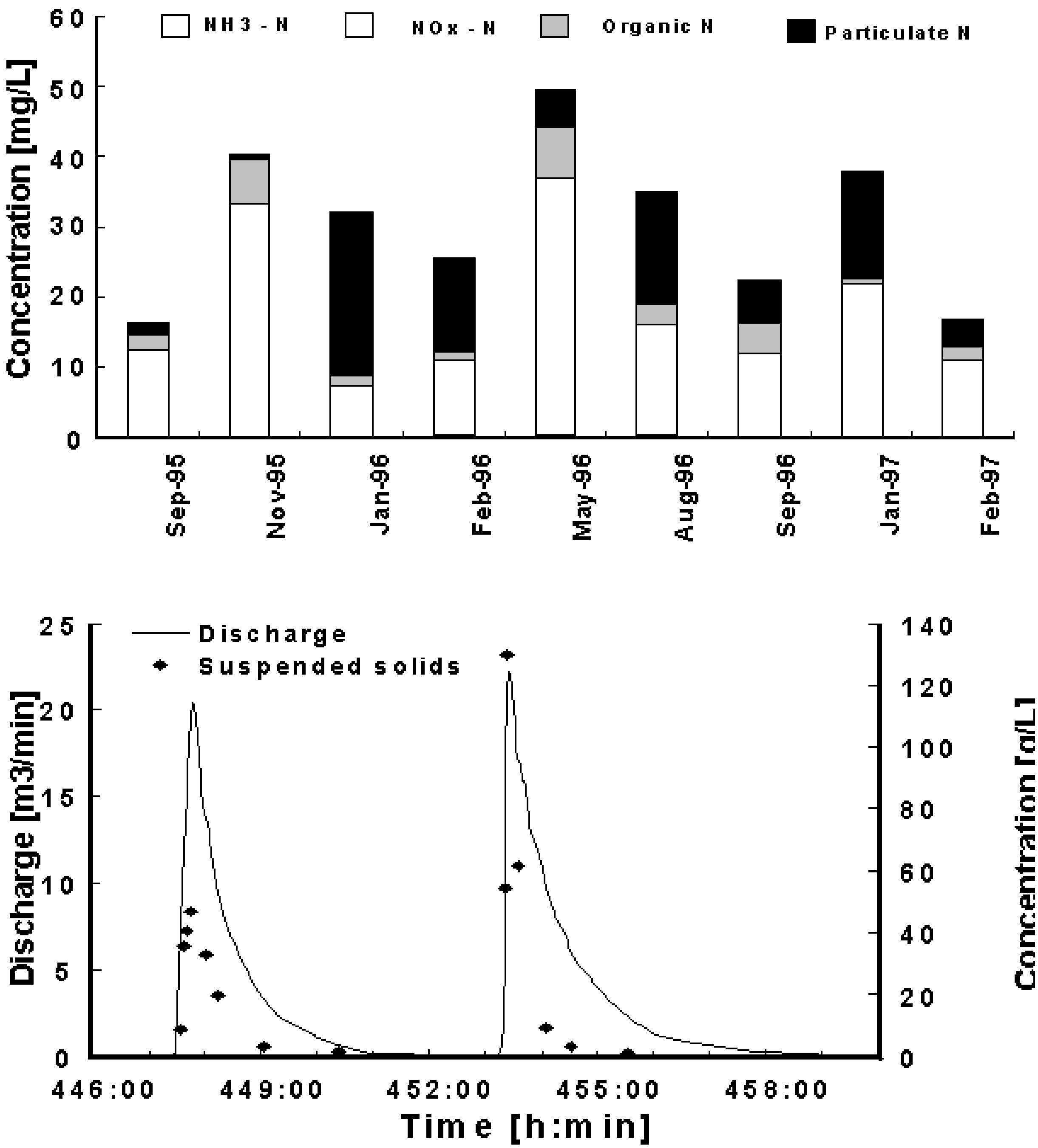
60
50
40
30
20
10
0
Concentration [mg/L]
NH3 - N
NOx - N
Organic N
Particulate N
Sep-95
Nov-95
Jan-96
Feb-96
May-96
Aug-96
Sep-96
Jan-97
Feb-97
25
20
15
10
5
0
Discharge [m3/min]
Discharge
Suspended solids
140
120
100
80
60
40
20
0
Concentration [g/L]
446:00
449:00
452:00
455:00
458:00
Time [h:min]

Figure 1

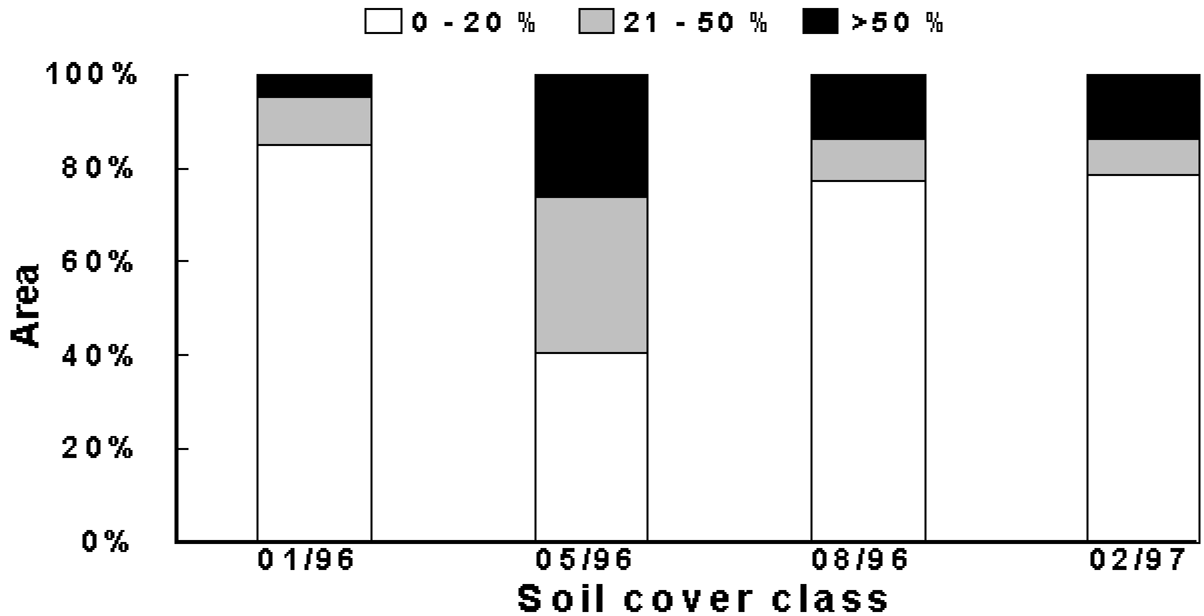


Figure 2

*Soil cover and surface condition*

For events separated by one to four weeks, the concentration of SS decreased in the second event, presumably due to surface sealing during the first event followed by drying. This was particularly noticeable between the January and February 1997 events (separated by 11 days).

Soil cover was less than 20% on the majority of the farm, particularly in January, 1996 (Fig. 3). Spatially averaged soil cover on the 6.3 ha vegetable growing area ranged from 15% in January/February, 1996 to 31% in May, 1996.

Soil loss data from field scale plots on the Eastern Darling Downs in Queensland indicates that erosion is negatively and exponentially correlated with surface cover similarly to the relationship used in the USLE (4). ?There are two mechanisms by which this occurs: (i) interception of rainfall, thereby reducing rainsplash and surface sealing; and (ii) providing resistance to overland flow thus slowing surface water velocity and generating turbulence which hinders concentration of flow, thus minimising rill development (5). Freebairn and Wockner (4) suggested that 30% cover is the critical level for reducing soil loss. Although soil cover varied, it was generally low and for the majority of the time was less than 30%. The lowest soil cover also occurred when the most intense storm occurred (January, 1996) and contributed to the very high concentrations of SS (Fig. 2). The combination of these factors resulted in the loss of 240 t of sediment which is equivalent to approximately 2.5 mm of soil over the 6.3 ha area.

Conclusions

The results show that on the poorly drained loams derived from Wianamatta shale, traditional market gardening practices are detrimental to the environment. ?Excessive and poorly managed fertiliser use resulted in substantial losses of sediment and nutrients in runoff. ?Sediment loss was equivalent to 2.5 mm of soil over 2 years and resulted in 90% of P loss. N lost in runoff was very high and equivalent to 30% of fertiliser inputs. The results highlight the need for farming practices on these soils to combine erosion prevention and control measures, and decreased fertiliser use based on regular soil and plant nutrient tests.

Acknowledgments

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