Occasional Report No. 17
ISSN 0112-9902

Proceedings of the Workshop

TOOLS FOR NUTRIENT AND POLLUTANT MANAGEMENT

Applications to agriculture and environmental quality

Massey University, Palmerston North, New Zealand

2 - 3 December, 2003

Editors

L D Currie and J A Hanly

In conjunction with

FERTILIZER & LIME RESEARCH CENTRE

ASPAC
Australasian Soil & Plant Analysis Council Inc.

Massey University

TOOLS FOR NUTRIENT AND POLLUTANT MANAGEMENT

Applications to agriculture and environmental quality

Proceedings of the 17th Annual Workshop held by the

FERTILIZER AND LIME RESEARCH CENTRE

MASSEY UNIVERSITY

in conjunction with the Biennial Conference of the

AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

at

Massey University, Palmerston North, New Zealand

2 – 3 December, 2003

Editors

L D Currie and J A Hanly

The correct citation for these proceedings is

Author(s), 2003. Title of paper. In *Tools for nutrient and pollutant management: Applications to agriculture and environmental quality.* (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 17. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. pp

TABLE OF CONTENTS

SOIL AND PLANT TESTS AS DIAGNOSTIC TOOLS FOR PRODUCTION

Chairman: **Dr Leigh Sparrow**
Tasmanian Institute of Agricultural Research, Australia

ASSESSING SOIL HEALTH AND ENVIRONMENTAL QUALITY

Chairman: **Professor Russ Tillman**
Institute of Natural Resources, Massey University, New Zealand

---

ASSESSING SOIL HEALTH AND ENVIRONMENTAL QUALITY...continued

Chairman: **Dr David Horne**
Fertilizer and Lime Research Centre, Massey University, NZ

DECISION SUPPORT SYSTEMS

Chairman: **Graham Price**
Nutrient Management Systems, Queensland, Australia

EMERGING TECHNOLOGIES AND NEW METHODS

Chairman: **Dr Roger Hill**
Hill Laboratories, Hamilton, New Zealand

WORKSHOP SESSIONS

The following organisations have given financial support to this event:

HILL LABORATORIES, LANDCARE RESEARCH, CROP & FOOD RESEARCH, AGMARDT, ANALYTICAL RESEARCH LABORATORIES, HORTRESEARCH, SUMMIT-QUINPHOS, BALLANCE AGRI-NUTRIENTS

We are grateful for this support that allows for presentations by invited speakers, involvement of students from several universities and enables registration costs to be kept to a minimum.

HIGH BASE FLOW CONCENTRATION OF TOTAL REACTIVE PHOSPHORUS IN A MANAWATU STREAM, NORTH ISLAND, NEW ZEALAND

A Tri Priantoro, Ian Valentine and John Holland

Institute of Natural Resources, Massey University, Palmerston North, New Zealand

Abstract

The purpose of this research was to determine the source of phosphorus in a Manawatu stream draining an agricultural catchment. Total reactive phosphorus levels were measured at down the stream of junction with major tributaries and other potential sources at 14 days interval for seven months. This period included a dry spell when base stream flow was maintained by springs. Grab water samples were collected near the middle of the stream, and frozen within 8 hours. Unfiltered samples were analysed for reactive phosphorus using Mo-blue reaction.

Results showed that concentration of total reactive phosphorus in the stream were high during this base flow period. The mean reactive phosphorus concentrations along the stream were between 0.03–0.06 g/m^3 with the highest value in the middle catchment. One of worst sites was at the confluence with a tributary that had spring water as a source and flowed through a wetland. The water from the spring and out of the wetland was high in reactive phosphorus (0.13 g/m^3). Other permanent tributaries and ditches/gullies had high phosphorus concentrations, between 0.02–0.16 g/m^3, while concentration in tile drains that enter the stream varied from 0.01 to 0.05 g/m^3. Phosphorus levels increased following rainfall events and higher stream flows. Spring water, rainfall and land management all contribute to these levels.

Introduction

New Zealand has undergone massive change in vegetation cover over the last 150 years, much of the original native ecosystem being replaced with agricultural land. The change is most apparent in the lowland plains and wetlands, and to a lesser extent in the high country. Agriculture now occupies some 65% on land in surface area (Dept. of Statistic, 1992). In some districts over 90% of total land is under agriculture (MWRC, 2000).

The dominance of agriculture is likely to have two side effects. In one hand, the development of agriculture in New Zealand has brought an important contribution to the economy and welfare of this country. On the other hand, the predominance of agriculture means that it is a major cause of environmental impacts. These impacts can be direct, such as decreasing land productivity, but also indirect impacts, such as nutrients or sediment from eroded soil in streams and rivers reducing water quality.

Water quality in streams and rivers can be reduced by point source discharges that emanate from specific identifiable source such as pipe effluent, and non-point source (NPS) or diffuse discharges that arise from run-off or leachate from a non-discrete source onto land or into water bodies (MWRC, 1998). The degradation of surface water quality through NPS discharges is a continuing issue throughout New Zealand. MfE (1997) contend that non-point discharges from agricultural land is a major problem in New Zealand where organic matter, nutrients and sediment washed into waterways create adverse effects including turbidity and profuse growth of nuisance plants and fungi.

The primary sources of nutrients in agricultural catchments, particularly phosphorus (P) are assumed to be fertiliser application and livestock waste (Caruso, 2000; Saggar et al. 1990). Small amount of phosphorus also exist naturally in rock material, soil, rainfall, and leachate from plant materials (Caruso, 2000). It can also be removed through erosion and transported in surface runoff to streams during storm events (Pionke et al. 1996).

To mitigate the adverse effect NPS pollution, targeting critical contaminant source areas is needed for the cost effective use of best management practices (BMPs) (Caruso and Ward, 1998). To achieve this, effective water quality monitoring is essential for assessing source areas and their impact on receiving waters, and for evaluating the effectiveness of control measures.

The objective of this study was to identify the source of NPS phosphorus in a stream with poor water quality that drains a rural catchment. High levels of periphyton growth had been reported in this stream (Fowler, et al., 1999). This was carried out by measuring the spatial and temporal variability of total reactive phosphorus concentration in surface waters. The stream drained an agricultural catchment of a Manawatu stream.

Methods

Study site

The study site is located in the catchment of Mangaone West Stream (East 175° 28' to 175° 36' and South 40° 9' to 40° 16'), which is a tributary of Makino Stream (Fig.1). It drains about 71.5 km^2 of rolling hill country to the south west of Feilding, New Zealand. The catchment is dominated by pastoral agriculture grazing sheep and cattle. Soil types of this area are Halcombe soil and Marton loam/silt loam. Some other soil types can be found also in the catchment including Kairanga fine sandy loam and Milson silt loam. The upper reaches of the catchment have a steeper gradient with ephemeral streams. There are several springs in the lower reaches of the catchment that maintain a continuous flow.

Annual rainfall is 900 to 1300 mm, which is reliable and evenly distributed throughout the year. The temperature is warm in summer and mild winter. West to northwest winds prevails with relatively frequent gales.

The riparian vegetation forms a fairly dense canopy on the stream banks with little direct light penetrating to the stream. Some obstructions can be found in the stream channel including trees, dense weed growth, and debris build up against fallen trees and branches crossing the stream.

Data collection and analysis

Surface water quality was monitored from January to July 2003. Samples were taken from the main stream, downstream of major tributaries (see map, Figure 1). These include Head water (1), Railway bridge (2), Halcombe Road bridges (3), Te Rakehou Road bridge (4), Mark's Farm (5 and 6), Sandon Road bridge (7), Garry's Farm (8 and 9), and Feilding-Awahuri Road bridge (10). Also several major tributaries were sampled. Water samples were also collected from overland flow and water channels, including a drainage tile and ditches/gullies entering the stream at 3 identified sites. Sampling was performed fortnightly at all location and after rain at some locations.

Two grab samples were collected from near the middle of the stream. These were refrigerated and then frozen within 8 hours until the time of analysis for reactive phosphorus. Turbidity and pH were measured directly from the field using portable HACH 2100P Turbidimeter 46500-00 and portable DSE pH-meter respectively. Discharge was measured as stream height (cm) using non-permanent staff gauge at outlet of the catchment at Feilding-Awahuri Road Bridge (10).

Unfiltered samples were analysed for reactive phosphorus using Mo-blue reaction (Murphy & Riley, 1962; Hygarth & Sharpley, 2000) in GBC Contra 20 UV-Visible Spectrometer at 712 nm using 1 cm cell.

Figure 1. The location of study site

1-10 = Water sampling sites on the main stream,
a-l = Water sampling sites on tributary/ditch/gully/tile
m = East Spring
n = West Spring

Results

Spatial trends in stream water reactive phosphorus concentrations along the stream in the Mangaone West Stream Catchment showed the highest value in the middle catchment (Fig 2). The averages of reactive phosphorus concentration at Sites 1, 2 and 3 were 0.03 g/m^3. At the Site 4 the concentration doubled to 0.06 g/m^3. From this point the concentration was steady until Site 5, and then it declined to 0.04 g/m^3 at St 9. The average concentration of reactive phosphorus in the outlet of the catchment (10) was 0.05 g/m^3.

These figures are high, and well above the levels required for periphyton growth. High concentration of reactive phosphorus in the middle catchment might relate to discharges from its tributaries (Fig. 2). The highest level of reactive phosphorus was from tributary (a) that was 0.13 g/m^3. This tributary was fed by a spring that had reactive phosphorus of 0.12 g/m^3 and during winter received treated effluent from a piggery. Another tributary that might contribute to the level of reactive phosphorus in the stream was located at Site g with an average concentration of reactive phosphorus was 0.04 g/m^3. This contribution was indicated by higher level of the concentration down stream at Sandon Road Bridge (Site 7).

Water from permanent tributaries and ditches/gullies below Site 4 had high levels of reactive phosphorus concentrations; they varied between 0.02-0.16 g/m^3. The highest level was water from ditch/drainage channel enter the stream near Site 7 of which accepted the outflow of an aerobic/aerobic treatment of cowshed effluent (Horizons.mw, 2002). Tributaries in the lower part of the catchment had lower phosphorus levels.

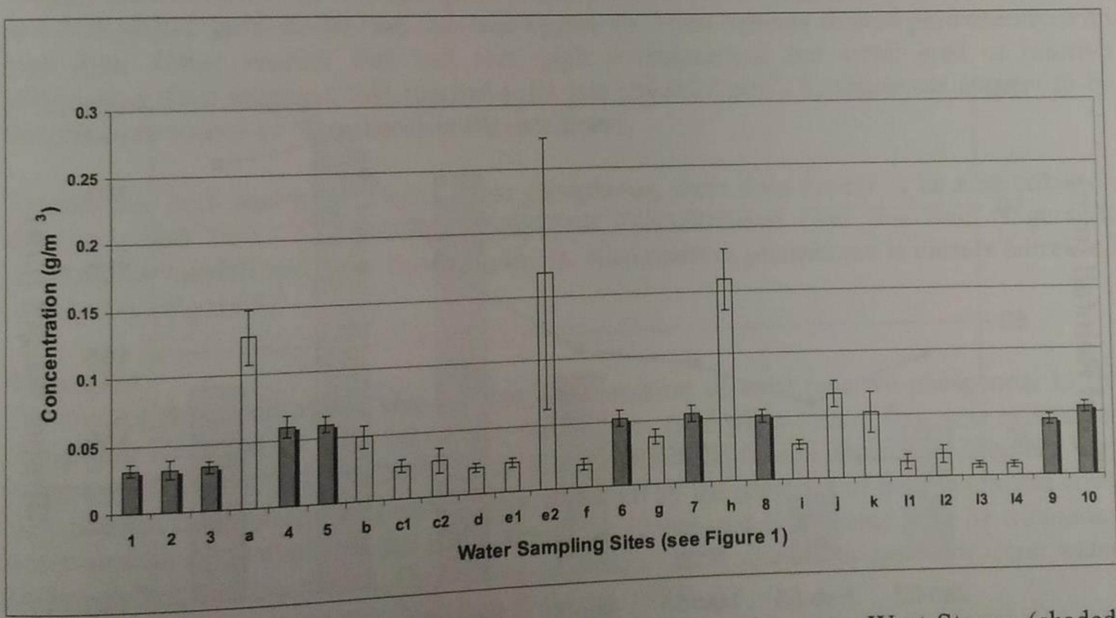

Figure 2. Average of Reactive Phosphorus (g/mg^3) along Mangaone West Stream (shaded) and its tributaries/ditches/tiles

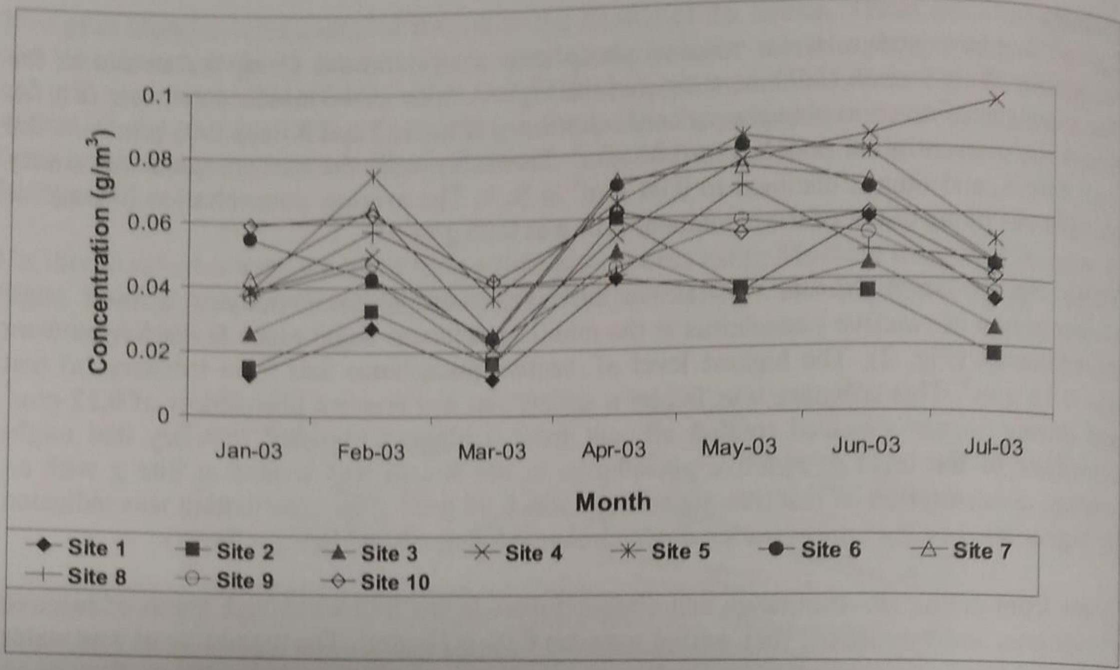

Figure 3. Average of reactive phosphorus concentration along Mangaone West Stream (see Figure 1) January-July 2003

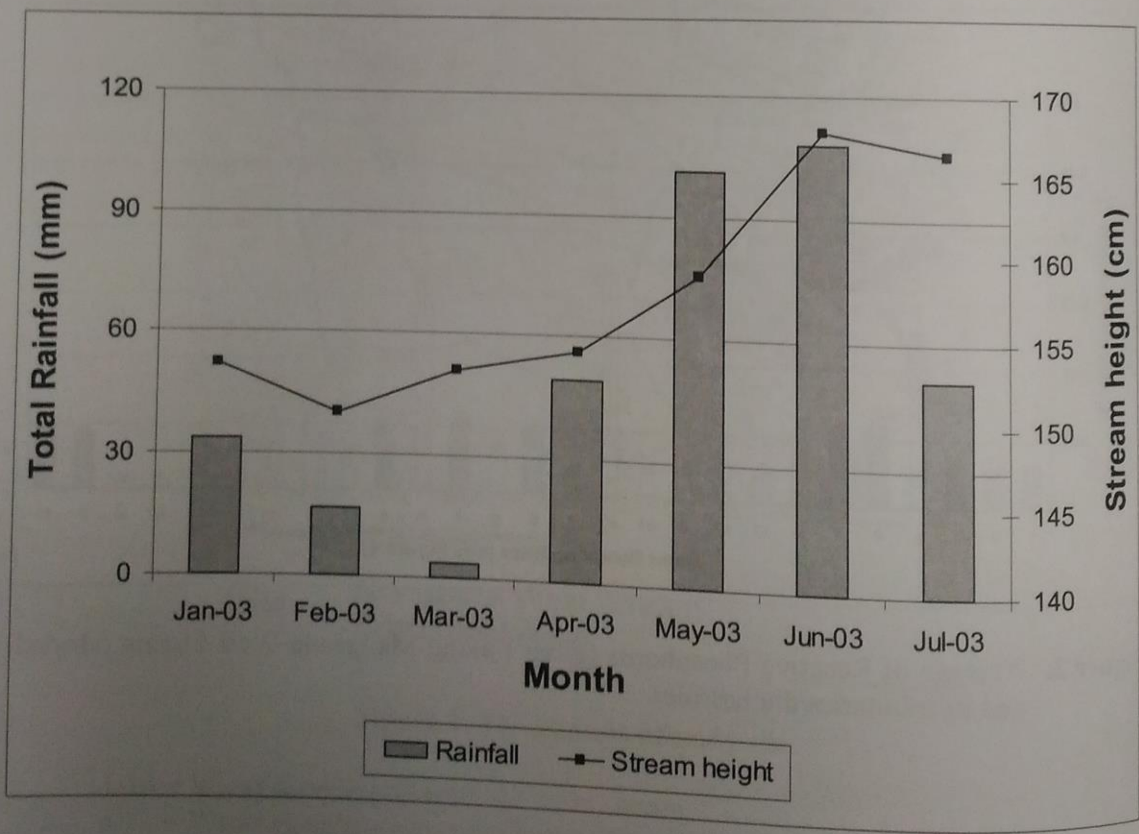

Figure 4. Monthly Rainfall (mm) in Mangaone West Stream Catchment (Bar) and Stream Height (cm) at the outlet of the catchment (Line)

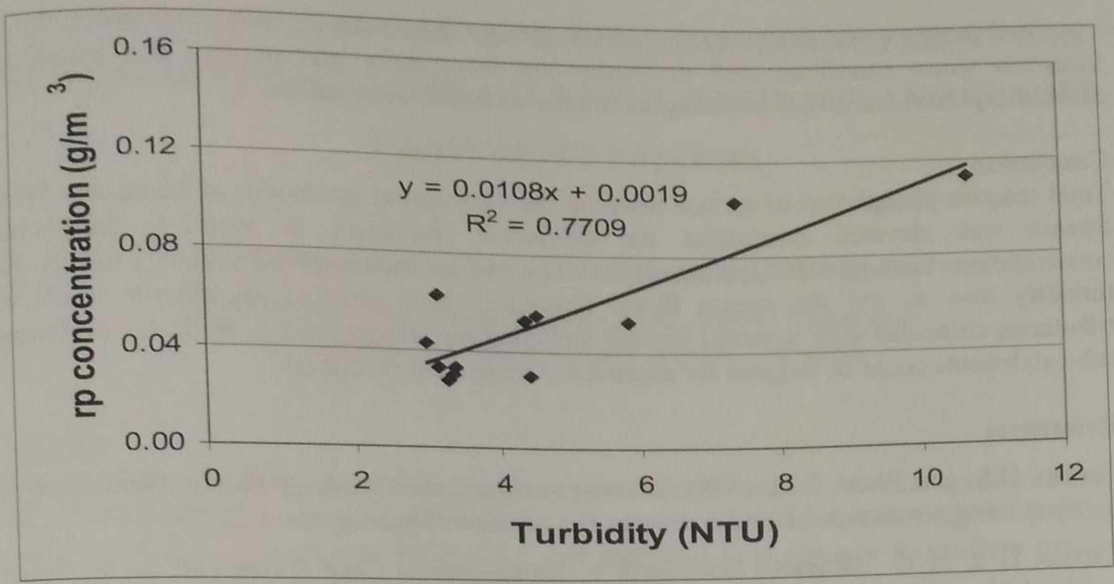

Figure 5. Regression analysis of reactive phosphorus vs turbidity

There are numerous cases of ground water emerging as springs and seeps in the lower catchment. These are at the foot of the scarps on the East and West side of the valley. The average concentrations of two springs over this period were 0.114±0.012 g/m^3 in the west (n) and 0.39±0.012 g/m^3 in the east (m) (see Figure 1). These springs flowed permanently with high load. Other sources that had very high concentrations but small load of reactive phosphorus were seepages that reached 0.19 g/m^3 and 0.27 g/m^3. Spring water appears to be the principle source of phosphorus in the catchment.

Against this high background of reactive phosphorus, there does appear to be a contribution from overland flow. The reactive phosphorus concentrations over this time (Figure 3) matched the rainfall and river flow (Figure 4). Also reactive phosphorus is closely correlated to turbidity (Figure 5).

Discussion

The results described above showed that concentration of total reactive phosphorus in the Mangaone West Stream were high, even during base flow when stream flow was maintained by springs (January to April 2003). During this period the stream appeared eutrophic. Very high nutrient concentrations/loadings were indicated by the presence of periphyton that cover water surface particularly in the pools along the stream and confluence with its tributaries, ditches/gullies and tile drains. This nuisance growth was facilitated by low flow, clear water, and stable surfaces for growth (McBride & Quinn, 1993)

Identification of diffuse contaminant source areas is crucial in order to improve the quality of surface water in the Mangaone West Stream Catchment. This could be realised by using water quality data (Caruso, 2001). The high phosphorus level during the low flow period is indicative of a point source. This instance it appears that the source was natural springs. The higher phosphorus levels during higher stream flows could be due either to NPS discharge from land, or disturbances of in-stream sediment. The high variability of reactive phosphorus at Site e2 indicates the influence of stock in that waterway which was unfenced. These areas may need further management to decrease phosphorus loss to surface water. Measures should focus on storm runoff as well as wastewater from dairy and piggery and excluding cattle/sheep from the stream including its tributaries and ditches/gullies.

Conclusion

Total reactive phosphorus of surface water in the agricultural catchment of Mangaone West Stream was elevated throughout the catchment. Increases in reactive phosphorus concentrations were recorded following rainfall events that increased from January to July. As turbidity rose so did the stream flows. Especially high reactive phosphorus levels of tributaries coincided with potential sources including piggery and dairy. With this evidences sub-catchments could be targeted for improved management practices.

References

Caruso, B.S. and Ward, R.C. 1998. Assessment of nonpoint source pollution from inactive mines using a watershed-based approach. *Environmental Management 22*: 225-243

Caruso, B S, 2000. Integrated assessment of phosphorus in Lake Hayes catchment, South Island, New Zealand. *Journal of Hydrology* 229:168-189

Caruso, B.S. 2001. Risk-based targeting of diffuse contaminant sources at variable spatial scales in New Zealand high country catchment. *Journal of Environmental Management* 63: 249-268

Department of Statistics, 1992. Agricultural Statistics 1991. Wellington, New Zealand.

Haygarth, P.M. and Sharpley, A.N. 2000. Terminology for phosphorus transfer. *Journal of Environmental Quality 29*: 10-23

Horizons.mw, 2002. Mangaone West Stream Report. Manawatu-Wanganui Regional Council (MWRC).

Manawatu-Wanganui Regional Council (MWRC), 1998. Manawatu Catchment Water Quality Regional Plan.

Manawatu-Wanganui Regional Council (MWRC), 2000. Research 2003 Framework.

McBride, G.B. & J.M. Quinn, 1993. Quantifying water quality standards in the Resource Management Act. National Institute of Water and Atmospheric Research, Hamilton

Ministry for Environment (MfE), 1997. The State of New Zealand's Environment.

Murphy, J. and Riley, J.P., 1962. A modified single solution method for determination of phosphate in natural waters. *Analytica Chimica Acta* 27: 31-36

Pionke, H.B.; Gburek, W.J.; Sharpley, A.N.; Schnabel, R.R. 1996. Flow and nutrient export patterns for agricultural hill-land watershed. *Water Resource Research 32:* 1795-1804

Saggar, S.; MacKay, A.D.; Hedley, M..J.; Lambert, M.G.; Clark, D.A. 1990. A nutrient-transfer model to explain the fate of phosphorus and sulfer in a grazed hill-country pasture. *Agriculture, Ecosystems and Environment* 30: 295-315.