Measuring buffer strip effectiveness in a deeply permeable sandy soil: Beltrum, NL

Marius Heinen, Gert-Jan Noij
Hanneke Heesmans
Contents

- Introduction
- Experiment at Beltrum
- Results and Buffer Strip Effectiveness \( BSE \)
- Alternative definitions \( BSE \)
- Findings so far
Introduction

- Buffer Strips (BS) along water courses were suggested by EU
  - Doubts about effectiveness for specific geo-hydrological conditions in the NL

- 3rd Action Program Nitrates Directive
  - Along selected natural brooks: 5 m wide BS ✓
  - Do experimental research on effectiveness for other NL situations (+ model, + cost effectiveness)

- 5 Experimental sites: 2006-2010
  - **Beltrum** 16 m deep permeable sand
  - Zegveld peat
  - Winterswijk thin sand layer
  - Loon op Zand sand with loam layer at 2 m depth
  - Lelystad light clay with pipe drains
Buffer Strip (BS): unfertilized field edge
Treatments, replications

- Unfertilized buffer strip (BS) versus fertilized reference strip (REF)
- Replication A: start 2006
- Replications B&C: start 2007
Flow proportional sampling

\[ Q \]

\[ C \quad \text{[flow proportional]} \]

DITCH WATER

WATER IN RESERVOIR

GRASS (BUFFER)

5 M

QC

1 cm

RESERVOIR WALL

(not at scale)
Upper groundwater: average pattern

![Graph showing NO₃-N concentration (mg N l⁻¹) vs. distance from the centre of the ditch (m). The graph includes different samples such as Reference A, Buffer 5 A, Reservoir Reference A, etc., with various markers indicating the concentration levels.]

- **Introduction, Experiment, Results, Definition BSE, BSE Beltrum, Summary**
Cumulative discharge and load, and concentration: $N_{\text{tot}}$

Patterns in discharge dominate patterns in load. We prefer to use flow-averaged concentrations.

\[ \sum L = \sum QC \]

\[ \overline{C} = \frac{\sum L}{\sum Q} \]
Cumulative discharge and load, and concentration: $P_{\text{tot}}$

- **Discharge** ($Q$) in $m^3$
  - **Beltrum, A**
  - Reference plot
  - Buffer strip plot

- **Load phosphorus** ($L$) in g
  - $\sum L = \sum QC$

- **Concentration** (mg P $l^{-1}$)
  - $\bar{C} = \frac{\sum L}{\sum Q}$

P loads do not follow discharge pattern, opposite to N.
Buffer Strip Effectiveness: $BSE$

\[ BSE = \frac{\overline{C}_{REF} - \overline{C}_{BS}}{\overline{C}_{REF}} = 1 - \frac{\overline{C}_{BS}}{\overline{C}_{REF}} \]

Upper bound: $BSE = 1$
Lower bound: $BSE \to -\infty$
BSE for surface water $N_{\text{tot}}$: total period
$BSE$ for surface water $P_{tot}$: total period
Different $BSE$ formulations

$I$

$$BSE = 1 - \frac{Y_{BS, out}}{Y_{BS, in}}$$

$BS$ = buffer strip

$II$

$$BSE = 1 - \frac{Y_{BS, out}}{Y_{REF, out}}$$

$REF$ = reference strip

$III$

$$BSE = 1 - \frac{Y_{BS, a, out}}{Y_{BS, b, out}}$$

$IV$

$$BSE = 1 - \frac{Y_{BS, a, out}}{Y_{REF, b, out}}$$

$BS$ = buffer strip

First leaching season serves as the before-treatment period

b = before installing treatment

a = after installing treatment

Introduction, Experiment, Results, Definition BSE, BSE Beltrum, Summary
**BSE based on upper groundwater**

- **Introduction, Experiment, Results, Definition BSE, BSE Beltrum, Summary**

**I:** $BSE = 67.3\%$  
$BSE = 67.7\%$  
Average $BSE = 67.5\%$

**II:** $BSE = 67.1\%$  
$BSE = 63.1\%$  
Average $BSE = 65.0\%$
$BSE$ for surface water $N_{\text{tot}}$: total period

Method I not possible.

For nitrate similar patterns were obtained.
Average (A,B,C) $BSE$ for surface water $N_{\text{tot}}$

- Method II
- Method III
- Method IV

$BSE$ based on $C$, $N_{\text{tot}}$ (%)

- LS 1
- LS 2
- LS 3
- LS 1-3

Introduction, Experiment, Results, Definition BSE, BSE Beltrum, Summary
Average $BSE$ for surface water $P_{tot}$
Findings so far

- **Beltrum**: deep sandy soil: *great effect in upper ground water, but not in ditch water*
  - Ditch obtains water from greater depths not influenced by the BS
  - Denitrification in ditch bank and ditch bottom

- **BSE** for surface water for the deep sandy soil at Beltrum
  - Variation between replicates
  - $N_{tot}$: low, around zero
  - $P_{tot}$: positive, about 10%

- **General**: there are several ways to compute **BSE**
  - The different methods yield different estimates of **BSE**
  - The method that takes into account before-treatment measurements AND reference treatments should be preferred (method IV)
Acknowledgement

Research funded by the Dutch ministry of Agriculture, Nature and Food Quality and the Dutch ministry of Housing, Spatial Planning and the Environment

Thanks to all co-workers

Jan van Kleef, Han te Beest, Antonie van der Toorn
Meint Veninga, Gerben Bakker, Laboratory Staff CBLB
Arie van Kekem, Reind Visschers, Willy de Groot, Falentijn Assinck
Thank you