NATIONAL INSTITUTE OF PUBLIC HEALTH AND THE ENVIRONMENT
BILTHOVEN, THE NETHERLANDS

Report no. 714801021

Monitoring bentazone concentrations in the uppermost groundwater after late season applications

A.A. Cornelese and A.M.A. van der Linden

July, 1998

This investigation has been performed by order and for the account of the Ministry of Housing, Spatial Planning and the Environment.

National Institute of Public Health and the Environment (RIVM), P.O. Box 1,
3720 BA Bilthoven, the Netherlands
Telephone: +31 - 30 - 274 91 11, telefax: +31 - 30 - 274 29 71

MAILING LIST

1-5	Directeur van de Directie Drinkwater, Water en Landbouw van het Directoraat-Generaal Milieubeheer van het Ministerie van VROM - G.J.A. Al
6	plv. Directeur-Generaal Milieubeheer -B.C.J. Zoeteman
7	Ministerie van Landbouw, Natuurbeheer en Visserij, directie Gewasbescherming
8	M.v.d. Gaag DGM/DWL
9	W.W.M. Brouwer Plantenziektenkundige Dienst
10	College Toelating Bestrijdingsmiddelen
11	J. Boland
12	S.Beulke, Cranfield University (UK)
13	K.Jilderda, BASF
14	Depot Nederlandse publikaties en Nederlandse bibliografie
15	Directie RIVM
16	F. Langeweg (SB5)
17	L.H.M. Kohsiek (SB5)
18	R.v.d.Berg (LBG)
19	A.H.M. Bresser (LWD)
20	J.J.B. Bronswijk (LBG)
21	J.A. Hoekstra (MNV)
22	R.A. Baumann (LOC)
23	A. Tiktak (LBG)
24	H. Mesters (LBG)
25	Bibliotheek CSR
26-29	auteurs
30-35	perceelseigenaren
36	Hoofd Bureau Voorlichting en Public Relations
37	Bibliotheek RIVM
38-47	Bureau Projecten en Rapportenregistratie
48-58	Reserve

GOOD LABORATORY PRACTICE COMPLIANCE STATEMENT

STATEMENT OF COMPLIANCE

Study Title:	Monitoring of bentazone concentrations in the uppermost groundwater after late season applications.
Protocol Number:	715804004
LBG Project Number:	715801
Test Substances:	Bentazone
Study Director:	A.M.A. van der Linden

This study was conducted in compliance with Good Laboratory Practice Regulations (OECD Paris, 1987), except for the concentration measurements and the characterisation of soils. The bentazone analyses were performed by the Laboratory for Organic Analytical Chemistry of the RIVM according to the STERLAB criteria EN 45001. The analyses for soil characteristics were performed by the Laboratory for Soil and Crop analysis at Oosterbeek. Also this laboratory has a QA certificate according to the STERLAB criteria. No raw data evaluation according to the GLP principles took place.

Study Director: ....
A.M.A. van der Linden

02-07-1998
Date

Laboratory management: ....
R. van den Berg

02-07-1998
Date

Raw data records will be kept in archive conform the protocol for 5 years at the RIVM/LBG, A.v.Leeuwenhoeklaan 9, 3721 MA Bilthoven.

PREFACE

The authors would like to thank everyone who contributed to the sampling in the field, especially J. Boland who did all the work in contacting the farmers and contributed for a great part in the final field selection. Furthermore the large contribution of the laboratory for organic chemistry, department of pesticide analyses, who performed all the bentazone analyses, is gratefully acknowledged. Last but not least we are very grateful to the farmers who supported this investigation by giving information on field management and giving permission to enter their fields.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABSTRACT

The herbicide bentazone has been detected in groundwater in several monitoring programs, with most of the findings possibly related to applications early in the growing season. Because of a very low sorption constant, bentazone can be very easily transported in soil with the waterflow. This means that the leaching risk increases with increasing precipitation excess in the autumn. For this reason, a monitoring programme, taking place in 1996, was set up to measure the occurrence of bentazone in the uppermost groundwater after late-season application. On five fields where bentazone was applied, the groundwater was sampled and analysed for bentazone at two points in time. On 2 out of the 5 fields a concentration of bentazone was determined in the first sampling round and on one additional field in the second sampling round. The results of this study do not allow to answer the research question: 'What is the threat of bentazone leaching to groundwater after late season (September 1st) application?'. Too few fields met the requirements of the study. In addition, extrapolation with a simulation model could not be performed because too many parameters of the PESTRAS model had to be adjusted to match calculation results with observations in the field.

SUMMARY

In several monitoring programmes the herbicide bentazone has been detected in groundwater. Most of the findings of bentazone in groundwater are reported from maize growing areas. All these measurements can be related to early season application.
Because of the very low sorption constant bentazone can be transported in soil with the waterflow very easily. This means that the risk of leaching increases with increasing precipitation excess in autumn. Besides, a lower soil temperature in the late season may lead to a higher apparent half-life time which also increases the risk of leaching. To diminish the load of bentazone to Dutch groundwater the use of the compound is restricted to the period March to October 1st.
A monitoring program was designed to measure the occurrence of bentazone in groundwater after late season (September 1st) applications. In 1996 on 5 fields the uppermost groundwater was sampled and analysed for bentazone residues at two moments in time. The dates of sampling were chosen based on a simulated leaching peak. In the first sampling round on 2 out of the 5 fields a concentration of bentazone above the detection limit was determined and in the second sampling round on one field more. Statistical calculations show that for field 2 and 3 in the second sampling round both the detection limit and the critical level of 0.1 µg/l are within the 95% confidence interval of the measurements. On field 1 in the second sampling round the maximum value of the 95% confidence interval is below 0.1 µg/l.
Unfortunately the research question of the study; 'Does bentazone occur in groundwater after late season application and if so, to what extent', can not be answered because too few fields were found that met the requirements. In addition, bentazone concentrations in groundwater could only be simulated after adjustment of the parameters of the PESTRAS model to field specific observations, among which seepage phenomena. Because such information is not available on a national scale it is irresponsible to evaluate the threat of leaching of bentazone in the Netherlands after late season applications based on this study.

SAMENVATTING

In verscheidene meetprogramma's is het herbicide bentazon aangetoond in het grondwater. Het meest wordt de stof gevonden in gebieden met vrijwel uitsluitend maisteelt. Al deze metingen kunnen worden gerelateerd aan toepassingen vroeg in het groeiseizoen.
Als gevolg van een lage sorptiecoefficient beweegt bentazon zich erg gemakkelijk met het watertransport mee in de bodem. Dit betekent dat de kans op uitspoeling toeneemt naarmate het neerslagoverschot toeneemt, met name in de herfst. Een daarbij komende lagere temperatuur in de bodem kan leiden tot een toenemende halfwaarde-tijd, die tevens leidt tot een grotere kans op uitspoeling. Om de vracht van bentazon naar het grondwater te verminderen is het gebruik van de stof slechts toegestaan in de periode maart tot 1 oktober.
Er werd een meetprogramma ontworpen om het voorkomen van residuen van bentazon in het grondwater na late-seizoenstoepassing te bepalen. In 1996 werd op 5 velden het bovenste grondwater bemonsterd en geanalyseerd op bentazon op twee verschillende tijdstippen. Het tijdstip van bemonsteren werd bepaald op basis van een gesimuleerde uitspoelingscurve. In de eerste bemonsteringsronde werd op 2 van de 5 velden bentazon aangetoond in concentraties boven de detectielimiet. In de tweede bemonsteringsronde werd op een derde veld bentazon aangetroffen. Statistische berekeningen laten zien dat voor 2 velden in de tweede ronde de kritische waarde van 0.1 µg/l binnen het 95% betrouwbaarheidsinterval van de metingen ligt. Voor veld 1 ligt de maximumwaarde van het betrouwbaarheidsinterval in de tweede ronde beneden 0.1 µg/l.
Helaas kunnen de onderzoeksvragen van de studie; 'bereiken residuen van bentazon het grondwater na late-seizoenstoepassing, en zo ja in welke mate', niet worden beantwoord omdat er te weinig velden gevonden werden die aan de gestelde eisen voldoen. De concentraties bentazon in grondwater konden met het model PESTRAS slechts worden gesimuleerd na aanzienlijke aanpassing van parameters aan veldspecifieke omstandigheden, waaronder kwelverschijnselen. Daar deze gegevens op landelijke schaal niet bekend zijn is het onverantwoord het risico van uitspoeling van bentazon in Nederland na late seizoenstoepassingen te evalueren op basis van dit onderzoek.

GENERAL INFORMATION

General

Sponsor:	VROM/DGM/DWL Rijnstraat 8 NL-2515 XP Den Haag
Testing Facility:	Rijksinstituut voor Volksgezondheid en Milieu (National Institute for Public Health and the Environment) A. van Leeuwenhoeklaan 9 NL-3721 MA Bilthoven
Protocol Number:	715804004, RIVM
Test Substance:	Bentazone, CAS RN. 25057-89-0
Test System:	Dutch agricultural areas with renewed grassland or arable land.

Staff

Study Director:	A.M.A. van der Linden, RIVM/LBG
Principle Scientist:	A.A. Cornelese, RIVM/LBG
Scientific staff/assistants:	R.A. Baumann, RIVM/LOC V.M. 't Hart, RIVM/LOC P. Kaim, RIVM/LOC L.J.M. Boumans/LBG
Quality Assurance:	RIVM/LBG Quality Assurance Professional

Time Schedule

Protocol date:	October 30, 1995; RIVM
Start of the sampling:	June 14, 1996
Completion of the sampling:	December 18, 1996
Reporting of the analyses:	March 4, 1997 (RIVM/LOC)
Reporting:	Draft report: November 01, 1997 2nd draft report: December 19, 1997 Final draft report: February 09, 1998
Study completion date:	Final report: July 1, 1998

Summary of Protocol Amendments

There was one amendment to the study protocol after inspection of the final draft report.

Deviations from the protocol

Sampling started 7 months later than stated in the protocol because selected fields were treated between June and October 1995, the calculated leaching peak appeared to be around one year

after application. Therefore the sampling was postponed, as well as the reporting date. It was agreed with the sponsor that there were only two sampling rounds instead of three.
It appeared to be impossible to find eight fields that received late season application of bentazone. Climatic conditions in 1996 were very favourable for grass growth; many farmers decided to leave out a herbicidal treatment. Six fields could be selected and five fields were sampled. Only one of the selected fields met the criterion of application after September 1st.
No measurement of the redox potential of the groundwater according to SOP/LBG 114 took place, because the method is not suitable for application in the field.
Field control samples consist of blind duplicate samples of one field instead of bidistilled water sampled in the field.

Archiving
RIVM/LBG will archive the following data for at least 5 years after the final report date:
- Raw data not concerning the analysis method, protocols including any amendments and reports including any addenda.
- Correspondence
- Audit reports of the Quality Assurance Officer.
- Summarised information concerning education, skills and training of the staff.
- Chronological collection of the Standard Operation Procedures, NEN's and Protocols.

Raw data remain property of the sponsors also after the period of 5 years.

1. INTRODUCTION

1.1. General introduction

In several groundwater monitoring programmes the herbicide bentazone has been detected in the uppermost groundwater (top 1 meter of the groundwater) beneath treated fields (Cornelese and van Maaren, 1992 and 1993). Also in deeper groundwater residues of bentazone have been detected (Boland *et al*, 1994), though here a relationship with field treatments is hard to demonstrate. By far the largest amount of bentazone is used in maize growing areas (ISBEST, 1995). As a result most of the findings of bentazone in groundwater are reported from these areas, concentrations ranging from <0.05 up to 1.1 µg/l) were measured. Also in the flowerbulb area some very high values were measured in the range from 3.6 to 98 µg/l (Cornelese and van Maaren, 1993). All measurements from these monitoring programs can be related to early season application. And, because most of the findings are based on one to three samples per field at one moment in time, and the time series were not dedicated to observe leaching peaks, it might be incorrect to extrapolate these results to fieldscale and quantify the leaching amounts. Furthermore, the sampling method as formerly used by RIVM might give erroneous results due to the disturbance of soil layers while sampling. Therefore RIVM designed a new sampling method for the monitoring of pesticide residues in the uppermost groundwater.
The most important features of the present sampling and analysis methods are:

- twenty sampling lances are installed randomly in the field with filters in the groundwater 50 centimetres below groundwater level;
- water is obtained from each lance by means of a vacuum suction method;
- the twenty groundwater samples are randomly mixed into four composite samples (each consisting of five original samples);
- the composite samples are then transported to the analysing laboratory and analysed for their bentazone content by means of a HPLC method.

A comparable method applied to a field situated in Noord-Brabant where year after year maize is grown showed concentrations of bentazone in the uppermost groundwater up to 49 µg/l (Boekhold et al, 1993).
Because of the very low sorption constant of bentazone the compound can be transported in the soil with the waterflow very easily. This means that the risk of leaching to the groundwater increases with increasing precipitation excess. On average the half-lifetime for bentazone at reference conditions (20 °C) is approximately 16 days; this means that transformation may attenuate the risk of leaching substantially. However at applications in the late season, when soil temperature is lower and therefore the apparent half-life time is higher, the risk of leaching increases. To decrease the load of bentazone to Dutch groundwater the use of bentazone is restricted to the period March to October 1st. A monitoring program was designed to investigate whether this restriction indeed results in a decreasing load of bentazone to groundwater. Because the use of bentazone in maize growing is limited to the period May-June other treatments were to be under investigation. Two soil types were selected: a light sandy soil and a heavier clay or loam soil.
The objectives of the monitoring program were:

- to measure the occurrence of bentazone in the uppermost groundwater after late season applications;

- to evaluate whether the concentrations of bentazone in the uppermost groundwater are in the same order of magnitude as former measurements after early season applications;
- to evaluate the threat of leaching of bentazone in the Netherlands after late season applications.

1.2. Design of the study

The design of the study was to select fields with a bentazone application after the first of September 1995. The total number of fields was anticipated to be eight.
Unfortunately the criterion of eight fields to be selected could not be met. A number of addresses of farmers was kindly supplied by the Plant Protection Service. Out of the contacts with the farmers it appeared that a late season application of bentazone, as defined in the protocol, is not very common in Dutch agricultural practice. This contradicts (earlier) statements of the Plant Protection Service and BASF that late season application in renewed grassland and in grass-seed cultivation is an important share of the total market. Late season application of bentazone is usually done in renewed grassland. Renewing grassland however is not limited to the period August-September but also takes place in June. Furthermore a number of farmers did not use bentazone on their fields in 1995 because of favourable weather conditions for grass growth.
As a result we had six fields available for which the farmers stated late season application, two fields with a sandy soil, one loam soil and three clay soils. After the start of the monitoring program it appeared that from these six fields only three met the criterion of an application after September 1st, two fields were treated late August and one mid June. Because the information became available only after the start of the sampling and the scarcity of suitable fields , we decided to continue the monitoring program in spite of deviations from the protocol. During the first sampling round it then appeared that for two fields sampling was impossible with the sampling method used. For one of the two fields a substitute field was available, which however was treated with bentazone already in June. Because there was already another field sampled with a June treatment the field was incorporated in the monitoring program. For the other field no substitute could be found.
As a result for five fields the uppermost groundwater was sampled and analysed for bentazone residues. The moment of application varies from mid June to early October. Sampling took place between 249 and 452 days after application in the first sampling round and between 411 en 484 days after application in the second sampling round. The rather large variation in times between application and sampling also is due to the difficulties encountered in finding suitable fields.

2. Materials and methods

2.1. Area description

All fields are situated in the so called Flevopolders in the province of Flevoland. In the eldest of these 3 polders part of the area consist of a sandy soiltype. In the newer polders soil types from loam up to heavy clay are found, mostly with a lot of peat fractions in the subsoil. The polders are relative new land and do not have a long agriculture history. The ripening of the soils in the polders is still going on. In the eldest part the 'Noordoostpolder' the first farmers started in the fifties, in 'Noordelijk-Flevoland' this was in the sixties. In large parts of the Flevopolders most farms are dedicated to modern intensive agriculture which implies an efficient lay-out of the fields, optimised access to the field and strict farm management. Almost all fields are drained at a level of 0.8-1.25 meters below soil surface.

Field 1 and 2 are situated in the 'Noordoostpolder' the eldest of the 3 polders that build the province of 'Flevoland'. Both fields consist of a sandy soiltype low in organic matter for top and subsoil.
The groundwater level at the first day of sampling was at 0.6 and 0.7 m below soil surface for field 1 and 2 respectively. At the second sampling round this was 0.8 and 0.9 m below soil surface respectively.
Field 3 is situated in the polder 'Noordelijk Flevoland', the second eldest part of the 'IJsselmeerpolders'. The top soil consists of a heavy clay soil up to 40 cm depth. Below 40 cm up to a depth of 1.4 m the clay is less heavy and contains peat residues. Below 1.4 m the soil consists of grey reduced sand. The groundwater level at the first day of sampling was at 1.4 m depth. At the second sampling round this was 1.5 m.
Field 4 is situated in the 'Noordoostpolder' like field 1 and 2 but somewhat more to the north. The top soil consists of sandy loam up to 40 cm below soil surface, low in organic matter. From 40 up to 80 cm below soil surface the soil consists of loam with inclusions of peat. Up to approximately 1 to 1.2 meter we find a predominantly peaty layer and below that we find a sandy soil. The groundwater level at the first day of sampling was at 0.8 to 1 m below soil surface, the same level as during the second sampling round.
Field 5 is situated in the polder 'Zuidelijk Flevoland'. This field was selected for sampling in the first place, however because of a very immature subsoil (this polder is the newest of the 'IJsselmeerpolders') it appeared impossible to extract groundwater with the method used.
Field 6 is also situated in 'Zuidelijk Flevoland'. The upper 40 cm of the soil consists of clay which becomes heavier below 40 cm up to about 1 meter. In this layer small rests of peaty material are present. From a depth of 1 meter up to 1.40 meters the clay is very humid (immature). Below 1.40 meters we find a sandy layer which is reduced below the groundwater level (grey colour). The groundwater table at the day of sampling was found at 1.60 to 1.70 meters below soil surface.

For each field mixed soil samples from two layers were analysed at the Laboratory for Soil and Crop Analysis at Oosterbeek for pH, organic matter content $CaCO_3$ content and lutum (% < 2μm). Also on each field the pH of the groundwater was measured in the field. The results of these analyses are presented in chapter 3.

2.2. Application of bentazone

The amount of bentazone applied ranges from 144 grams active ingredient to 720 grams active ingredient per hectare. Because on farms in the Flevopolder most of the farm work, including plant protection treatments, is done by an agricultural contractor it was for some fields impossible to derive the exact spraying amounts. Normally applications in this region are done with half or one tenth of the recommended dose depending on the amount of weeds. Infestation of soils with weeds is rather low in this area. On fields 4 and 5 a mixture of bentazone and mecoprop-P was used, on the other fields only bentazone was used.

2.3. Sampling

On each of the selected fields a net field is selected with an area of at least 5000 m^2 showing as much visible homogeneity as possible. The net field is situated in such way that the borders of the net field are at least ten meters away from the border of the total field and from often used wheel tracks. The net field is divided into 4 equal sections. On each section 5 sampling points situated on a traverse sight line are selected randomly with the help of the computer program UNCSAM (LBG/SOP 647). Figure 1 in appendix 1 presents an example of the layout of the sampling scheme. At the predetermined 20 sample spots a hole is drilled with a 9 cm diameter hand auger up to a depth of approximately 30 cm. A plastic core is placed in this hole to prevent soil from falling in. With a second hand auger (7 cm diameter) the hole is drilled further up to c. 75 cm below the groundwater level. A sampling lance is lowered and pushed into the borehole until the centre of the filter unit is c. 50 cm beneath the groundwater level. The lance is kept in this position during sampling with the help of a tennisball. The stainless steel capillary that is positioned in the sampling lance is connected to a bottle under vacuum pressure. The capillary is pre-rinsed with some volume of groundwater before the sample bottle is connected. After the bottle is filled in this way it is stored in a temperature controlled cooling box with ice. Samples are labelled according to the protocol.
After transportation to the laboratory, 4 composite samples for analysis were prepared according to a random scheme.
The monitoring existed of two sampling rounds. The start of the first sampling round was determined with the help of the PESTRAS model (Tiktak *et al.*, 1994; Freijer *et al.*, 1996) on the basis of literature data on the behaviour of bentazone in soil (Linders *et al*, 1994), but with the DT_{50} value taken from Boekhold *et al.*, 1993.
In each sampling round one of the fields was sampled in duplicate in order to check the sample preparation and the analysis procedure Duplo samples for analysis were coded in such a way that they were blind samples to the analyst.
Sampling heavy soils like clay and loam soils with the method described takes a lot more time than sampling sandy soils, and on immature clay soils it is difficult or even impossible to collect the desired amount of groundwater.

2.4. Analysis

The analysis of bentazone is performed with a HPLC method according to SOP LOC/201/01. 200 or 250 ml of sample is brought to pH 2 by adding 400μl concentrated acetic acid. The samples are than extracted over a C18 SPE column. The SPE column is sucked dry during at least 30 minutes. The bentazone is desorbed with 2 ml of acetone into a calibrated glass tube. The organic phase is removed under nitrogen flush by placing the tube in a hot water bath (c. 90°C). The residue is resolved by adding at first 400 μl methanol followed by 1600 μl 0.1%

phosphoric acid. The extract is injected in a column switching RPLC-system. Bentazone is detected with a UV detector at 220 nm wavelength.

2.5. Additional observations

2.5.1. Field observations

On the day of sampling on every field in situ measurements on pH of the groundwater were performed. The results of these measurements are reported in table 3.1.
Some fields are used as meadow and others as arable land. Therefore there is a difference in soil management procedures. Soil tillage may influence the leaching of bentazone as with soil tillage the compound is artificially brought to a greater depth. Therefore dissipation under influence of light as well as surface volatilisation are inhibited.
Field 1 was used for tulip growing in 1995, after the harvest grass was sown. Bentazone was used in the new grass. At the time of sampling in 1996 the field was grassland.
Field 2 was meadow in 1995 and also at the time of sampling. Bentazone was used in the grass that was renewed.
Field 3 is arable land on which in 1995 beans were grown and at the time of sampling potatoes. Bentazone treatment took place two times with a 7 days interval in the beans.
On field 4 potatoes were grown in 1995 after the harvest grass was sown on the field. At the time of sampling the field was used as meadow for cattle. Bentazone was used in the new grassland.
Field 5 is used for grass seed growing. This field is not further taken into account.
Field 6 is arable land. In 1995 onions were grown and in 1996 wheat was grown on the field. Bentazone was applied in the onions crop. Sampling took place after harvest of the wheat.

2.5.2. Weather observations

Fields 1 to 4 are sampled in weeknumber 24 in 1996, field 6 is sampled in week 35 in 1996. Weather conditions during sampling were the same in both periods. On each sampling day it was cloudy and between 15 and 20 °C.
More important however for the results are the weather conditions (especially precipitation amounts) between the day of application and the day of sampling. In figure 2.1 the daily precipitation for the period May 1st 1995 to January 1st 1997 is given for the weather station Lelystad.
A number of fields was sprinkled in 1995. Field 1 was sprinkled 2 times with an amount of 30 mm a day. The first time was before bentazone application but the second time was around the day of application. Also field 2 was sprinkled on two dates with an amount of 20 to 25 mm a day each date. The moments of sprinkling are around the moment of application. On field 3 an amount of 20 mm a day was sprinkled once. The date of sprinkling was one week after the second application. Field 4 was sprinkled three times in summer with an amount of 15 mm a day each time. These dates are long before bentazone was applied. Field 5 and 6 were not sprinkled.

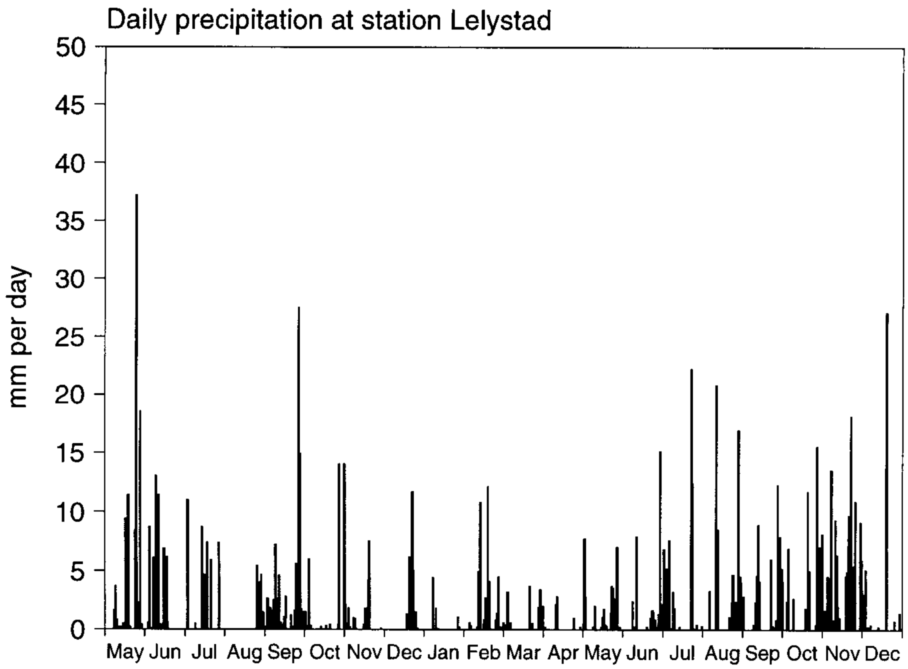


Figure 2.1: Precipitation pattern from May 1995 through December 1996.

3. Results and discussion

3.1. Field characteristics

At the day of sampling for each field the pH of the groundwater is determined by taking a mixed sample of at least two sampling spots. In the first sampling round for each field, except for field 6, soil samples were taken from two layers to analyse for physical and chemical properties. The results of these measurements are reported in table 3.1.

Table 3.1: Physical and chemical properties of soil and groundwater

field code	depth cm	pH-KCl soil	organic matter %	$CaCO_3$ %	% < 2μ	pH ground-water
1-BENT-S	0-40	7.4	2.3	4.5	5.7	7.3
1-BENT-S	40-80	7.9	0.8	8.5	5.9	7.3
2-BENT-S	0-40	7.4	1.7	4.7	4.5	7.5
2-BENT-S	40-80	7.8	0.8	7.8	3.7	7.5
3-BENT-C	0-40	7.4	1.7	9.7	28.2	6.7
4-BENT-L	0-40	7.5	1.3	3.7	5.0	7.1
4-BENT-L	40-80	7.7	1.0	4.7	6.2	7.1
6-BENT-C[#]	0-40	7.4	5.1	9.0	4.7	7.0

[#] Results reported to the farmer in 1993. Analyses by the same institute.

3.2. Bentazone analysis results

In table 3.2 the results of the first sampling round are reported for each field (4 mixed samples per field).

Table 3.2: Analysis results from the first sampling round, concentrations in μg/l

field code	S1	S2	S3	S4
1-BENT-S	<0.05	<0.05	<0.05	<0.05
2-BENT-S	0.07	0.08	<0.05	<0.05
3-BENT-C	0.06	<0.05	0.07	0.06
4-BENT-L	<0.05	<0.05	<0.05	<0.05
6-BENT-C	<0.05	<0.05	<0.05	<0.05

During the first sampling round bentazone was detected in the uppermost groundwater of two out of five fields.

Table 3.3: Analysis results from the second sampling round, concentrations in μg/l

field code	S1	S2	S3	S4
1-BENT-S	0.07	<0.05	<0.05	<0.05
2-BENT-S	0.19	<0.05	<0.05	0.08
3-BENT-C	0.27	0.06	0.16	<0.05
4-BENT-L	<0.05	<0.05	<0.05	<0.05
6-BENT-C	not sampled	not sampled	not sampled	not sampled

In the second sampling round in one of the mixed samples from field 1 bentazone was detected whereas in the other three it was not.

3.2.1. Quality control analysis

In both sampling rounds one of the fields was sampled in duplicate by filling 2 sample bottles on each sampling spot. The samples were then treated as a separate field. Mixed samples were blind samples to the analyst. In the first sampling round field 1 was sampled in duplicate, in the second sampling round field 4 was sampled in duplicate. The results from the duplicate analyses are reported in table 3.4

Table 3.4: Results of duplicate analyses

field code	mixed sample 1	mixed sample 2	mixed sample 3	mixed sample 4
1-BENT-S	<0.05	<0.05	<0.05	<0.05
DUPLO	<0.05	<0.05	<0.05	<0.05
4-BENT-L	<0.05	<0.05	<0.05	<0.05
DUPLO	<0.05	<0.05	<0.05	<0.05

Accidentally both duplicate samplings took place on a field with no detectable bentazone in the uppermost groundwater. Nevertheless, duplicate samples are in agreement with each other.

3.3. Statistical analysis per field

With the statistical package GENSTAT we can analyse if the average concentration per field significantly exceeds the detection limit and/or the value of 0.1 μg/l. All 4 individual results per field are used as input values for the calculation. A one sided t-test is performed or equivalently the lower limit of a one sided 95% confidence interval is calculated ($X - t_{(0.95,n)}$ * s.e.d.). To calculate the lower 95% confidence limit values below the detection limit were set to zero. With these values the mean value and the lower limit per field are calculated.
To calculate the upper 95% confidence limit all measurements below 0.05 μg/l were set to a value of 0.05. Again the mean value per field is calculated. The upper limit of confidence is than calculated by ($X + t_{(0.05,n)}$ * s.e.d.). From the calculated lower limit we conclude which fields clearly had a concentration above the detection limit.
The results of the calculation of the lower and upper ($X + t_{(0.05,n)}$ * s.e.d.) confidence limit for each field per sampling round are presented in table 3.5.

Table 3.5: Lower and upper confidence limits of bentazone concentrations.

sampling round	field number	lower 95% limit	upper 95% limit	remark
1	1	0	0	#
1	2	-0.032	0.086	
1	3	-0.003	0.073	
1	4	0	0	#
1	6	0	0	#
2	1	-0.038	0.071	
2	2	-0.076	0.198	
2	3	-0.066	0.298	
2	4	0	0	#
2	6	not sampled	not sampled	

: no bentazone detected in the groundwater.

From the results of the statistical analysis we learn that on none of the fields the detection limit is exceeded significantly, the lower limit of the 95% confidence interval is on or below the detection limit. For the fields numbered 1, 4 and 6 no bentazone was detected in the groundwater in the first sampling round. Therefore no confidence interval for the measurements of round 1 can be calculated. This goes for field 4 in the second sampling round as well (field 6 was not sampled in the second sampling round). For field 1 measured concentrations between lower than the detection limit (lower 95% confidence limit is a negative value) and 0.071 µg/l can be expected in the second sampling round.
For field 2 the lower 95% confidence limit is a negative value in both the first and the second sampling round. The upper 95% confidence limit is 0.086 and 0.198 µg/l respectively for the first and the second sampling round. This means that measured concentrations may be expected between lower than the detection limit (<0.05 µg/l) and 0.086 and 0.198 µg/l respectively. This means that there is a possibility of measuring bentazone concentrations above the value of 0.1 µg/l (EC drinking water standard). The same goes for field 3 were measured concentrations may range from lower than the detection limit to 0.073 and 0.298 µg/l respectively for the two sampling rounds. So for field 3 only in the second sampling round there is a chance to measure concentration above the value of 0.1 µg/l.
The mean value calculated for all individual measurements is 0.0325 µg/l.

In another statistical calculation it is tested if the average values per field differ from each other and if the differences between fields are influenced by the factor sampling round. The expected values for variances are calculated. All 4 individual results per field are used in the calculation. Also in this calculation values below the detection limit are arbitrarily set to zero. To stabilise variances within the statististical calculation values are linearized by taking the logarithmic value. Because values below the detection limit are set to zero, and it is impossible to calculate the logarithmic value of zero, an arbitrary value of half the detection limit (0.025) is added to the results. The GENSTAT program is given in Appendix 1.
From this calculation we see that there is a significant influence of the factor field (perc); F pr < 0.05. Statistically seen we cannot prove that there are no differences between the fields. The difference between fields is however not caused by the factor sampling round (F-prob >0.05). Statistically it cannot be demonstrated that the sampling round has influence on the

differences between fields. There is a clear indication that the fields under investigation differ from each other, and the difference is not determined by the sampling round.

3.4. Mutual comparison of the fields

The average concentration on field 2 and 3 is obviously higher in the second sampling round than it was in the first. On field 1 in the second sampling in one of the mixed samples bentazone was detected whereas in the first sampling round no bentazone was detected. Based on the results from these two sampling rounds it would have been interesting to sample the fields 1 to 3 for a third time to see if the peak maximum for leaching was already achieved or not. Unfortunately the project ran out of money so no third sampling round was possible. Remarkable is that for fields 2 and 3 the respective farmers stated that bentazone was used on the fields in 1991 as well. On field 1 and 4 there was no known use from former years. For field 6 this information was not available, however it seems realistic to suppose that there is also former use on this field considering the use as arable land.
It might be possible that there was still some residue concentration present in the profile of field 2 and 3 as a result of former application. Because no pre-application sampling was performed this information is lacking. There is however a clear increase in concentration between the first and the second sampling round which is attributed to the 1995 application. Because all fields are situated in polders also seepage phenomena could have influenced the concentration of bentazone in the uppermost groundwater. Seepage phenomena might influence the decrease of the concentration by dilution, by inducing horizontal transport and extra drain transport or by prohibiting bentazone from reaching the sampling depth. Fields 1, 2 and 4 are situated on locations in the polders were an upward seepage of 0-1 mm per day (average concentration over a year, seasonal fluctuation may occur) might be expected (Groen, 1997), whereas fields 3 and 6 are situated on locations with downward seepage and no seepage expected, respectively. On both fields 2 and 3 some bentazone concentrations were detected in the groundwater. To what extend this is influenced by seepage phenomena is unclear. In table 3.6 relevant information about the fields is summarised and related to the field average concentration of bentazone.

Table 3.6: Relevant information about the fields in relation to average concentration

field no.	soil type	agricul-tural use	applied amount kg a.i./ha	applied on (date)	former application in	avg.conc 1st round µg/l	avg.conc 2nd round µg/l	seepage @
1	sand	grass	0.72#	23/8/95*	never	<0.05	0.036	up
2	sand	grass	0.72#	23/8/95*	1991	0.05	0.08	up
3	clay	arable	2x0.144	12/6 and 19/6/95	1991	0.054	0.129	down
4	loam	grass	0.72	7/10/95*	never	<0.05	<0.05	up
6	clay	arable	0.144	1/6/95	no inf.	<0.05	NA	no

approx. half the recommended dose (gewasbescherminggids,1993).
* date estimated because exact date is unknown.
@ information from Groen, 1997.

3.5. Comparison with model simulations

In table 3.7 the day of application and the days of sampling are reported, January first of each year is day number 1. Sampling is planned around the estimated peak maximum. Because planning is based on the standard scenario and therefore might differ somewhat from the time of peak maximum calculated with more field specific data.

Table 3.7: Application and sampling dates (January 1st is day 1)

field code	day of application 1995	day of 1st sampling 1996	day of second sampling 1996
1-BENT-S	235*	165	281
2-BENT-S	235*	165	281
3-BENT-C	163 and 170	164	282
4-BENT-L	280*	164	282
6-BENT-C	152	239	no sampling

*: The exact date of application is not known, daynumber is chosen based on expert judgement of the author and information of the farmer.

In the monitoring program the PESTRAS model (Freijer *et al*, 1996) is used to predict the moment of leaching of bentazone to a depth of 1 to 2 meter below soil surface. For this simulation the standard scenario is used adjusted for data on environmental fate from literature. No value for interception of the compound by the crop was incorporated in the simulations. During the monitoring program when more field specific data become available, model simulations can be performed using these data to adjust the sampling program.
For the fields under investigation three different simulations are performed:
- Grassland on sandy soil, an application of 0.72 kg a.i./ha on day 235, organic matter content in the top soil of 1.9%. K_{om} and DT-50 for bentazone are set to 4 dm^3/kg and 16 days respectively. Precipitation data from the weather station 'Lelystad' from 1995 and 1996 are used.
- Grassland on clay soil, an application of 0.72 kg a.i./ha on day 280, organic matter content of the topsoil of 1.7%. Other data are similar to the simulation as mentioned above.
-Arable land on clay soil, two applications of 0.144 kg a.i./ha on day 163 and day 170, organic matter content of the top soil of 1.7%. In this simulation the field is ploughed up to a depth of 40 cm on day 280. Other data are equal to the other simulations mentioned above.
- Arable land on clay soil, an application of 0.144 kg a.i./ha on day 152, organic matter content of the top soil of 5.1%. In this simulation the field is ploughed up to a depth of 40 cm on day 280. Other data are equal to the other simulations mentioned above.

The graphical results of the simulations are presented in figures 1 to 4 in Appendix 3.

Model calculations show a large leaching peak for bentazone on sandy soil at approximately 450 days after application (figure 1, appendix 3). The calculated maximum concentration is around 9 µg/l. If we compare calculated results with measured concentrations in the first sampling round for field 1 and 2, we see that on field 1 no bentazone was detected in the uppermost groundwater in the 1st round and on field 2 two out of four mixed samples show a concentration above the detection limit. The concentration is however below 0.1 µg/l. Sampling in the 1st round was performed on day 530 for both fields, which is somewhat later

than the time of the calculated peak maximum. Second sampling was done at day 646, at this time the calculated peak is going downward again. However, the calculated concentration between 1 and 2 meter depth is still far above the detection limit.
In comparison, measured concentrations in the second sampling round were somewhat higher than in the first sampling round. On field 1 one out of four mixed samples showed a concentration above the detection limit at 0.07 μg/l, but still clearly below 0.1 μg/l. Field 2 showed in two out of four mixed samples concentrations bentazone above the detection limit. In one sample a concentration of 0.19 μg/l was measured. So in the field the concentration still seem to increase at this moment, whereas the model calculates a decrease already.
Field 3 is related to the simulation as presented in figure 3 in appendix 3. The PESTRAS model calculates a peak maximum of about 0.65 μg/l around day 400, about 240 days after the day of application. The first sampling round on field 3 was performed at day 529 which is probably somewhat after the calculated peak maximum. On field 3, three out of four mixed samples showed a concentration of bentazone just above the detection limit. Second sampling was performed at day 647. In the model calculations the concentration bentazone in the groundwater is decreasing again at this time. However, the measured concentration on field 3 in the second sampling round was clearly higher for two out of four mixed samples. A third mixed sample shows a measured concentration just above the detection limit and the fourth is below this limit. Again the measured concentrations in the field seem to increase where the model predicts a decrease already. Field 6 is related to the simulation as presented in figure 4 in appendix 3. On field 6 first sampling took place not until day 604. This was because the field was a last moment substitute for another field which was treated with bentazone much later. Therefore, compared to the model calculations, first sampling took place just after the calculated peak maximum. The calculated peak maximum for field 6 is around 0.085 μg/l, not far above the detection limit of 0.05 μg/l. Field 6 was not sampled for a second time because of unfavourable weather conditions later on in the year and lacking capacity.
In figure 2 in appendix 2 the calculated results of field 4 are presented. From figure 4 we see that the calculated peak maximum is reached around day 500, about 220 days after the day of application. The calculated maximum concentration is around 25 μg/l.
Measured concentrations on field 4 however did not show any detectable bentazone present in the uppermost groundwater. Apparently the model is strongly influenced by the moment of application and the applied dose whereas under field conditions probably other factors are important too.
In the simulations performed as much as possible fieldspecific data for application, rainfall and organic matter content of the soil are used. However, average data on K_{om} and DT_{50} are used and default values for interception of the compound by the crop.
If we use the interception rate given in USES (Jager and Visser *eds,* 1994) for grassland and onion crop as input value for interception the maximum concentration leached decreases with a factor 2. According to USES the in grassland and onion crop about 50% of the applied pesticide reaches the soil. On field 3 beans were grown during application. For beans there is no value for interception available in USES. Probably the amount of pesticide reaching the soil is lower. In Appendix 4 the results of simulations with 50% interception of the pesticide by the plants is incorporated by applying half the actual amount. As a result we see that calculated maximum concentrations are also 50% lower. For field 3 calculation with a more realistic interception of the pesticide by the crop results in an overestimation of the measured concentration with a factor of 2. Also for field 6 no large differences between model calculations and measured results are demonstrated now. For the other three fields the model still overestimates the detected concentrations.

Remarkably is that on field 3 there is probably downward seepage and on field 6 there is no seepage. Up till now PESTRAS has been most frequently used for sandy soils in downward seepage (infiltration) areas. Rather little experience exists for soils with upward or mixed seepage conditions. For this study in addition no specific information on the seepage conditions for each field was available and therefore parameters were not adjusted. Parameters used are suitable for downward water transport (infiltration) conditions. Deviations from this situation might have contributed to the differences between calculated and observed concentrations.
A monitoring study like this however is not designed to validate the model. The model is used as a tool to indicate at which time interval the compound might leach to the groundwater. The apparent mismatch between observations and calculations, the rather limited number of observations and the limited experience with PESTRAS in upward seepage situations, led to the decision of not extrapolating the results to the national situation.

3.6. Comparison with former measurements

The goal of this monitoring program; to measure occurrence of bentazone in the uppermost groundwater after late season application, could not be met, because not enough fields meeting the criterion could be found.
The evaluation whether concentrations of bentazone in the uppermost groundwater are in the same order of magnitude as concentrations found after early season application is impossible, because the contrast early season application versus late season application does exist for too few fields. However, because former measurements after early season applications done by RIVM are mostly from maize growing areas, and only a small number of monitoring data originate from other regions we can compare former measurements from maize growing areas with measurements from other crops in this monitoring program. Furthermore we can compare the measurements from this program with the results from monitoring on arable land other than maize obtained with a different sampling method.
From a monitoring program performed by RIVM between 1985 and 1991 a median value for bentazone of <0.05 µg/l for two maize growing areas can be derived. For other arable land a median value of <0.05 µg/l is found. Maximum measured concentrations are 0.92 and 0.65 µg/l respectively. Though results from former monitoring programs are obtained with a different sampling method and a different program set-up, measured concentrations in this monitoring program are in the same order of magnitude. Concentrations however are far beneath the concentrations measured in the flowerbulb area and in a field experiment performed on a maize field (Boekhold *et al.*, 1993).

4. Conclusions

-The goal of this study was to measure the occurrence of bentazone residues in the uppermost groundwater after late season application to support the criteria stated in the draft canalisation agreement. However, it appeared impossible to find enough fields that met the criterion set; application after September 1st.
-On five fields the uppermost groundwater was sampled and investigated for bentazone residues. On two out of these five fields a concentration of bentazone above the detection limit was determined in the first sampling round. The average concentration for the two fields in the first sampling round was 0.05 and 0.054 μg/l respectively. In the second sampling round this was 0.08 and 0.129 μg/l respectively. In the second sampling round on one field more, one out of four mixed samples showed a bentazone concentration above the detection limit.
-Bentazone was found under a sandy soil as well as a clay soil. Therefore, in this monitoring program the possible leaching of bentazone on a clay soil has been proved. The two fields where bentazone was detected in the groundwater consist of a sandy soil and a clay soil respectively. Seepage phenomena may influence the concentration in groundwater in this region. The two fields are situated on a location were upward seepage respectively downward seepage is expected. Seepage phenomena may decrease the concentration in groundwater by dilution or by inducing transport via drains to surface water.
-Initial calculations with the PESTRAS model showed concentrations 1 to 2 orders of magnitude above the measured concentrations. It was possible to adjust hydrological parameters of the model and match observed and calculated concentrations better for a number of fields. Too little experience, however, exists on using the model in situations with upward seepage and lateral drainage. Therefore it could not be decided whether adjustments were warranted. Because of this and the absence of such data on a national scale, it was decided not to extrapolate results to a national scale.
-With the results of this study it is not possible to answer the research questions stated in the protocol: 'what is the threat of leaching of bentazone to groundwater after late season application. Too few fields could be found that met the requirements and, in addition, too many parameters of the PESTRAS model had to be adjusted to match field specific observations

Recommendations

To be able to measure leaching behaviour of a pesticide in agricultural practice adequately the number of fields under investigation should be as large as possible, with a minimum number of eight fields. This criterion is hard to meet and in some cases it will be necessary to review the field selection criteria
If possible the fields should be sampled more often around the expected concentration peak in the groundwater to be able to reproduce the leaching peak. Of course the possibility of a renewed use of the pesticide under investigation can disturb the investigation.
The sampling method used in this study appears to be rather inconvenient in clayey/immature soils. Because such soils are abundant in the Netherlands and important for agriculture, it is recommended to develop a sampling method for such soils.
To be able to extrapolate data to the national situation the PESTRAS model should be more thoroughly validated, especially in situations with seepage phenomena and artificial drainage.

REFERENCES

- Ministerie van Landbouw, Natuurbeheer en Visserij (LNV), 1991. Meerjarenplan Gewasbescherming.
- A.E. Boekhold, F.A. Swartjes, F.G.G.Hoogenboom and A.M.A. v.d. Linden. Validation of the PESTLA model: Field test using data from a sandy soil in Schaijk (The Netherlands). Reportnumber 715802002, RIVM, 1993.
- A.A. Cornelese en H.L.J. van Maaren. Veldonderzoek bestrijdingsmiddelen; Resultaten van 1990. Rapportnummer 725803005, RIVM, 1992 (in Dutch).
- A.A. Cornelese en H.L.J. van Maaren. Veldonderzoek bestrijdingsmiddelen; Resultaten 1991. Rapportnummer 725803006, 1993 (in Dutch).
- C.Tomlin eds., 1994. The pesticide manual. 10^{th} edition.
- J.I.Freijer, A.Tiktak, S.M. Hassanizadeh and A.M.A. v.d. Linden. PESTRAS v3.1: A one-dimensional model for the assessment of the fate of pesticides in soil. Reportnumber 715501007, RIVM, 1996.
- K.P. Groen. Pesticide leaching in polders; field and model studies on cracked clays and loamy sand. 1997
- C.v. Heerden en A.Tiktak. Het grafisch programma XY; Een programma voor visualisatie van de resultaten van rekenprogramma's. Rapportnummer 715501002, RIVM, 1994 (in Dutch).
- D.T.Jager and C.J.M.Visser eds. Uniform System for the Evaluation of Substances (USES), version 1 (1994).
- J.B.H.J.Linders, J.W. Jansma, B.J.W.G. Mensink and K.Oterman. Pesticides: Benefaction or Pandora's Box? A synopsis of the environmental aspects of 243 pesticides. Reportnumber 679101014, RIVM, 1994.
- R.C.M. Merkelbach, G.Bor, J.Denneboom and P.G.Lentjes. ISBEST 2.0: en datasysteem met informatie over het bestrijdingsmiddelengebruik in Nederland. Rapportnr. 425, DLO-Staring Centrum, Wageningen, The Netherlands, 1995 (in Dutch).
- A.Tiktak, A.M.A. v.d. Linden and F.A.Swartjes. PESTRAS: A one dimensional model for assessing leaching and accumulation of pesticides in soil. Reportnumber 715501003, RIVM, 1994.

QUALITY ASSURANCE STATEMENT

Study Title:	Monitoring of bentazone concentrations in the uppermost groundwater after late season applications.
Protocol Number:	715804004
Test Substances:	Bentazone
Study Director:	A.M.A. van der Linden

In compliance with the Good Laboratory Practice Regulations this study was reviewed by the Quality Assurance Unit on:

October 16, 1995	By H.Mesters, LBG	report October 27, 1995
April 29, 1996	By H.Mesters, LBG	report April 29, 1996
May 1, 1996	By H.Mesters, LBG	report May 6, 1996
June 20, 1996	By H.Mesters, LBG	report June 20, 1996

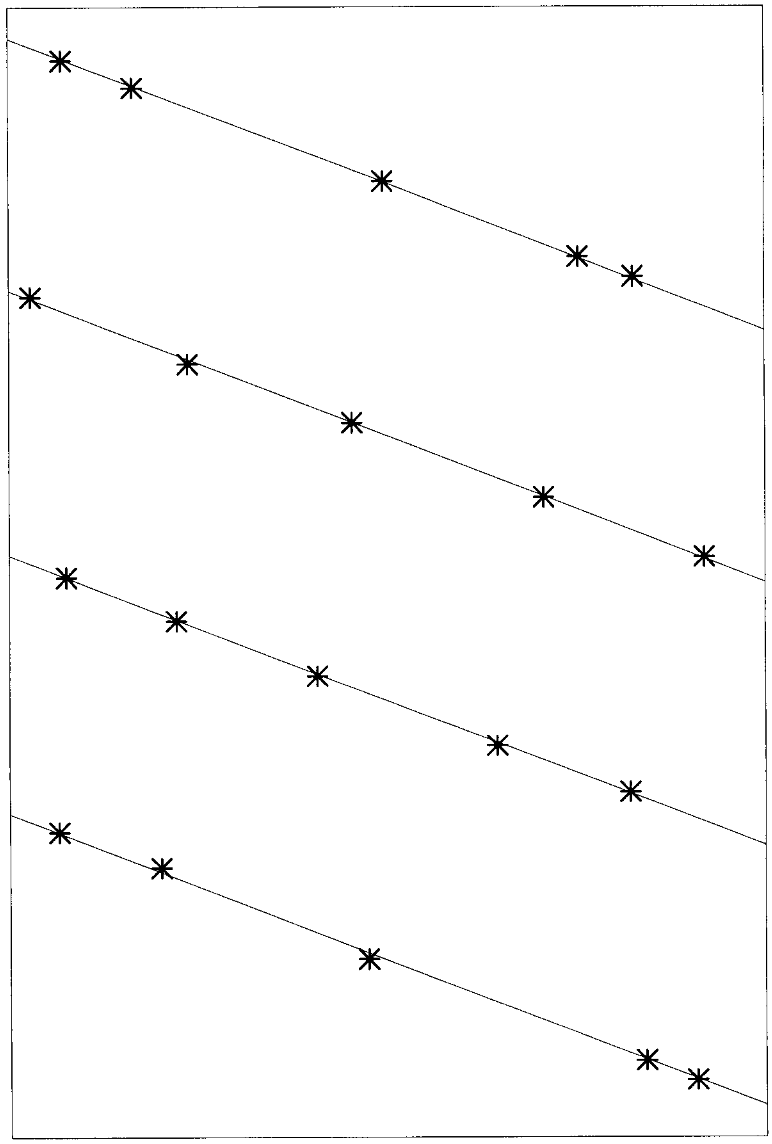
A report of the findings was submitted to the study director and to the management on: October 27,1995; April 29,1996; May 6,1996 and June 20,1996. The methods described were the methods followed and the data presented reflect the data collected during the conduct of the study.

Final Report Audit performed on March 19, 1998 report on June 9, 1998

.... 2/7-1998

H.Mesters Date

Appendix 1: Sample locations within a field



APPENDIX 2: GENSTAT PROGRAM USED TO TEST IF FIELDS ARE DIFFERENT

Genstat 5 Release 1.3 (DOS/386) Implemented by Marketing Risk Management


```
1 UNIT [40]
2 "generating factors"
3 FACT [LABEL=!T(r1,r2)] ronde
4 FACT [LABEL=!T(p1,p2,p3,p4,p5)] perc
5 VARI bent
6 OPEN 'result';CHAN=2
7 READ [CHAN=2] bent; FREP=LABEL
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
bent	0.00000	0.03250	0.27000	40	4	Skew

```
8 CLOSE 2
9 OPEN 'ronde';CHAN=2
10 READ [CHAN=2] ronde; FREP=LABEL
11 CLOSE 2
12 OPEN 'perc';CHAN=2
13 READ [CHAN=2] perc; FREP=LABEL
14 TREAT perc/ronde
15 CALC lgbent=LOG(bent+0.025)
16 ANOV [FPROB=y;PRIN=AOV] lgbent; RESID=r; FIT=f
```

***** Analysis of variance *****

Variate: lgbent

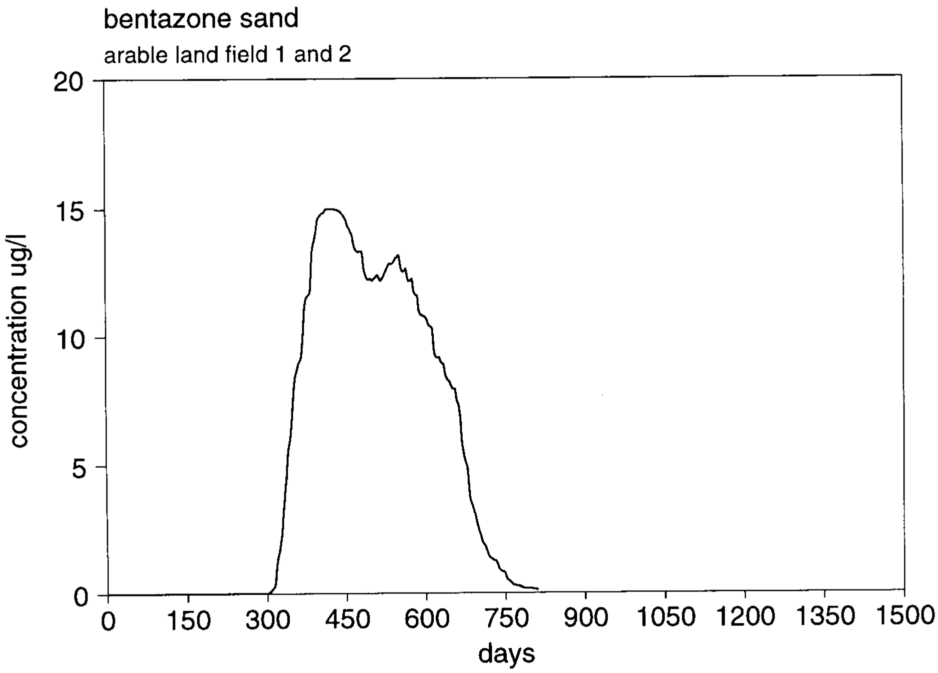
Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
perc	4	9.0489	2.2622	5.35	0.003
perc.ronde	4(1)	0.7637	0.1909	0.45	0.771
Residual	27(3)	11.4253	0.4232		
Total	35(4)	20.4989			

```
17 STOP
```

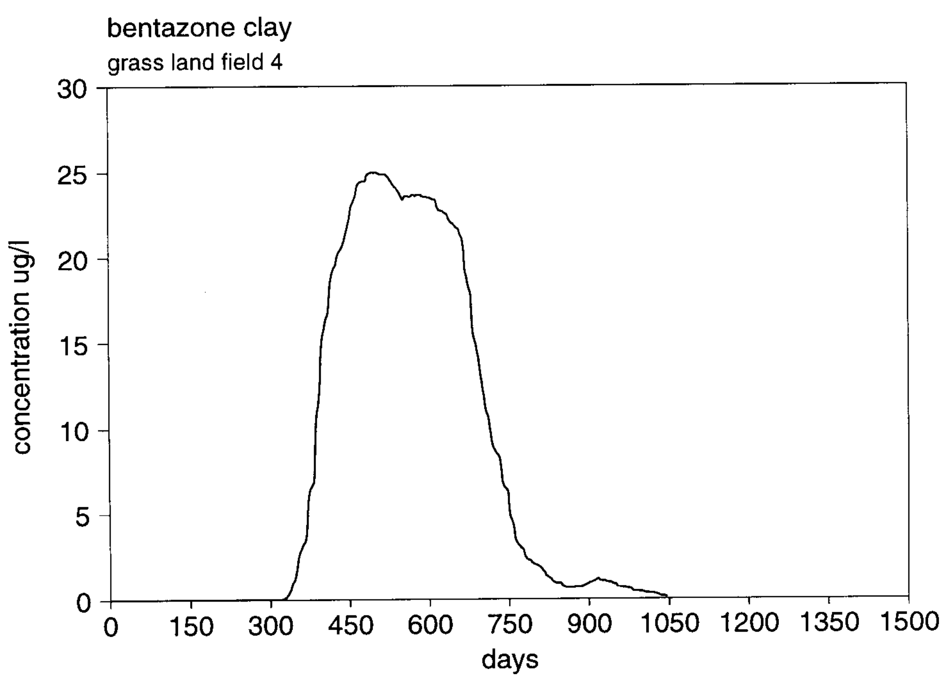
******** End of job. Maximum of 1836 data units used at line 15 (106190 left)

APPENDIX 3: MODEL SIMULATION RESULTS

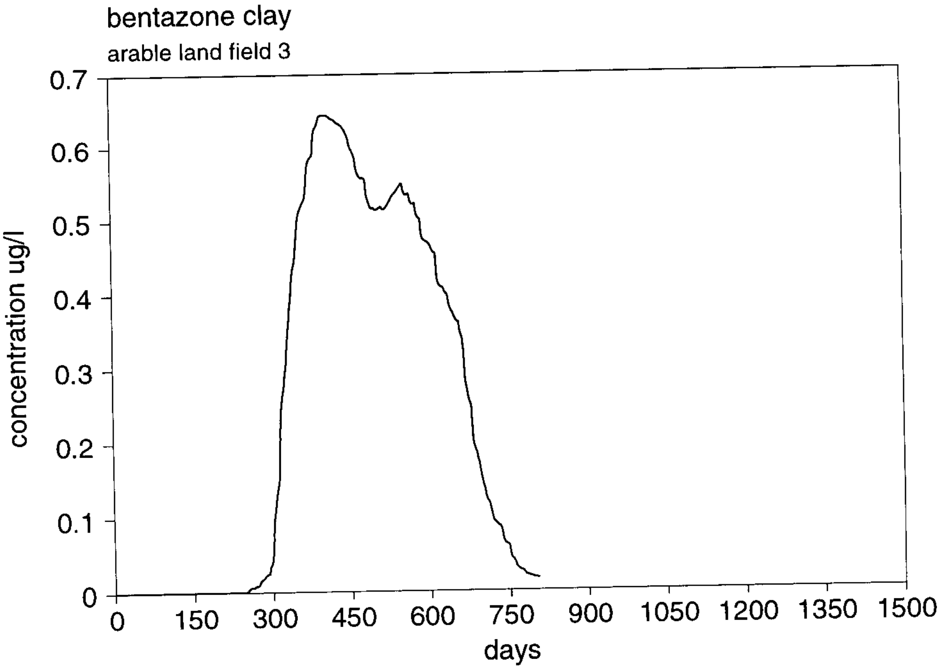
1st simulation, grassland on sandy soil
application: 0.72 kg active ingredient per hectare on day 235 (january 1st 1995 = day 1)
organic matter content in top soil: 1.9%
K_{om}: 4 dm^3/kg DT_{50}: 16 days



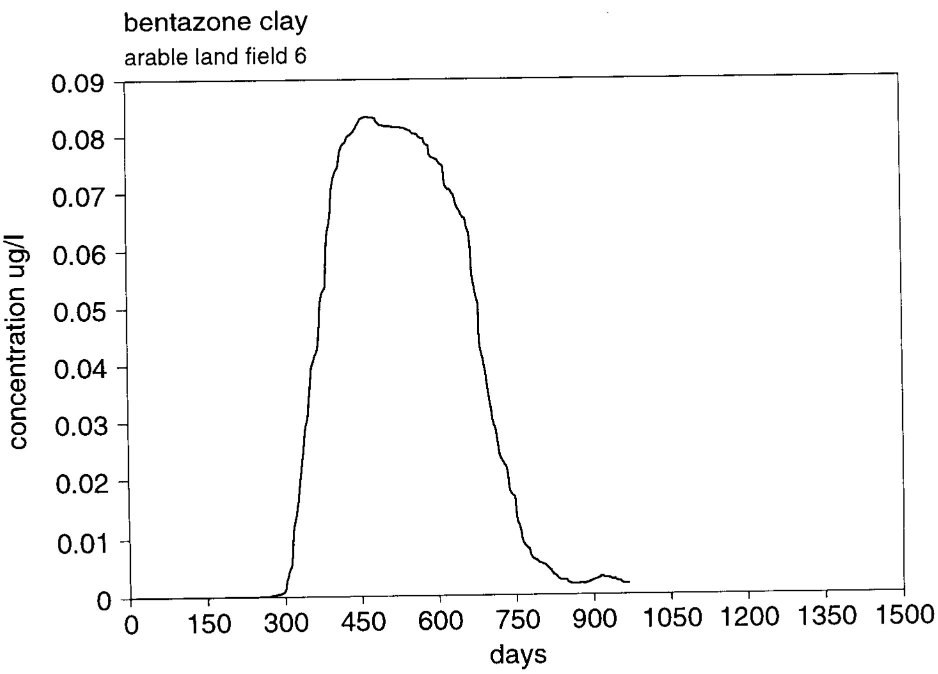
2nd simulation: grassland on clay soil
application: 0.72 kg active ingredient per hectare on day 280 (january 1st 1995 = day 1)
organic matter content top soil: 1.7%
K_{om}: 4 dm^3/kg DT_{50}: 16 days



3rd simulation arable land on clay soil
application: 0.144 kg active ingredient per hectare on day 163 and day 170
(january 1st 1995 = day 1)
organic matter content top soil: 1.7%
K_{om}: 4 dm^3/kg DT_{50}:16 days
ploughing upto a depth of 40 cm on day 280

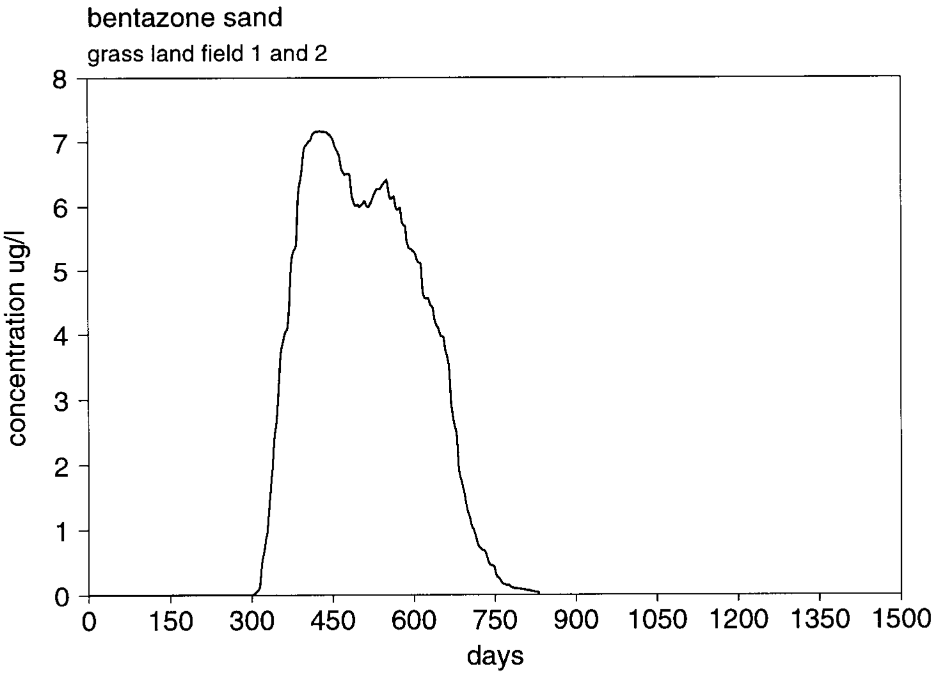


4th simulation arable land on clay soil
application: 0.144 kg active ingredient per hectare on day 152 (january 1st 1995 = day 1)
organic matter content top soil: 5.1%
K_{om}: 4 dm^3/kg DT_{50}:16 days
ploughing upto a depth of 40 cm on day 280

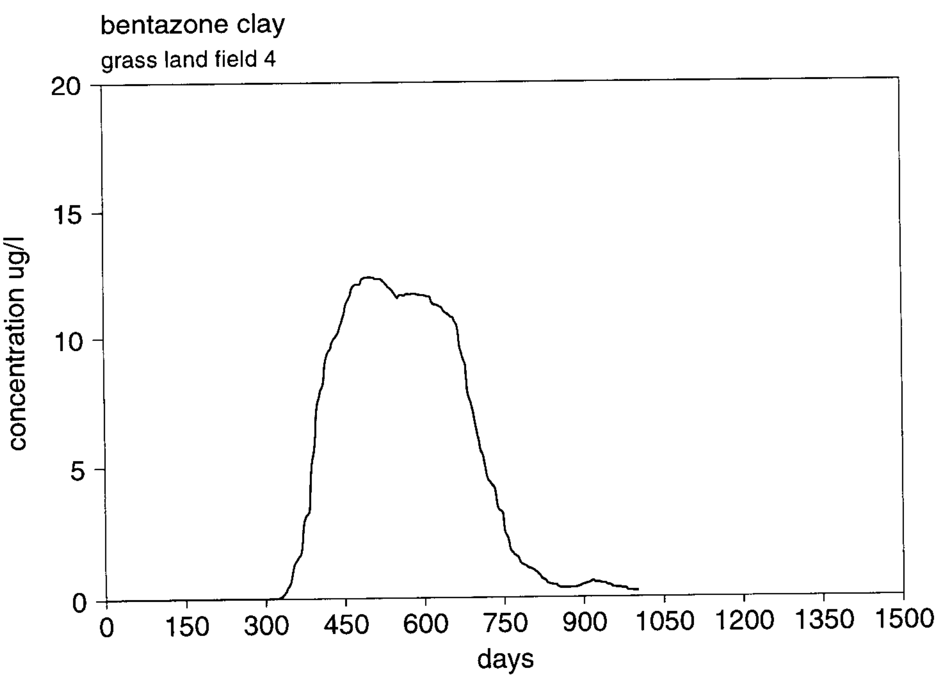


APPENDIX 4: MODEL SIMULATIONS WITH 50% INTERCEPTION OF THE COMPOUND BY CROP

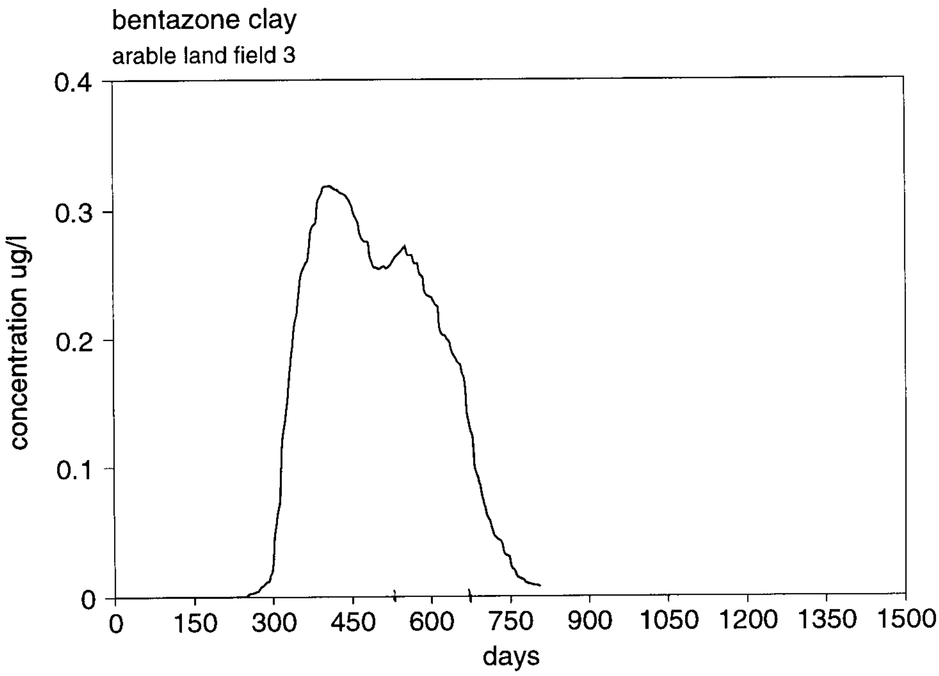
1st simulation, grassland on sandy soil
application: 0.36 kg active ingredient per hectare on day 235 (january 1st 1995 = day 1)
organic matter content in top soil: 1.9%
K_{om}: 4 dm^3/kg DT_{50}: 16 days



2nd simulation: grassland on clay soil
application: 0.36 kg active ingredient per hectare on day 280 (january 1st 1995 = day 1)
organic matter content top soil: 1.7%
K_{om}: 4 dm^3/kg DT_{50}: 16 days



3rd simulation arable land on clay soil
application: 0.072 kg active ingredient per hectare on day 163 and day 170
(january 1st 1995 = day 1)
organic matter content top soil: 1.7%
K_{om}: 4 dm^3/kg DT_{50}:16 days
ploughing upto a depth of 40 cm on day 280



4 th simulation arable land on clay soil
application: 0.072 kg active ingredient per hectare on day 152 (january 1st 1995 = day 1)
organic matter content top soil: 5.1%
K_{om}: 4 dm^3/kg DT_{50}:16 days
ploughing upto a depth of 40 cm on day 280