

Residues of atrazine in agricultural areas of Serbia

S. GAŠIĆ[#], M. BUDIMIR, D. BRKIĆ and N. NEŠKOVIĆ

Institute for Plant Protection and Environment, T. Drajzera 9, 11000 Belgrade, Yugoslavia

(Received 2 July 2002)

Abstract: In this paper the results of a five-year investigation of the pollution of soil, as well as of surface and groundwater by atrazine are reported. The soil samples were collected from different localities, from the tillage level, at two depths (0–15 and 15–30 cm) during the period September–November from 1995 to 1999. The surface and groundwater samples were taken from the same localities during the same period. The residues were detected by the ELISA test. The results showed that almost all the analysed soil samples contained residues of atrazine. These quantities varied from 0.02 to 0.10 mg/kg (0–15 cm), and up to 0.05 mg/kg (15–30 cm), depending on the locality, soil type and the year of investigation. Concerning the residues in the surface and groundwater, it was found that most of the analysed samples contained atrazine residues. In the case of the surface water, the quantity of the residues ranged from 1.0 to 4.13 µg/L, while the ground water contained up to 0.3 µg/L depending on the locality and the year of investigation.

Keywords: atrazine, soil, groundwater, surface water.

INTRODUCTION

Atrazine is a triazine herbicide, used worldwide since 1952 to control weeds in corn, sorghum, sugar cane, orchards, pastures and non-crop areas. Atrazine is widely applied for annual weed control in corn and it can be said that it is one of the most commonly used herbicides in Serbia. In spite of the existence of new chemical compounds, atrazine is still being used in great quantities worldwide.¹

In cultivated soils, atrazine is considered to be moderately persistent and highly mobile. Numerous results have shown the presence of atrazine residues in groundwater.^{2–5} Hence, atrazine represents a potential risk to the environment and human health. Subsequent to its extensive use, numerous reports on soil, surface and groundwater contamination have been documented. Owing to its impact on groundwater, atrazine has been banned in many countries and consequently producers and environmental scientists have focused their attention on possible substitutes. Beside this, there is a risk of carryover of phytotoxic residues into the next growing season resulting in possible damage to succeeding susceptible crops.^{6,7}

[#] Serbian Chemical Society active member.

In order to bring to light the situation in Serbia, an attempt was made in this study to obtain more information about atrazine residues in the soil, as well as the surface and groundwater in a five-year investigation in typical crop growing areas.⁸ The point of this investigation was to determine the atrazine residues after years of application and to assess the risk to the environment and human health.

EXPERIMENTAL

Soil samples for the analysis were collected from six different localities: Sombor, Kikinda, Šabac, Surčin, Paraćin and Negotin, in areas of intensive crop production, from 1995 to 1999. The samples were taken from two depths (0–15 cm and 15–30 cm) during the period September–November. The surface and groundwater samples were taken from areas near the above mentioned areas.

The residues of atrazine were detected using the ELISA test according to the procedure given by the producer.⁹

RESULTS AND DISCUSSION

The results of the determination of atrazine residues in the soil samples taken from both depths are presented in Figs. 1 and 2, respectively. Concerning the samples from a depth of 0–15 cm, 63.3 % contained atrazine residues up to the 0.05 mg/kg level, while 36.6 % contained residues from 0.05 to 0.10 mg/kg. In the underlying layer (15–30 cm), atrazine residues were detected in 53.3 % of the samples which contained up to 0.05 mg/kg. In 16.7 % of the samples only traces of atrazine residues were detected, while 30 % of the samples contained no detectable residues.

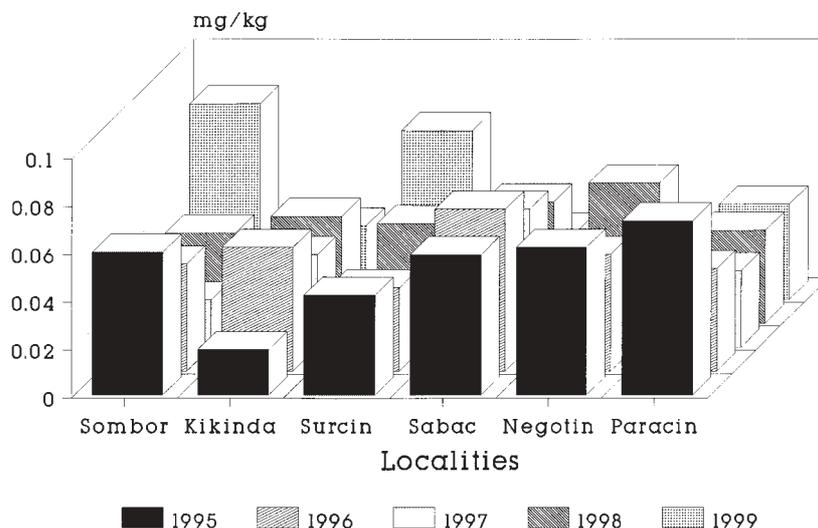


Fig. 1. Atrazine residues in soil (0–15 cm).

Generally, it can be said that whether atrazine resides in the soil depend on the soil composition, temperature, pH and soil humidity. After application to soil, atrazine is subject to sorption and to several chemical and biological degradation mechanisms that promote the reduction of the atrazine concentration in the soil.^{10,11} The amount of atrazine that

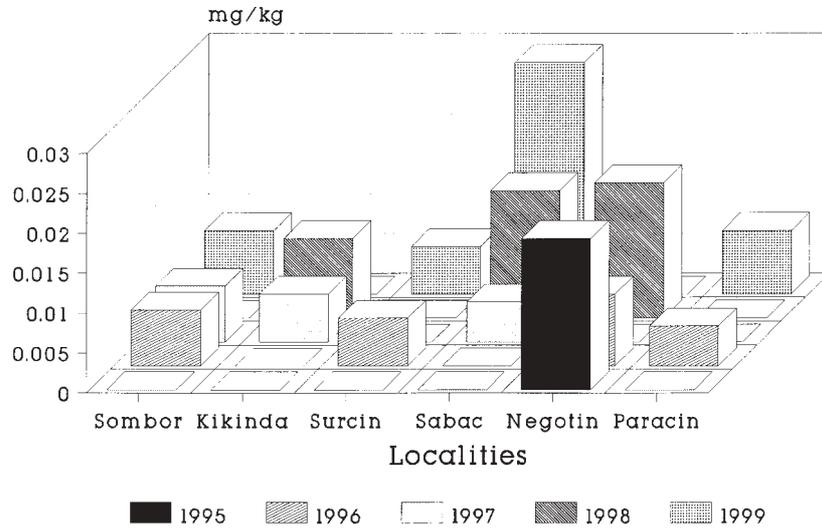


Fig. 2. Atrazine residues in soil (15-30 cm).

resides in the top surface soil one year after its application is estimated to be around 8 to 20 % of the initial level.

When applied on soil, atrazine migrates to other areas of the environment by several processes such as volatilisation, leaching and run-off. The risk of groundwater contamination by vertical transport is ultimately determined by the balance between the rates of chemical sorption and degradation in the soil.^{12,13}

Comparing the results obtained in this study to the results from other sources, it can be said that they are more or less comparable to the results obtained in other countries. For example, in Spain it was found that ten months after application 48 % of the analysed sam-

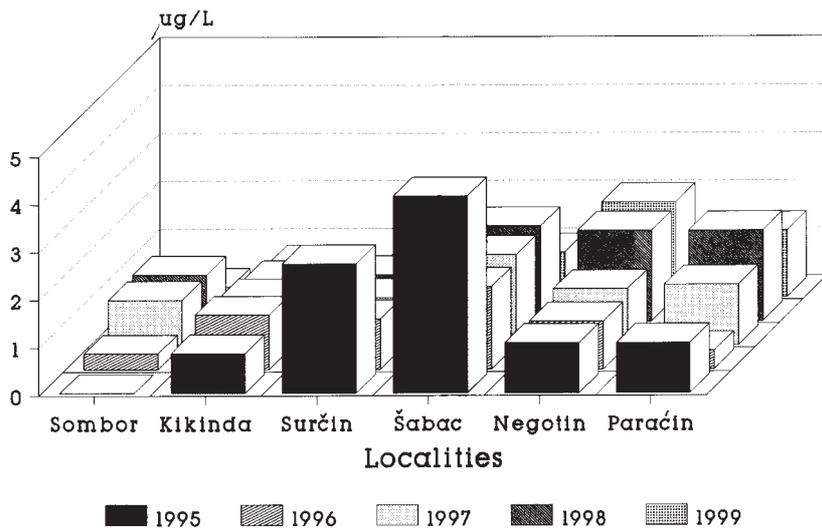


Fig. 3. Atrazine residues in surface water.

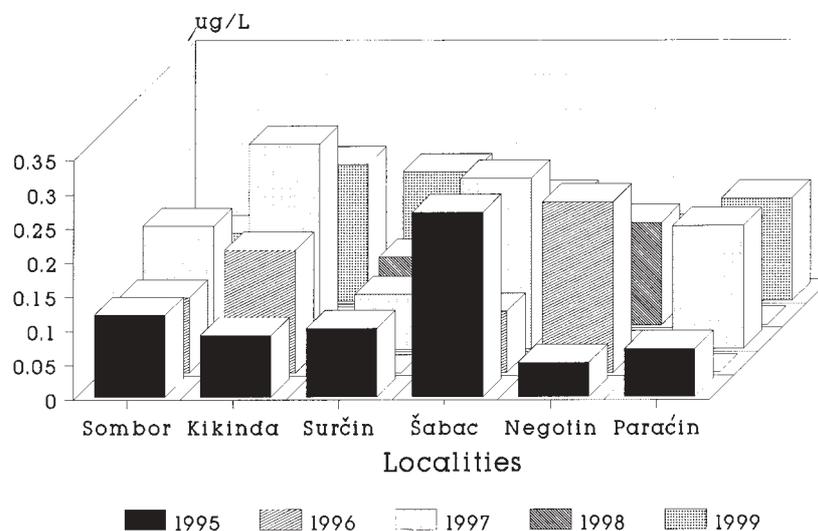


Fig. 4. Atrazine residues in groundwater.

ples contained up to 0.05 mg/kg of atrazine residues, while 20 % contained more than 0.1 mg/kg.¹⁴ In Italy it was found that atrazine residues were present in amounts at 0.01 mg/kg about 194 days after application.¹⁵

From the results of the monitoring of the surface water samples (Fig. 3) it is clear that atrazine residues were present in 60 % of the samples at a level between 1.0 and 4.13 µg/L, in 23.4 % of the samples up to 1 µg/L of atrazine residues were detected, while in 16.6 % samples no detectable residues were found.

Numerous reports and publications exist on the level of atrazine contamination of surface waters in various countries.^{3-5,16} The concentration of atrazine in water depends on the season, with the maximum concentration being registered during the application period. In studies in eight European countries, the detected amount of residues ranged from 0.17 to 10.0 µg/L.¹⁶ In USA rivers, atrazine concentrations of up to 87 µg/L were found. Hence, our results are comparable to the results of other countries.

The presence of atrazine residues in groundwater were confirmed in 83.3 % of the samples while in 16.7 % of the samples no detectable atrazine residues were found (Fig. 4). In 33.3 % of the samples, atrazine residues were present at a concentration of up to 0.1 µg/L, 36.6 % of the samples contained atrazine residues at a level between 0.1 and 0.2 µg/L, while in 13.3 % of the samples atrazine residues were present at a level between 0.25 and 0.30 µg/L.

A large data set is now available that shows the presence of many pesticides in groundwater at levels which rarely exceed the guideline values defined by the World Health Organisation on the basis of their toxicological properties.^{16,17} Atrazine was monitored in the surface and groundwater in agricultural areas of South Africa and about 20 % of the surface and groundwater samples contained between 0.29 to 298.2 µg/L of atrazine residues.¹⁸

CONCLUSION

– All the analysed soil samples from the surface layer (0–15 cm) contained residues of atrazine. These quantities varied from 0.02 to 0.10 mg/kg, depending on the locality and soil type, as well as on the year of investigation.

– In the underlying layer (15–30 cm) almost 70 % of the analysed samples contained atrazine residues, up to the 0.015 mg/kg level.

– It was found that most of the analysed samples of surface and groundwater also contained atrazine residues. In the surface water, the quantities of residues ranged from 1.0 to 4.13 µg/L, while the groundwater contained up to 0.3 µg/L of residues, depending on the locality and the year of investigation.

– The results show that soil and water contamination by atrazine is considerable. The biological and toxicological significance of these residues in the environment will be the subject of further investigations.

ИЗВОД

ОСТАЦИ АТРАЗИНА НА ПОЉОПРИВРЕДНОМ ЗЕМЉИШТУ СРБИЈЕ

С. ГАШИЋ, М. БУДИМИР, Д. БРКИЋ и Н. НЕШКОВИЋ

Институт за заштитиу биља и животиуу средину, Т. Драјзера 9, 11000 Београд

У раду су приказани резултати одређивања остатака атразина у узорцима земљишта, површинским и подземним водама, праћеним у петогодишњем периоду. Узорци земљишта узимани су на различитим локалитетима са две дубине (0–15 и 15–30 cm) у периоду од 1995. до 1999. године. Узорци површинских и подземних вода узимани су са истих локалитета у истом периоду. Остаци атразина одређивани су помоћу ELISA тестова. Резултати су показали да сви анализирани узорци земљишта садрже остатке атразина, при чему количине варирају од 0,02 до 0,10 mg/kg за горњи слој (0–15 cm), а за доњи слој (15–30 cm) крећу се до 0,05 mg/kg, у зависности од локалитета, типа земљишта и године испитивања. Што се тиче површинских и подземних вода утврђено је да већина анализираних узорака садржи остатке атразина. У случају површинских вода количина остатака се креће од 1,0 до 4,13 µg/L, док је у подземним водама садржај остатка до 0,3 µg/L, у зависности од локалитета и године испитивања.

(Примљено 2. јула 2002)

REFERENCES

1. D. L. Regehr, P. L. Barnes, D. L. Devlin, R. J. Rector, *BCPC Symposium: Pesticide Behaviour in Soils and Waters*, Symposium Proceedings No. 78, Brighton, UK, 2001, p. 373
2. R. Frank, G. J. Sirons, *Bull. Environ. Contam. Toxicol.* **34** (1985) 541
3. H. R. Buser, *Sci. Technol.* **244** (1990) 1049
4. W. E. Pereira, C. E. Rostad, *Environ. Sci. Technol.* **4** (1990) 144
5. K. R. Solomon, D. B. Baker, R. P. Richards, K. R. Dixon, S. J. Klaine, T. W. La Point, R. J. Kendall, C. P. Weisskoopf, J. M. Giddings, J. P. Giesy, L. W. Hall Jr., W. M. Williams, *Toxicol. Chem.* **15** (1996) 31
6. S. U. Khan, P. B. Marriage, *Weed Res.* **21** (1981) 9
7. A. R. Saghir, A. M. Choudhary, *Weed Res.* **6** (1967) 272
8. S. Gašić, M. Budimir, D. Bošković, N. Nešković, *11th International Symposium on Environmental Pollution and its Impact on Life in the Mediterranean Region*, Abstract Book, Limassol, Cyprus, 2001, C21
9. Anon.: EnviroGard Triazine Plate Test Kits 72110, Millipore (U.K.) Ltd., Watford, Hertfordshire WD1 8YW, UK, 1997

10. H. O. Esser, G. Dupuis, E. Ebert, C. Vogel, G. J. Marco, in *Herbicides - Chemistry, Degradation, and Mode of Action*, Vol. 1, P. C. Kearney and D. D. Kaufman, Eds., Marcel Dekker, Inc., New York, 1979, p. 129
11. C. S. Helling, W. Zhuang, T. J. Gish, C. B. Coffman, A. R. Isensee, P. C. Kearney, D. R. Hoagland, M. D. Woodward, *Chemosphere* **17** (1988) 175
12. G. Sposito, L. Martin-Neto, J. Yang, *Environ. Qual.* **25** (1996) 1203
13. C. Vazzana, M. Franci, V. Vecchio, *Proc. of the EWRS Symposium: Theory and Practice of the Use of Soil Applied Herbicides*, 1981, p. 149
14. A. Obrador, M. T. Matienzo, J. M. Garcia-Baudin, J. L. Tadeo, *Brighton Crop Protection Conference - Weeds*, 4D-1, 1991, p. 471
15. E. Capri, M. Trevisan, E. Bergamaschi, A. A. M. Re Del, *Brighton Crop Protection Conference - Weeds*, 6D-3, 1993, p. 795
16. S. Bintein, J. Devillers, *Chemosphere* **32** (1996) 2441
17. WHO: *Guidelines for Drinking Water Quality - Recommendations*, Vol. 1, 2nd Edition, World Health Organization (WHO), Geneva, 1993
18. L. P. Van Dyk, F. E. Pick, E. Botha, *Brighton Crop Protection Conference - Weeds*, Vol. 2, Brighton, UK, 1993, p. 861.