XXXVIII IAH Congress

Groundwater Quality Sustainability

Krakow, 12–17 September 2010

Extended Abstracts

Editors:
Andrzej Zuber
Jarosław Kania
Ewa Kmiecik

University of Silesia Press 2010

abstract id: **327**

topic: **1**
Groundwater quality sustainability

1.4
Groundwater quality and agriculture

title: **The evaluation of long-term trends in groundwater pollution with nitrates based on the study of surface water**

author(s): **Józef P. Górski**
Adam Mickiewicz University, Department of Hydrogeology and Water Protection, Poland, gorski@amu.edu.pl

keywords: nitrates, surface water, groundwater, influence of groundwater on surface water quality

INTRODUCTION

Groundwater is a significant component in the balance of rivers and lakes recharge. The results of the research show that the groundwater discharge to the rivers in Poland constitutes about 60% in relation to the surface runoff, with up to 80% in some catchment areas (Jokiel, 1994). These proportions indicate that the quality of surface water is to a large extent affected by groundwater, and the analysis of long-term study of surface water quality may be used in the evaluation of groundwater quality changes. Such an analysis may be conducted taking into account the long-term changes of nitrate content in river water. The source of the above changes may be in particular the groundwater from shallow circulation systems.

The paper presents the evaluation of groundwater pollution with nitrates based on the analysis of their content in the Warta River water in the years 1958–2008.

CHARACTERISTICS OF THE WARTA CATCHMENT TO THE POZNAŃ GAUGING SECTION

The Warta catchment to the Poznań gauging section comprises the area of 25083 km^2 (Fig. 1), that is the upper and middle section of the whole Warta catchment basin. In the upper part of the catchment, the substratum consists of the carbonate Jurassic and partly Cretaceous formations, while the middle part consists of post-glacial formations — sands, gravels and glacial tills.

The area is mainly utilised as arable land occupying over 60% of the whole area. The mean precipitation for the whole Warta catchment basin based on the data from the years 1951–1980 amounted to 561 mm, and in the driest year 1959, it only amounted to 358.5 mm (Pasławski, 1992). The mean discharge (SQ) in the Poznań gauging section amounts to 102 m^3/s and the mean low discharge (SNQ) — to 37 m^3/s.

Figure 1. Catchment of the Warta River to the gauging section in Poznań on the background of the map of Poland.

The total runoff from the catchment to the Poznań gauging section amounts to 3.57 $L/s/km^2$, and the groundwater runoff — to 2.34 $L/s/km^2$ (Pasławski, Koczorowska, 1974). High variability of the groundwater runoff may be observed. The highest values of 3.0–4.5 $L/s/km^2$ may be stated only in the upper part of the catchment, formed on the substratum of karstic carbonate rocks. In the remaining part of the catchment, the groundwater runoffs are low — of 1.5–2.0 $L/s/km^2$. The amount of groundwater runoff in this part of the catchment constitutes 85 to 93% of the mean discharge.

The groundwater from the southern part of the catchment occurs in the fractured and karstic carbonate rocks. In the other part of the catchment, the main role in supplying the surface water is played by shallow groundwater circulation systems connected with the sands of river valleys and sandurs as well as shallow aquifers between the layers of glacjal tills.

THE TREND OF NITRATE INCREASE AND THE EVALUATION OF ITS CAUSES

The graph of nitrate concentrations in the Warta river water at the Poznań gauging section presented in Fig. 2 shows a clear increasing trend.

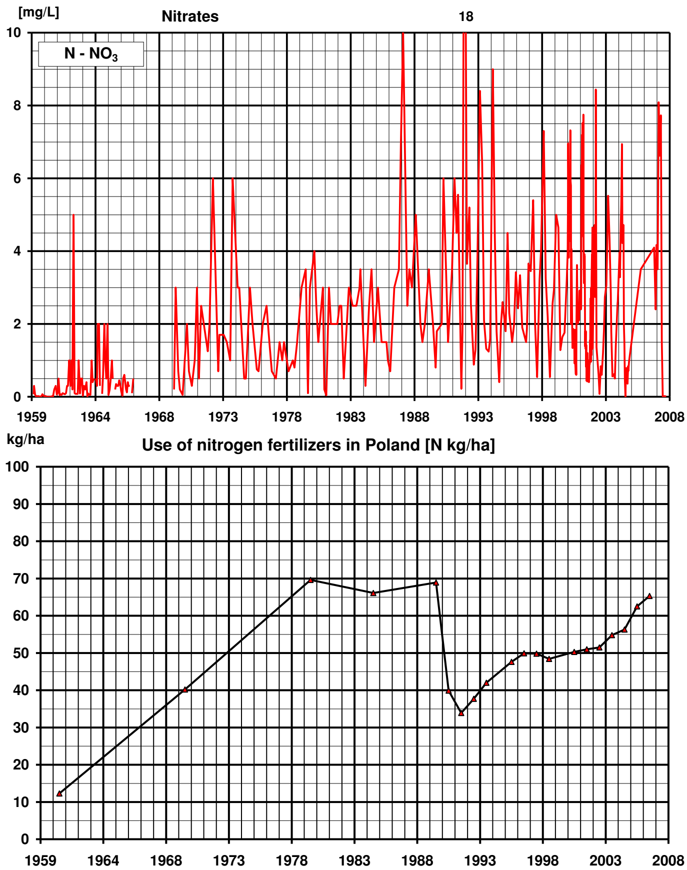

Figure 2. Changes of nitrates in the River Warta water and the use of nitrogen fertilizers in Poland in the years 1959–2008.

The trend is clearly visible regardless of large seasonal and periodical variations. Seasonal variations are connected with the phases of flora and fauna growth in the river. High concentrations only occur in the extra vegetative period, that is in the late autumn, winter and early spring. In the vegetative period, biological absorption of nitrates occurs and their concentration quickly decreases (Fig. 3). Long-term variations, that is the occurrence of particularly high concentrations in some years can be linked to the hydrological and meteorological situation, and especially to the occurrence of longer dry periods.

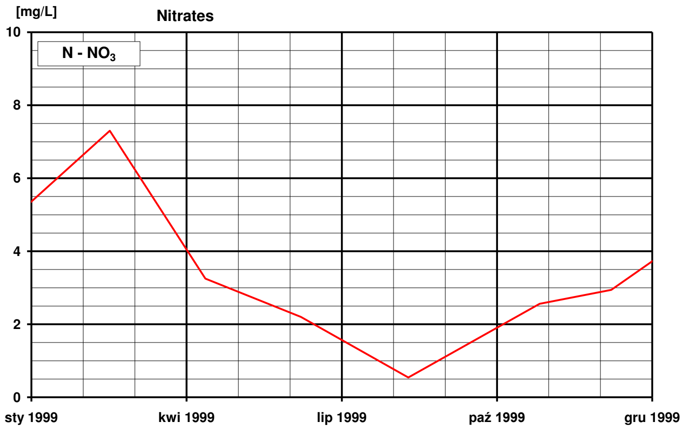

Figure 3. Seasonal changes of nitrate concentrations in the Warta River water.

The reason for the general trend of nitrate increase in river water can be undoubtedly linked to the inflow of more and more polluted groundwater from shallow circulation systems, especially from the agricultural areas. The trend may be noticed in the conditions of progressive lowering of the level of charging the river with sewage and the more frequent application of biogenic removal technology.

This phenomenon is observed in the river water, among other things in the form of systematic decrease in ammonia nitrogene and colour concentrations, which has been presented in Fig. 4. The trend of nitrate increase is clearly correlated with the level of artificial nitrogene fertilizers consumption in Poland (Fig. 2).

The use of fertilizers was low until the early 60s and did not exceed several kgN/ha. Starting from the mid-60s, there was a fast increase in the use of fertilizers which on average amounted to about 70 kgN/ha, reaching up to 100 kgN/ha in the large areas of the investigated catchment.

At the beginning of the 90s, due to the social and economic transformations, there was a decrease in the use of fertilizers to the level of about 35 kgN/ha, which is illustrated by the decrease in the concentrations of nitrates in the years 1995–1998 (Fig. 2). However, the decrease was short-lasting and at present the use of nitrate fertilizers is reaching the level of 70 kgN/ha.

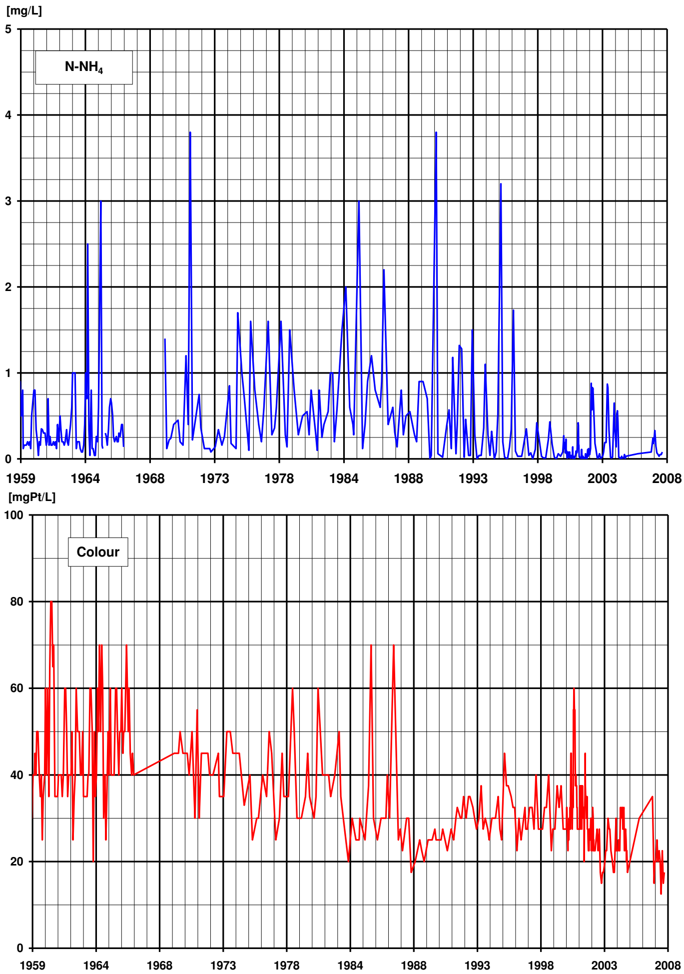

Figure 4. Changes of concentrations of ammonium and colour in the Warta River water in the years 1959–2008.

THE EFFECT OF THE 1989–1992 DROUGHT ON NITRATE CONCENTRATIONS IN RIVER WATER

The analysis of the graph in Fig. 2 indicates the occurrence of particularly high concentrations of nitrates in the years 1992–1994. This phenomenon may be linked to the deep hydrological drought which occurred in Poland, and especially in the Wielkopolska Region and in the Warta River carchment, in the years 1989–1992, which is presented by the comparison of annual precipitation and the Warta River water level (Fig. 5).

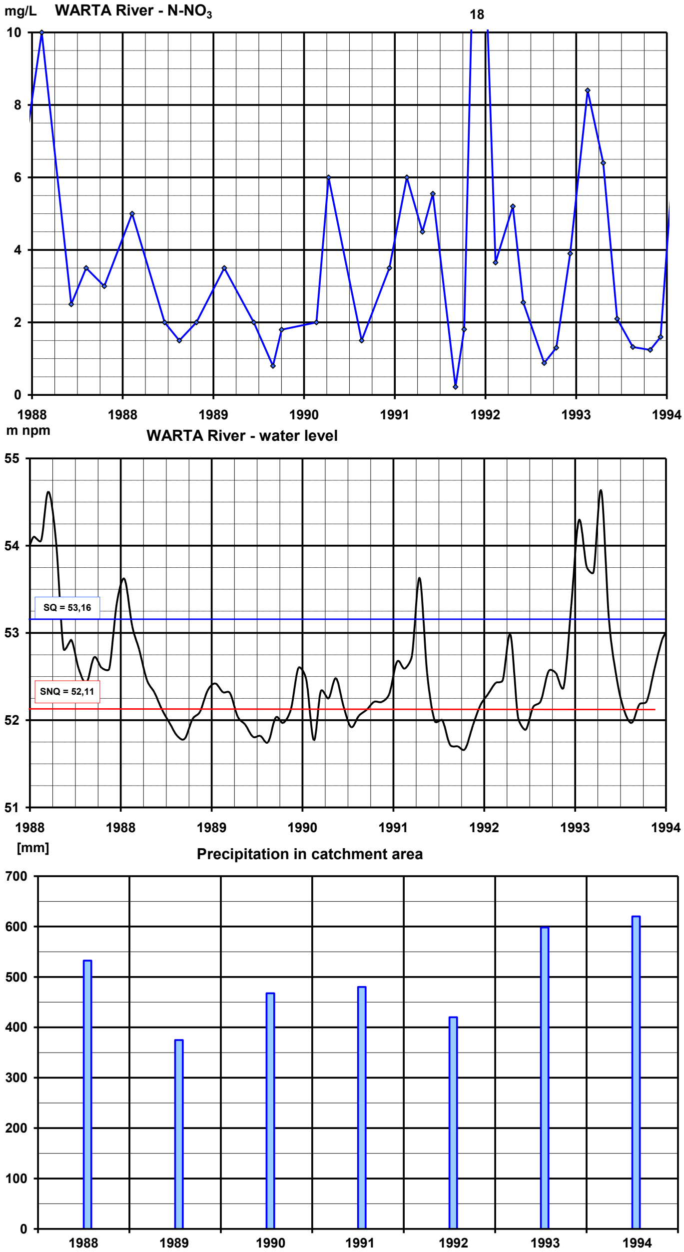

Figure 5. Changes of nitrate concentrations in the Warta River water on the background of river water level fluctuations and precipitation in the catchment area in the years 1988–1994.

During the drought, in the conditions of highly limited infiltration recharge of groundwater, the accumulation of nitrates in soil and aeration zone occurred. After the drought finished, the nitrates were moved to shallow groundwater and next to surface water. This phenomenon was also confirmed by the study of nitrates in groundwater conducted within the network of 8 wells and observation wells in the area of the unconfined aquifer in the Poznań-Warsaw ice marginal valley (Tab. 1). The study revealed a significant increase of nitrates concentrations at the end of 1992, 3 months after the drought finished. The results confirm the phenomenon of nitrate accumulation in the agricultural areas during the drought and explain their high concentrations in the river water after the drought finished.

Table 1. Nitrate concentration in water of chosen wells and observation wells in groundwater recharge area of Mosina well field in different dates.

No of well	Depth of well screen	Nitrates as a $N\text{-}NO_3$ mg/L		
		08.1989	12.1992	09.1993
2[1]	33.3–46.8	0.02	1.2	0.025
36[1]	24.3–37.8	0.1	1.6	0.03
X[2]	7.5–12.5	0.02	1.2	0.00
8b[2]	17.0–19.0	0.3	2.0	0.00
18b/2[2]	12.0–14.0	0.2	1.4	0.02
47b/1[2]	17.0–19.0	0.04	6.0	1.0
71b[2]	26.2–30.9	0.4	1.4	0.1
6k[2]	7.2–9.2	0.1	1.6	0.015

1 – well, 2 – observation well

SUMMARY

The presented materials prove a great usefulness of the analyses of nitrate content in surface water for the evaluation of the contamination and state trends of changes in groundwater pollution with nitrates. Such evaluation should be an important supplementation of traditional monitoring of groundwater quality. It is also of great educational value in terms of showing interrelations between ground and surface water, as well as the necessity to take crucial action to protect groundwater, which is also essential for the protection of surface water.

REFERENCES

Jokiel P., 1994: *Zasoby, odnawialność i odpływ wód podziemnych strefy aktywnej w Polsce (Resources, renewal and runoff of groundwater In Poland).* Acta Geografica Lodziensia, pp. 66-67, Łódź.

Pasławski Z., Koczorowski J., 1974: *Odpływy podziemne rzek na obszarze dorzecza Warty. (Groundwater runoff to the rivers on the catchment of Warta River).* Prz. Geof., 19, 1.

Pasławski Z., 1992: *Hydrogeologia i zasoby wodne dorzecza Warty. (Hydrogeology and water resources of Warta River catchment).* W: Ochrona i regionalne wykorzystanie zasobów wodnych na terenach rolniczych Wielkopolski: 3-28. Komisja Ochr. Środ. Oddz. Pozn. PAN. Poznań.

International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0