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## EXAMINATION OF NITRATE CONCENTRATION IN GROUND WATER IN THE TRZEBOWNISKO COMMUNE

Nitrate concentrations in ground water of western part of the Trzebownisko commune were determined. The characteristics of communal water intakes have been presented and nitrate concentrations measured in the past in those intakes have been analysed. An attempt to define the predicted tendency in forthcoming changes of nitrate concentration has been undertaken with reference to standard concentration values. The paper also gives the results of twofold tests of nitrate concentration in water (surface and ground) of the area under investigation. The results of authors' own research and the analysis of data from the past concerning agricultural and non-agricultural activities (the influence of the airport) lead to the conclusion that the increased amount of nitrogen in water is of anthropogenic origin.

### 1. INTRODUCTION

Nitrogen compounds found in water environment provide an evidence of growing anthropogenic contamination. Excessive quantities of nitrogen compounds in food and fodder are known to be particularly harmful to alive organisms due to their toxic properties. The State Environmental Inspectorate in their reports monitored the concentrations of nitrates in environment. Their reports allowed the following conclusion: a general increase in the content of nitrogen compounds in surface and ground water on the one hand and stricter regulation over the use of water on the other one resulted in the shortage of water for domestic use and for running some businesses, because in many parts of the country they necessitated treatment.

The efforts undertaken to estimate the nitrogen circulating in the environment in order to prevent its further contamination have not confirmed the suitability of methods of looking for the sources, as well as migration ways of nitrogen compounds in the environment. The complexity of the problem lies, among others, in complicated phenomena of physico-chemical changes of nitrogen in the environment, which largely depend on hydrogeological structure of real investigated regions of nitrogen compounds circulation.

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## 2. CHARACTERISTICS OF THE AREA INVESTIGATED

As an administrative unit, the Trzebowniko commune belongs to Rzeszów district – Podkarpacie Province. The commune area comprises about 9000 ha. It is inhabited by almost 17 220 people. Table 1 presents the number of people and the area of four village administrative units (Jasionka, Nowa Wieś, Tajęcina, Zaczernie) in the region where a gradual increase of nitrate content in drinking water has been observed.

Table 1

The area and the number of people in the places threatened with nitrates

| Village   | Area [ha] | Number of inhabitants |
|-----------|-----------|-----------------------|
| Jasionka  | 230       | 1900                  |
| Nowa Wieś | 586       | 1180                  |
| Tajęcina  | 109       | 178                   |
| Zaczernie | 613.5     | 2718                  |
| Total     | 1556.5    | 5976                  |

The area under investigation is a flat land with low relief, generally sloped in the direction of the Wisłok river.

The Trzebowniko commune is of farming-industrial character and its largest production plants represent food industry. Poultry farming has grown to a merchandise scale. A gradual decrease in arable land in respect to the whole area has been observed over the past ten years. The structure of arable land was given in the agricultural registration of 1996 (table 2).

Table 2

The structure of ground utilisation in the Trzebowniko commune according to agricultural registration of 1996 [2]

| Year | Whole area [ha] | Arable land   |                  |               |              |               | Woods [ha] | The remaining land and waste land [ha] | Arable land participation [%] |
|------|-----------------|---------------|------------------|---------------|--------------|---------------|------------|--|-------------------------------|
|      |                 | Together [ha] | Arable land [ha] | Orchards [ha] | Meadows [ha] | Pastures [ha] |            |  |                               |
| 1996 | 8827            | 6091          | 3966             | 133           | 1609         | 383           | 841        | 1895                                   | 78                            |

Geological feature and hydrogeological conditions of the area being examined and comprising water intakes in Zaczernie, Tajęcina, Jasionka, Łąka were described in reports on water law given in previous years. Based on physico-geographical division almost the entire Trzebowniko commune belongs to the subprovince of North Podkarpacie, called Podkarpacka Proglacial Stream Valley. To the north, a part of the commune belongs to Kolbuszowski Plateau.

The region of the Trzebowniko commune lies within the borders of Podkarpackie depression which is filled with the Miocene deposits (Tertiary period) of the thickness of 1800 m. The Krakowieckie clays constitute the ceiling part of deposits which, because of their special features, form an impervious bedding for the quaternary water-yielding stratum. Quaternary deposits consist mainly of sandstone, gravel, loose clay and sand-dust and sand-gravel mixtures. The materials are of fluvial and fluvio-glacial origin. The thickness of those formations in the region being investigated is within 12–15 m in the area of Zaczernie and around 24 m in the area of Jasionka.

In the whole area, there are no impermeable formations that would shield water-yielding stratum on the surface side. The geological structure presented here shows that water-yielding stratum is fed due to infiltration of rain water or surface water. The above-mentioned water intakes were wells drilled in such a way that they reached down to practically impermeable Miocene bedding.

The thickness of water-yielding stratum is estimated to be 5–10 m (9 m on average), and its occurrence starts at 3–6 m BSL. The Mrowla (Czarna) stream, the left-side tributary of the Wisłok river (figure 2), is the main surface stream in the area described. It is of great importance as it feeds water-yielding stratum in dry seasons, and in wet seasons it drains water from the area. Moreover, all water from the drainage system of Jasionka airport is directed to the Mrowla stream.

### 3. UNDERGROUND WATER INTAKES IN THE AREA WITH AN INCREASED NITRATE CONTENT IN GROUND WATERS

Three communal intakes: Nowa Wieś – Jasionka, Tajęcina and Zaczernie are based on drilled wells supplied with quaternary water-yielding resources that occur shallowly. The lack of impermeable ceiling strata, which would protect the intakes against contaminants from the surface, is their characteristic feature [6].

Table 3

The nitrate content in underground water from water intakes in the area of Głogów Młp. in 1990–1999 [8]

| Place                 | Mean nitrate concentrations<br>[mg N-NO <sub>3</sub> /dm <sup>3</sup> ] | Range of variability |
|-----------------------|---|----------------------|
| Głogów Młp. (Zabajka) | 5.9   | 3.6–10.0             |
| Pogwizdów             | 3.2   | 1.3–6.5              |
| Przewrotne            | 4.2   | 3.5–6.0              |
| Rudna Mała            | 3.5   | 3.0–4.5              |

In order to determine objectively the nitrate content, several water intakes in the surrounding communes of similar geological characteristics (the area of the Głogów

Młp. commune) were examined. According to BOUCHARD et al. [7] a natural nitrate content does not exceed  $3 \text{ mg N-NO}_3/\text{dm}^3$ . Higher concentration is due to anthropogenic factors. Table 3 shows nitrate concentrations in the water from some intakes in the area of Głogów Młp. The natural background of nitrate content for that area is about  $3 \text{ mg N-NO}_3/\text{dm}^3$ . The permissible nitrate concentration in drinking water is  $50 \text{ mg}/\text{dm}^3$  ( $11.3 \text{ mg N-NO}_3/\text{dm}^3$ ) [8].

The analysis of data collected by communal officials [9] proves that nitrate concentration in the water from water intakes in Tajęcina, Zaczernie and Jasionka (figure 1) not only enables the observation of changeability of nitrate concentration, but also allows predicting nitrate concentration in the future.

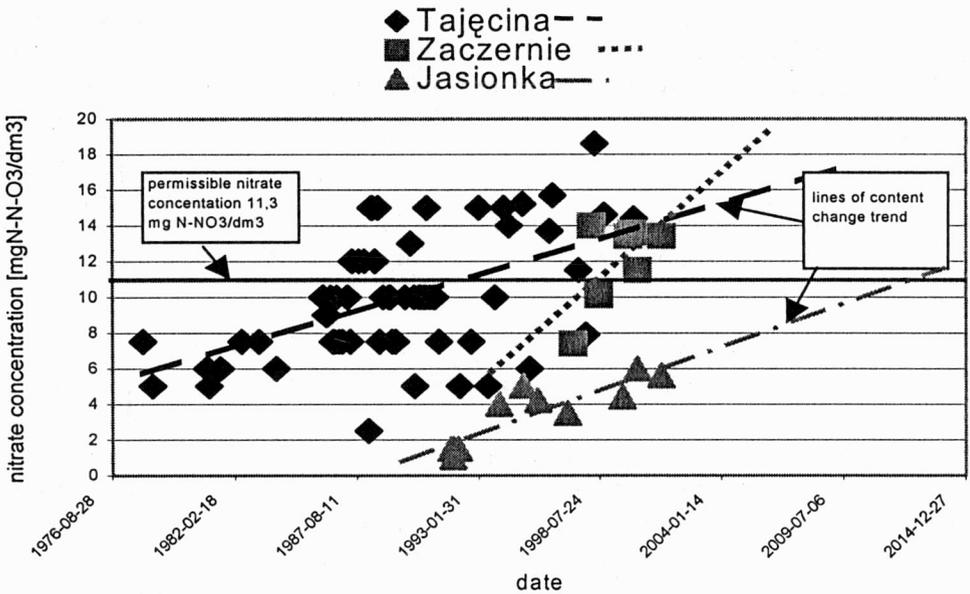


Fig. 1. The changes in nitrate content in water from intakes in Tajęcina, Zaczernie and Jasionka

Though in the last decade, both the decrease in farming production and development of sewage systems are observed, the nitrate concentration in the water being conditioned has successively increased and we may expect that it exceeds its permissible value as soon as in 2012–2013 in the Jasionka water intake.

#### 4. DETERMINATION OF NITRATE CONTENT IN WATER

In order to get quite a clear picture of water environment contamination by nitrates, the samples of water taken at different characteristic points were analyzed

twice (figure 2). The analyses were carried out in April 2000 and May 2001 for both subterranean intakes (one drilled and one dug individually) and reservoirs of surface water (table 4).

Table 4

Concentrations of nitrate compounds in ground and surface water at the chosen points in Trzebowniko commune in the years 2000–2001 [6]

| Village              | The point denotation on the map | The point of sample collecting        | Year 2000 | Year 2001 (02.05) |          |         |      |
|----------------------|---------------------------------|---------------------------------------|-----------|-------------------|----------|---------|------|
|                      |                                 |                                       | Nitrates  | Nitrates          | Nitrites | Ammonia | pH   |
| Zaczernie            | 1                               | water intake                          | 11.5      | 13.4              | 0.0037   | 0.08    | 6.60 |
|                      | 2                               | dug well (55)                         | 9.8       | 10.8              | 0.0037   | 0.08    | 7.05 |
|                      | 3                               | dug well (77)                         | 43.2      | 36.4              | 0.0074   | 0.14    | 6.46 |
|                      | 4                               | the Mrowla river                      | 2.6       | 2.3               | 0.09     | 0.78    | 6.95 |
| Tajęcina             | 5                               | water intake                          | 15.6      | 19.1              | 0.0021   | nw      | 5.53 |
|                      | 6                               | dug well (3)                          | 8.9       | 10.3              | 0.007    | 0.085   | 6.74 |
|                      | 7                               | dug well (5)                          | 14.6      | 13.5              | 0.012    | 0.35    | 6.41 |
|                      | 8                               | dug well (9)                          | 45.8      | 41.0              | 0.03     | nw      | 6.81 |
|                      | –                               | dug well – Wysoka Głogowska (381)     | 19.1      | –                 | –        | –       | –    |
|                      | 9                               | stream not called next to animal farm | 2.3       | –                 | –        | –       | –    |
|                      | 10                              | sand drift next to well 2             | –         | 0.97              | 0.03     | 0.16    | 6.82 |
| Nowa Wieś – Jasionka | 12                              | water intake                          | 6.0       | 5.65              | 0.0037   | 0.08    | 6.28 |
|                      | 13                              | dug well – Nowa Wieś 37               | 33.9      | 6.0               | 0.036    | 0.14    | 7.11 |
|                      | 14                              | a pond at the airport                 | 3.8       | 4.2               | 0.015    | 0.31    | 6.76 |
|                      | 15                              | stream not called – Jasionka          | 3.2       | 2.17              | 0.048    | 0.12    | 6.98 |
|                      | 16                              | the Mrowla river                      | 2.4       | 2.7               | 0.12     | 0.8     | 6.93 |

The wells being dug seem to be most contaminated (Tajęcina no. 9, 45.8 mg N/dm<sup>3</sup>, 2000; Zaczernie no. 77, 43.2 mg N/dm<sup>3</sup>, 2000), the wells being drilled were less contaminated, the lowest concentrations of nitrate compounds were found in streams and surface reservoirs (4.2 mg N/dm<sup>3</sup>, the pond at the airport).

It should be stressed that the measurements of nitrate concentration repeated after one year only slightly differed from the previous ones. This statement was not true

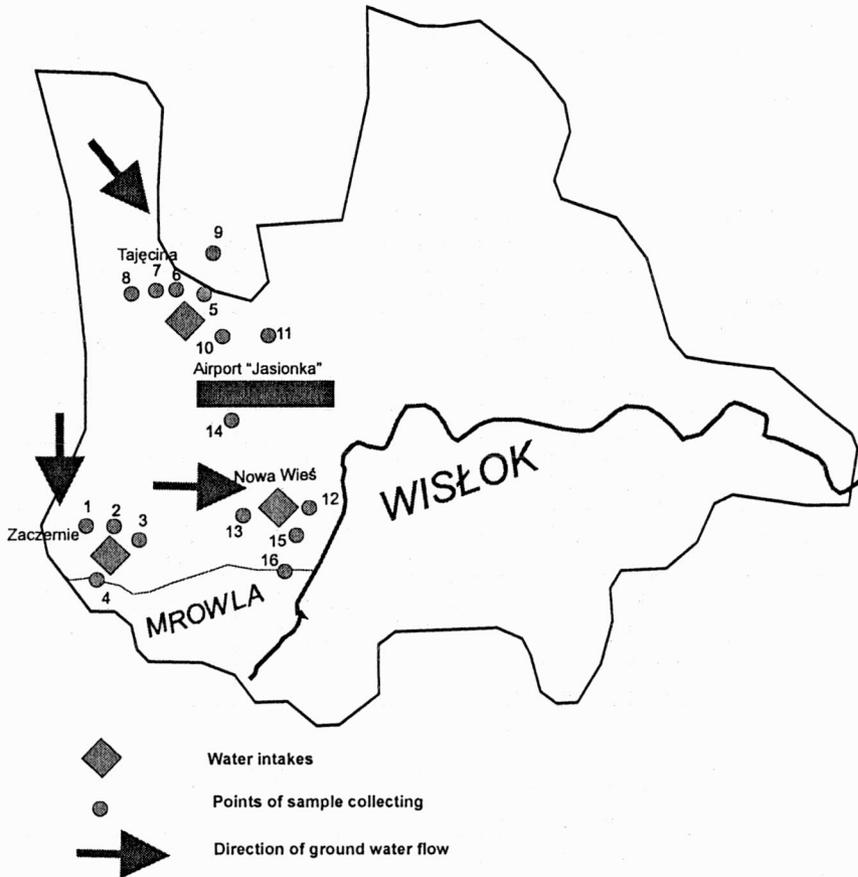


Fig. 2. The area with points of sample collecting

only for one well which was next to the estate Nowa Wieś 37, where nitrate concentration decreased seriously from 33.9 to 6.0 mg N/dm<sup>3</sup>. This may lead to the conclusion that the contamination of water-yielding stratum is of a progressive character and, which is more important, refers practically to the whole area.

## 5. CONCLUSIONS

- A continuous rise in nitrate content in ground water monitored by State Environmental Inspectorate was also observed in the Trzebowniko commune. The nitrate content in ground water in the western part of the commune exceeds its permissible level recommended for drinking water (the intakes in Tajęcina and Zaczernie). In the first half of 2001, the nitrate concentration in the water from Nowa Wieś intake

reached 6 mg N-NO<sub>3</sub>/dm<sup>3</sup>. However, if this growing trend remains steady, the standards predicted for 2013 will be exceeded.

- The contamination of water-yielding stratum is doubtlessly of anthropogenic character and concerns the whole area (control tests of individual wells). Unfavourable hydrogeological structure, mainly because of the lack of impervious bedding which would separate ground water resources from surface pollutants, imposes more stringent procedures of ground water resources protection in the commune (in agreement with present Polish legislation and EU recommendations).

- When the content of nitrogen compounds in water rises continuously in the period examined, strong measures need to be taken in order to improve water quality. Such measures should be put into operation particularly in farming activity, disposal of solid and liquid wastes and protection of the area against contamination by chemicals used to remove snow from the airfield. The most urgent and perhaps the most immediate kinds of activity should be as follows:

- building a sewage system in the village of Tajęcina,

- collection and neutralization of sewerage from the airport in Jasionka (the maintenance of airstrips and airways in winter).

- Because the chemism of water in the Trzebowniko commune was not tested regularly and active superficial, anthropogenic contamination took place, the water resources should be monitored not only in the region of the intakes being utilized, but also in the area occupied by neighbouring communes (Głogów Młp., Świlcza). Due to agricultural character of the region and a thin layer of easily permeable soil the soil tests ought to be carried out more effectively in order that the fertilizers can be used more rationally in soil cultivation and animal and poultry farming.

#### REFERENCES

- [1] HORDEJUK GAWIN A., *Stan jakości wód podziemnych na podstawie badań monitoringowych w latach 1996–1997*, Państwowa Inspekcja Ochrony Środowiska, Biblioteka Monitoringu Środowiska, Warszawa, 1998.
- [2] Data from agricultural registration in 1996, WWS, Rzeszów, 1996.
- [3] Hydrolegislative survey for water intake, a well utilisation together with a project of sanitary protection zone for the three drilled wells of water intake in Tajęcina, the Trzebowniko commune.
- [4] Hydrolegislative survey for ground water intake, utilization of water intake facilities and delimitation of protection zones of the intake. Ground water intake for village water supply for Jasionka, Nowa Wieś, Trzebowniko, Wólka Podleśna and Stobierna. Świlcza, 02.1997.
- [5] Hydrolegislative survey for ground water intake, utilization of water intake facilities and delimitation of protection zones of the intake. Ground water intake for village water supply for Zaczernie. Rzeszów, 06.1997.
- [6] NIEMIEC W., JASIŃSKI T., PIECH A., *Badanie wpływu otoczenia na zawartość azotanów w wodach podziemnych w rejonie ujęcia wody w Tajęcinie*, expert opinion, Rzeszów, 2001.
- [7] BOUCHARD C. et al., *Nitrate contamination of groundwater: sources and potential health effects*, Journal of American Water Works Association, 1992, 9, 85–90.

- [8] The Ministry of Health Ordinance from 04.09.2000 setting the requirements about drinking water and for household needs, water in swimming reservoirs and the methods of water quality control by Sanitary Inspectorate. Official Gazette Announcing Current Legislation No. 82, pos. 937.
- [9] Information and documents in the possession of and rendered by Trzebowńsko Commune Office, a subsidiary household.

#### BADANIE ZAWARTOŚCI ZWIĄZKÓW AZOTU W WODACH PODZIEMNYCH GMINY TRZEBOWNISKO

Oznaczono zawartość azotanów w wodach podziemnych zachodniej części gminy Trzebowńsko. Scharakteryzowano istniejące na tym terenie ujęcia komunalne oraz przedstawiono analizę danych historycznych dotyczących tych ujęć w odniesieniu do stężenia azotanów. Podjęto próbę określenia przewidywanej tendencji zmian w stężeniach normatywnych azotanów w najbliższym czasie. Przedstawiono również wyniki dwukrotnego badania stężenia azotanów w wodach omawianego obszaru (powierzchniowych i podziemnych). Rezultaty badań własnych i analiza danych historycznych o prowadzonej działalności rolniczej i pozarolniczej (wpływ lotniska) pozwalają autorom stwierdzić, że podwyższona zawartość związków azotu w wodzie jest pochodzenia antropogenicznego.

*Reviewed by Lesław Badura*