

Changes in the reserves of soil retention of arable lands in Central Sudety

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Abstract: *Changes in the reserves of soil retention of arable lands in Central Sudety.* The project presents research involving an analysis and evaluation of water supply of poorly permeable soils in drained arable lands. The analysis dealt with research conducted in 2003–2005 at similar meteorological conditions in an agricultural sub-mountain catchment area situated in Central Sudety. In particular, the analysis concerned water and air properties of examined deposits with regard to their water-retention. The measurements of moisture density of soil profiles and calculated water supplies in layers 1–100 cm showed a cross-section of reserves of soil retention. This depended on the depth and lay of the land as well as drainage conditions. In the lower drainage area at the foot of the slope there was a notably higher level of groundwater than in other places on the slope. In areas where rainfall was the exclusive source of groundwater the measured water-supplies were lower than in multi-sourced drainage areas. The amount of measured supplies for the vegetation period spanning the whole research time was not lower than 70% of the field-water capacity.

Key words: sub-mountain catchment area, soil-retention, drainage.

INTRODUCTION

Adverse changes in the environment caused by human economic activity frequently give rise to a reduction of natural retention-ability of the catchment

area, speeding up the water circulation in the environment (Dynowska, 1993; Mioduszewski, 1997).

An important directive is the complex handling of issues connected with developing, protecting and utilizing water supplies in agricultural catchment areas. In particular, this concerns the deterioration of the structural balance of water. Attention must be placed on the fact that considerable changes are taking place in the field of hill-farming techniques which has had a marked affect on balance. The main aim that we can set for research projects dealing with soil-subsystems is to estimate water supplies and to examine the influence of antropo-pressure on changes of elements in water-circulation in the catchment area in terms of quality and quantity (Radczuk, 2000; Mioduszewski, 2002).

The goal of this work is to judge the watersupplies of soils in sub-mountainous lands focusing on a systematically dehydrated drainage area. This will be carried out in standard gauge sections in varied drainage conditions (multi-sourced and rainfall drainage) between the years 2003–2005.

MATERIALS AND METHODS

The research subject Bogaczowice (16°11' E; 50°52' N) is situated on the borderland area of Pogórze Bolkowski-Wałbrzyskie and Góry Wałbrzyskie in Central Sudety. The catchment area of the subject is located at the northern and north-eastern slopes 400–500 metres above sea-level. The gradients are steep and range from 52–84%. The shape of the land is the result of the morphology of the Sudety, Góry Wałbrzyskie and Pogórze formed in the tertiary period (Czamara, 2001).

This catchment area is occupied mainly by arable lands partly dehydrated

by systematic drainage. This work analyzes in detail standard gauge sections located in the upper part (Section 11 and 12), lower part (Section 8 and 2) as well as at the foot of the slope (Section 1, Fig. 1). The subject is located in the pluvial-thermal foreland region on the border of the Wałbrzyski region (Kostrzewa, 2004). The annual rainfall for many years at the IMGW station in Szczawno Zdrój located near the subject was 655 mm, vegetation period (April – September) 430 mm. The average yearly temperature for many years was 7.3°C. The highest mean monthly air temperatures differing considerably from the monthly average temperatures



FIGURE 1. Study area

over many years from April–September were noted from May–August 2003 and from May–July 2005. The rainfall of the vegetation period (April–September) 2003–2004 was roughly 100 mm lower than the rainfall over many years with the exception of May 2003 (35 mm higher than the average over many years). In May, July and August 2005, there was notably higher rainfall than the average from over many years (respectively by 17, 73 and 9%. The vegetation periods (April–September) for the years 2003–2004 were classified as dry with rainfall amounting to 325 and 328 mm and the same period for 2005 as medium wet with rainfall amounting to 448 mm (Tab. 1). On the subject there are pseudo-white soils in general having a heavy clay composition, sometimes medium clay composition with a large content of structural soil (from 15–35%). The profiles are shallow and occur on the gravel fractions of the rocks. In the matrix in sections 1 and 2 at a depth of more than 45 cm (70 cm) light clay and light, dusty clay were found (sand content from 34–46%), whereas in section 12 medium dusty clay (up to 27% of sand), in sections 8 and 11 in sub-arable layer, exclusively heavy clay (24–34% of sand). In the top layers the examined deposits contain from 44–57% of drift parts 13–27% of dusty fraction and 26–34% of sand fraction. The amount of water occurring in different layers was established by means of a Eijelkamp block. In particular, the amount of available water filling the mezopores (8.5–0.2 m) and macropores (30–8.5 m) divided into difficult (pF 2.9–4.2) and easy (pF 2.0–2.9) availability also gravitational water at pF less than 2 occupying the volume of macropores

TABLE 1. Monthly and annual sums of precipitation (mm) for IMGW Szczawno Zdrój station

Year	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	IV–IX	XI–X
2002/2003	65	37	53	8	19	44	101	35	64	43	48	55	335	571
2003/2004	16	69	45	52	102	33	60	78	78	42	37	30	328	641
2004/2005	98	22	65	62	36	35	77	42	161	93	40	4	448	735
1972–1991	46	42	31	28	34	47	66	87	93	85	52	44	430	655

greater than 30 m. The soils of the analyzed sections have similar water properties.

The characteristics of moisture-density and suction pressure have shown that the amount of easily available water filling mezapores and macropores with a diameter 4–30 μm amounts to at most 6.8% of the volume in the arable layer (Section 2) whereas in deeper layers up to 4.7% of volume. However, the amount of water with limited availability filling mezapores 0.2–4 μm amounts up to 19.7% of volume (Section 12). Analogously, in deeper layers these figures range to 16.9% of volume. In section 8 at a depth greater than 50 cm the amount of water easily available for plants is very small (to 2.6% of volume) contrariwise the amount of water with limited availability was to 14.6%. In the analyzed profiles, the amount of water unavailable for plants (thus water in micropores with a diameter less than 0.2 μm) is considerable and ranges from 12.6–23.3% of volume.

RESULTS AND DISCUSSION

In order to determine the changes in soil retention reserves in the analyzed sections, the moisture density of soil profile in the top layer (0–100 cm) was measured. The moisture level was marked throughout the vegetation season by means of two methods: dry weighing and Time-Domain Reflectometry (TDR). On the basis of measured moisture density, water supplies were calculated in a 1-metre soil profile (Fig. 2). the water supplies were presented to a background of characteristic retention states, such as: Z_1 – maximum acceptable water supply

defined as supply by 15% air content in soil, Z_2 supply by field water capacity ($pF = 2.0$), Z_3 – supply by the absolutely smallest water capacity ($pF = 4.2$).

In the dry vegetation periods in the years 2003 and 2004 and in the medium wet period (April–September) of the year 2005, the measured water supplies in a 1-metre soil profile in the sections with multi-sourced drainage (Section 1, and 11) were usually higher (by about 5–10%) than supplies in the sections classified as exclusively rainfall drainage. In the sections of exclusive rainfall drainage (sections 2, 8 and 12) the retention supply in a one-metre profile was not notably varied; throughout the vegetation period the differences amounted to 20–30 mm.

The maximum supplies in soils of all sections were noted in the discussed years in the preliminary phase of vegetation period in April. These supplies mainly originated from post-winter retention supplies after the thaw in early Spring but only to a lesser degree from rainfall. It was claimed that this supply did not exceed the supply corresponding to field water capacity and it amounted to 376 mm (Section 1).

In the years 2003–2004 between the months of May and September the supplies of soil retention were gradually exhausted as a result of large-scale evapotranspiration as well as from modest rainfall. In the layer from 0–100 cm, the quantity of supplies decreased to about 260 mm which in general constituted more than 70% of field water capacity.

The rainfall in July 2005 which was higher by 79% compared to that of many previous years did not manage to increase the retention supplies considerably in

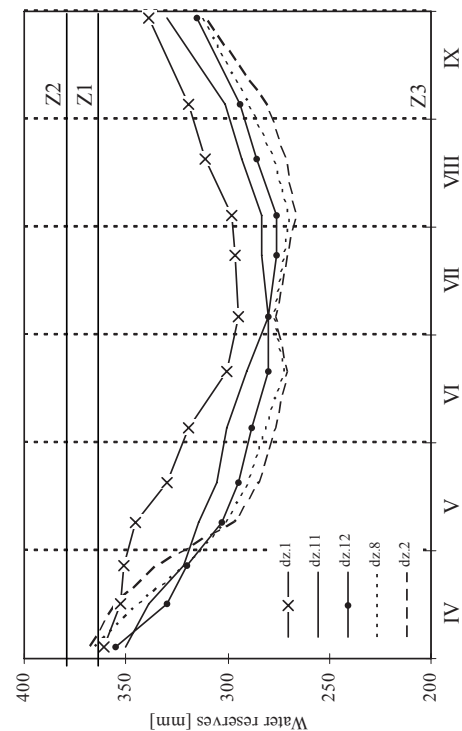
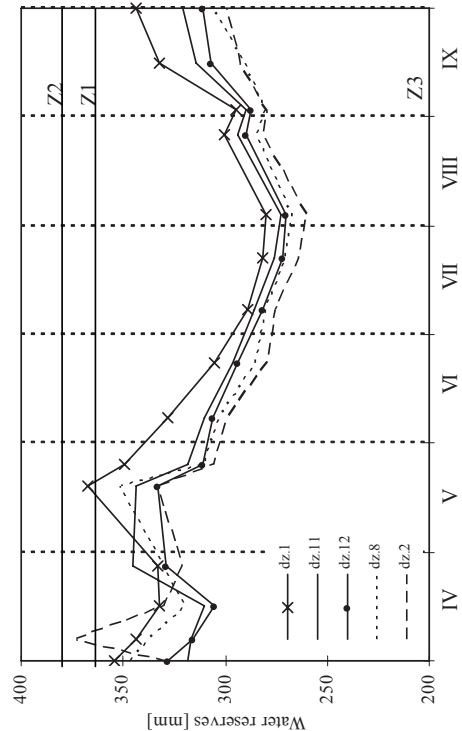
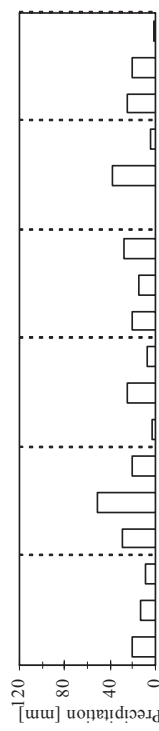
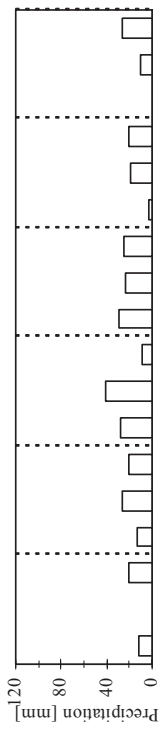


FIGURE 2a. The cross-section of the water storage in the soil profile 0–100 cm in the drainage sections 1, 11 (multi-sourced) drainage and 2, 8, 11 (rainfall drainage) with a background of a decade of rainfall data of normal vegetation period of 2004 year. Z1 – maximal acceptable water supply, Z2 – the supply by field water capacity, Z3 – supply by the absolutely smallest water capacity

FIGURE 2. The cross-section of the water storage in the soil profile 0–100 cm in the drainage sections 1, 11 (multi-sourced) drainage and 2, 8, 11 (rainfall drainage) with a background of a decade of rainfall data of normal vegetation period of 2003 year. Z1 – maximal acceptable water supply, Z2 – the supply by field water capacity, Z3 – supply by the absolutely smallest water capacity

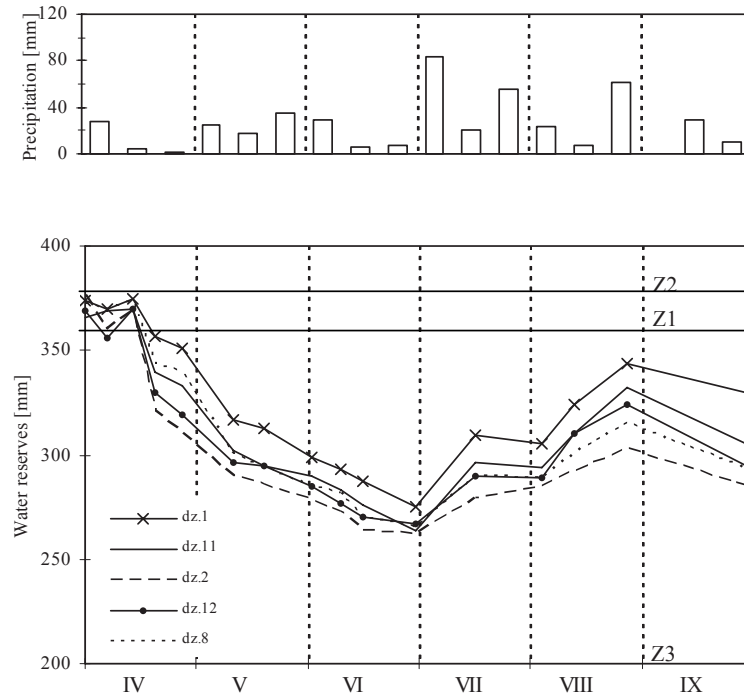


FIGURE 2b. The cross-section of the water storage in the soil profile 0–100 cm in the drainage sections 1, 11 (multi-sourced) drainage and 2, 8, 11 (rainfall drainage) with a background of a decade of rainfall data of normal vegetation period of 2005 year. Z1 – maximal acceptable water supply, Z2 – the supply by field water capacity, Z3 – supply by the absolutely smallest water capacity

soil profiles and especially in the layers at greater depths.

In the dry vegetation periods in 2003–2004, the lowest water supplies in soil profiles were noted between June and August. That period was characterized by higher mean monthly air temperatures compared to the that of many previous years and relatively small rainfall. In the medium wet vegetation period (April–September) of 2005 the amount of retention reserves in soil profile decreased to 69% of the field water capacity at the end of June for a short stint. However, in July and August after abundant rainfall which constituted 73% and 9% of that from many previous

years the water supplies increased by about 100 mm.

Szafrński (1993) has shown in his research that the greatest water supplies in the lake area (Pojezierze Gnieźnieńskie) occurred in soil profiles deposited in lower parts of the slope in places on the concave slope. Apart from the significant influence of the contours of the land the dynamics of changes in the water supplies depended on meteorological conditions over time in particular the rainfall. The water supplies in the soil profile, measured in the periods of modest rainfall, indicated that it was necessary to implement an operation designed to increase the retention capacity. Solarzski (1996) on the basis of research on

uneven ground in a part of the lake area Pojezierze Mazurskie claimed there was a significant influence of intensive contour change on the land on variability of water conditions and in particular soil moisture-density which is largely modified by the gradient of the land. The valleys and the base of the slopes usually showed an excess of soil moisture as a result of additional drainage from runoff at higher altitudes.

CONCLUSIONS

1. The characteristic structure of the soil profile occurring on the gravel fraction of the rock, composed mainly of heavy clays, was a contributing factor, to the fact that in the dry vegetation season in the years 2003–2004 soil retention reserves collected in the winter period were rapidly exhausted down to the value of 70% of the field water capacity, whereas in the medium wet vegetation period of the year 2005, they were higher by 50–100 mm.
2. The supplies maximum values were noted in the analyzed periods in the preliminary phase of the vegetation period in April. These supplies originated mainly from the post winter retention reserves after the early Spring thaw but only to a lesser degree did they originate from rainfall.
3. In the base section of the slope (Section 1) the water supplies in a 1 metre soil profile were in general higher by about 20 mm than in slope sections (Section 2, 8, 11 and 12).
4. The values of the measured water supplies in a one metre soil profile in the sections with multi-sourced drainage were higher by up to 40 mm than in the rainfall drainage sections.

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REFERENCES

- CZAMARA A. 2001: Charakterystyka warunków fizjograficznych zlewni górnej Strzegomki. Zesz. nauk. AR Wroc. ser. Inż. Środ. XII, 413, p. 245–255.
- DYNOWSKA I. (red.) 1993: Przemiany stosunków wodnych w Polsce w wyniku procesów naturalnych i antropogenicznych – UJ, Kraków, p. 380.
- KOSTRZEWA S., PĘCZKOWSKI G., STRZELCZYK M. 2004: Sprawność drenowania gleb orných w Sudetach Środkowych. Acta Scient. Pol. Kształt. Środ. 3 (1) p. 73–79.
- MIODUSZEWSKI W. 1997: Mała retencja i polityka melioracyjna. Zesz. Nauk. Komitetu „Człowiek i Środowisko”, 17, p. 49–62.
- MIODUSZEWSKI W. 2002: Kształtowanie zasobów wodnych w obszarach rolniczych. Wiad. Melior. i Łąk, 1.
- RADCZUK L. 2000: Rola zlewni eksperymentalnych w badaniach interdyscyplinarnych. Zesz. Nauk. AR we Wroc. Inż. Środ. 11 nr 385, p. 309–314.
- SOLARSKI H., RUDZKI R., FIEDORUK P. 1986: Problemy drenowania gruntów na Pojezierzu Mazurskim. Wiad. Melior. i Łąk, 2.
- SZAFRAŃSKI C. 1993: Gospodarka wodna gleb terenów bogato rzeźbionych i potrzeby ich melioracji. Roczn. AR w Poznaniu, Z. 244.

Streszczenie: *Zmiany zasobów retencji glebowej zdrenowanych gruntów ornych w Sudetach Środkowych.* Badania przedstawione w pracy obejmujące analizę i ocenę gospodarki wodnej gleb słabo przepuszczalnych zdrenowanych gruntów ornych. Analiza objęła badania przeprowadzone w latach 2003–2005 o zbliżonych warunkach meteorologicznych w rolniczej zlewni podgórskiej, położonej w Sudetach Środkowych. Szczegółowo analizowano właściwości powietrzno-wodne badanych utworów z uwagi na ich retencyjność. Przeprowadzone pomiary uwilgotnienia profilów glebowych i obliczone na tej podstawie zapasy wody w warstwie 0–100 cm wykazały zróżnicowanie rozkładu zasobów retencji glebowej w zależności od położenia w rzeźbie terenu, jak i warunków zasilania. W dziale drenarskim położonym w niższych partiach terenu, u podnóża zbocza notowano wyższe zapasy wody glebowej niż w miejscach położonych na stoku. W działach

o zasilaniu wyłącznie opadowym pomierzone zapasy wody były niższe niż w działach o zasilaniu złożonym. Wielkość obliczonych zapasów w okresie wegetacyjnym w całym cyklu badań nie była niższa niż 70% polowej pojemności wodnej.

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