INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr IV/4/2016, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 1947–1959
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2016.4.4.147

PRECIPITATION VARIATION IN THE WIDAWA RIVER BASIN IN THE MULTI-YEAR PERIOD 1956-2012

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Abstract

The paper analyses results of measurements of precipitation amounts in the Widawa River basin in the multi-year period 1956-2012. Analysed were annual, monthly and daily precipitation totals and the numbers of days with precipitation in a year and in a month. Trends of changes were determined and extreme monthly and daily precipitation totals were analysed. Annual precipitation totals over the analysed multi-year period were very strongly diversified. Despite a considerable spread of results, the distribution in time did not reveal any clear tendency of changes, the trend line was almost horizontal. The number of days in a year with precipitation revealed an obvious decreasing trend, particularly within the fraction of days with precipitation <1mm. Average daily precipitation obtained from the ratio of annual precipitation total and the number of days with precipitation showed a growing tendency. December was the month in which the highest number of days with precipitation was noted during the multi-year period 1956-2012. Considering the fewest number of days with precipitation, similar results were obtained for three months. In May and September the least number of days with precipitation was registered eleven times. Only once a less often mentioned number of days occurred in October. A summary of maximum numbers of days with precipitation occurring over a month revealed a declining trend. The diagram of the least number of days with precipitation in a month also revealed a decreasing tendency.

Keywords: precipitation, the Widawa River basin, multi-year period

INTRODUCTION

Precipitation in a catchment causes geological processes shaping the surface of the Earth. The amount and frequency of precipitation considerably affect water erosion, runoff dynamics in rivers and fluvial transport (Józefaciuk and Józefaciuk 1992, Mazur 2005, Michalczyk et al. 2012, Stępniewska and Stępniewski 2008). Precipitation also crucially influences crop production, particularly in the areas with rainfall-retention type of water management, where plant water requirements are mainly satisfied by precipitation and water stored in the soil (Grzywna 2005, Dzieżyc et al. 2012, Rymuza et al. 2012, Żmudzka 2004). The paper aimed to analyse the results of measurements of precipitation amount in the Widawa River basin during the multi-year period 1956-2012.

METHODS

Precipitation data published in the "Precipitation" annuals for the period 1957-1981 and the results of precipitation amount measurements in Jelcz Laskowice for the period 1956-2012 were used in the paper. Results provided by 12 precipitation measurement points and stations situated in the Widawa River catchment were analysed at the first stage of research. Annual precipitation totals were compared with the results obtained in Jelcz Laskowice and the dependence of annual average precipitation totals on the altitude of the measurement point location above sea level. Further analyses were conducted on the data for the multi-year period 1956-2012 for Jelcz Laskowice. The analysis covered annual precipitation totals, average for the multi-year period monthly precipitation totals, variability of monthly totals for individual months over the analysed multi-year period, the number of days with precipitation in a year during the multi-year period, changes of the number of days with precipitation <1mm in a year, average daily precipitation intensity, the highest maximum daily precipitation totals in a year and the dates of their occurrence, the highest and the lowest number of days in a year of maximum in a month number of days with precipitation and the frequency of their occurrence.

RESULTS

The Widawa River basin is situated on the Silesian Plain. The Widawa River, 267 km long, is the right bank tributary to the Odra river with its catchment area of 1716 km^2, managed for agriculture (Czaban 2009). Precipitation measurement points and stations in the Widawa basin were situated on various altitudes (Tab.1). Chełstów precipitation measurement point was located at the highest altitude – 240m a.s.l, while Łuczyna slightly lower, at 195 m a.s.l. The nethermost Wrocław Psie Pole measurement point was situated at 122 m a.s.l. close to the Widawa inflow into the Odra. Analysis of the annual precipitation totals for the years 1957-1981 revealed an apparent degree of correlation with the results of observations from Jelcz Laskowice (Laskowice Oławskie 135 m a.s.l.). Average annual precipitation during the discussed multi-year period ranged from 579.7 to 692.9 mm and was strongly correlated with the altitude on which the measurement points were located (Fig.1). Considering correlation of the precipitation height on individual measurement points, further analyses of time variability were conducted on the data from Jelcz Laskowice since 2012.

Table 1. Location of precipitation measurement points and stations and correlation of precipitation totals with results from Laskowice Oławskie (Jelcz-Laskowice) in 1957-1981

No.	Station-measurement point	Location			Correlation coefficient
		m a.s.l	N	E	
1	Laskowice Oławskie	134	51°03’	17°21’	1
2	Lipka	175	51°12’	17°37’	0.6775
3	Trębaczów	178	51°13’	17°48’	0.6499
4	Rychtal	165	51° 09’	17°51’	0.6884
5	Namysłów	155	51°05’	17°44’	0.7030
6	Bierutów	138	51°08’	17°33’	0.7843
7	Ligota Wielka	140	51°10’	17°23’	0.6771
8	Chełstów	240	51°20’	17°30’	0.6493
9	Sokołowice	156	51°15’	17°27’	0.7639
10	Wrocław Psie Pole	122	51°09’	17°07’	0.6815
11	Łuczyna	195	51°18’	17°17’	0.6374
12	Ligota Piękna	143	51°14’	17°03’	0.7707

Average annual precipitation total for the multi-year period 1956-2012 was 570.2 mm. Annual precipitation totals over the analysed period fluctuated from

401 to 794 mm (Fig.2). The lowest annual precipitation totals, slightly exceeding 400 mm were registered in the years 1959, 1969,1982, 1989 and 1992, whereas the highest, about 790 mm in 2009 and 2010. Despite a wide range of the results, their distribution in time did not reveal any tendency for changes, the trend line was almost horizontal (Fig.2).

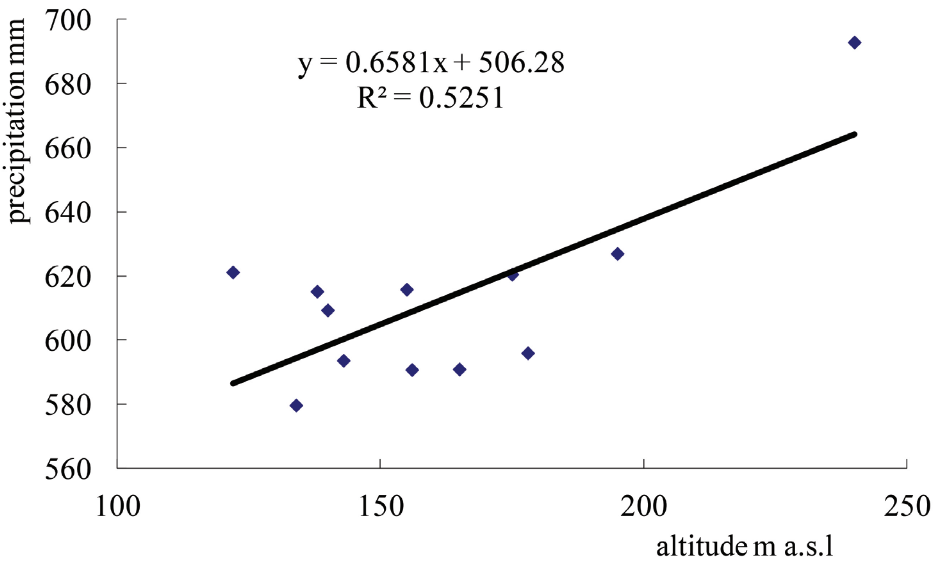

Figure 1. Dependence of average annual precipitation total for the years 1957-1981 on the altitude of measurement point location

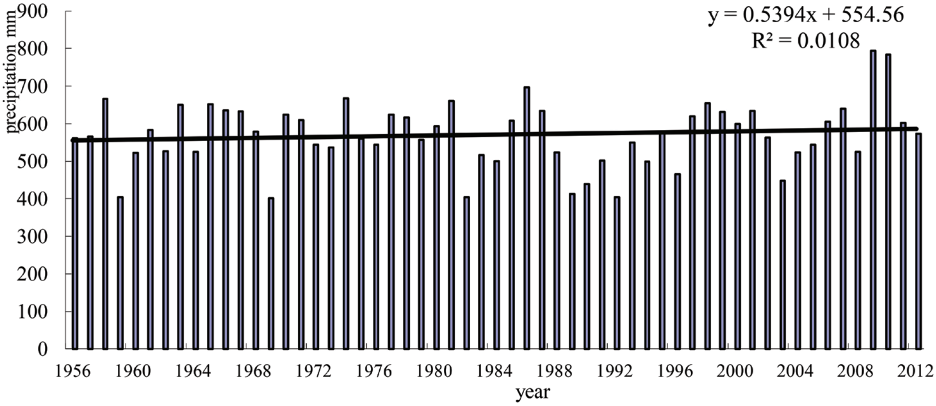

Figure 2. Annual precipitation totals in the multi-year period 1956-2012

For many reasons it is necessary to know the distribution of precipitation over a year. Average monthly precipitation totals fluctuated from 27.7 mm in February to 84.9 mm in July (Fig. 3). Kirschensztein (2005), who analysed multi-year changes of precipitation totals for north-western Poland, also obtained the extreme values of the precipitation totals for the above mentioned months. In the analysed data set from Jelcz Laskowice, extreme values very strongly differed from monthly averages. Maximum precipitation totals over three times exceeded the average value. The highest registered values reached about 220 mm in July. The lowest monthly precipitation amounts did not exceed 10 mm, whereas in November 2011 not even a single day with precipitation was registered. Majewski et al. (2010) obtained similar results while analysing the data for a multi-year period 1960-2009 for Ursynów SGGW meteorological station. The maximum monthly precipitation occurred also in July, it was slightly higher – 269 mm. Minimum monthly precipitation was also slightly higher, which did not exceed 17 mm. A month without precipitation – February was also noted in Ursynów.

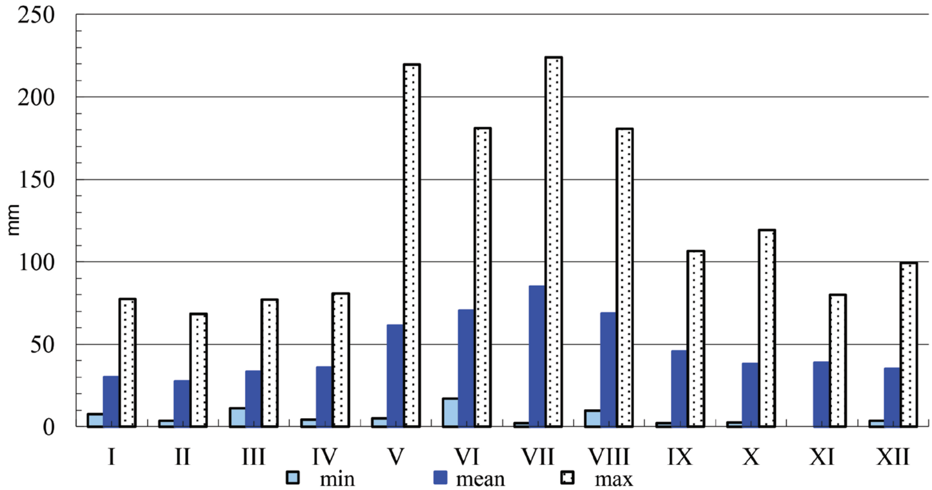

Figure 3. Monthly average precipitation totals for the multi-year period 1956-2012 against the background of extreme precipitations

Analysis of precipitation totals for the months of the first quarter revealed considerable differences in the analysed multi-year period. There was a ten-fold difference between the extreme values. Increasing trend was visible in all months of the first quarter. In the second quarter, at similarly great divergences of results, a slight downward trend was apparent in April and May at its almost horizontal position in June. In the following months, at considerable disparity of results, no apparent trend of changes was noted, whereas an upward trend was noted only in July. While analysing seasonal changeability of precipitation in Poland over the years 1951-2010 Czarnecka and Nidzgorska-Lencewicz (2012) demonstrated that a common phenomenon noticeable on the most of the territory of Poland is a tendency for an increasing precipitation amounts in the spring and autumn seasons but a decreasing share of summer rainfalls in the annual total.

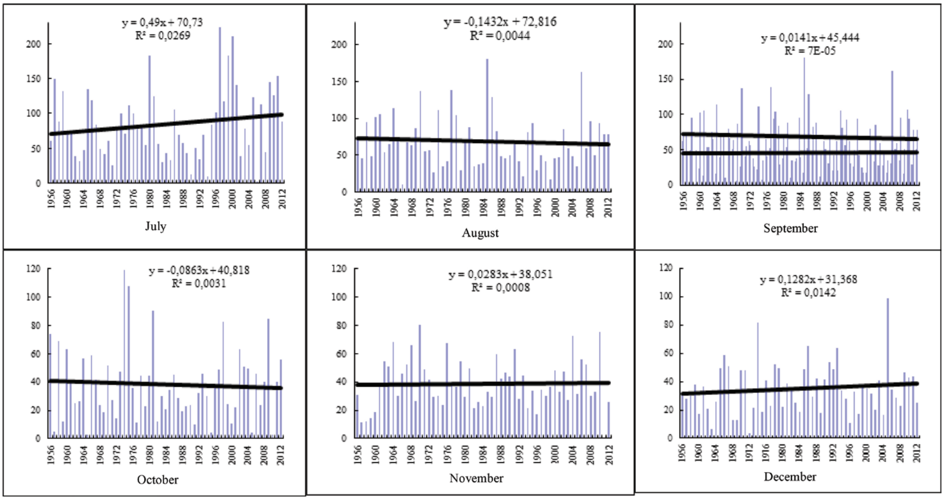

Figure 4. Monthly precipitation totals over the multi-year period 1956-2016

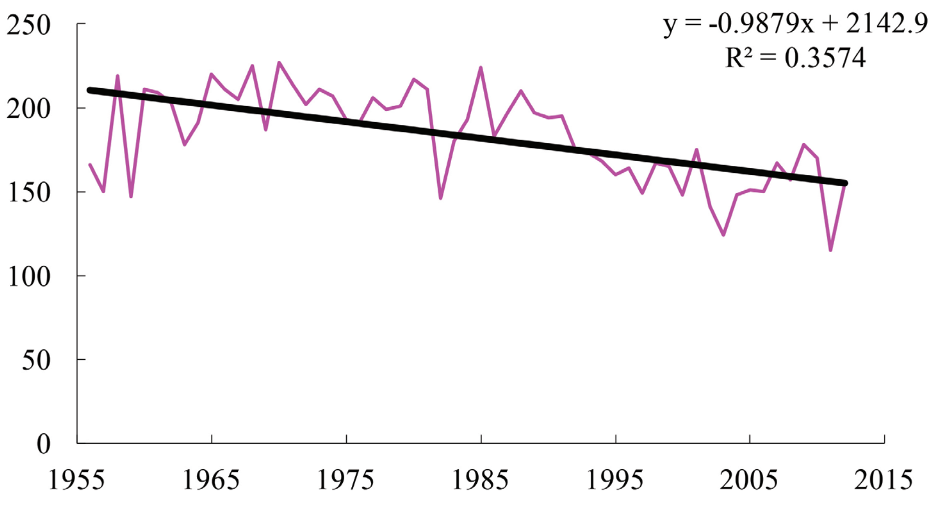

Figure 5. Number of days with precipitation in a year during the multi-year period 1956-2012

Soil water management and hydrological relations are influenced not only by the precipitation amount but also by the frequency of its occurrence. The average number of days with precipitation in Jelcz Laskowice located in the Widawa basin noted during the analysed multi-year period was 183 (Fig. 5). The number of days with precipitation in a year fluctuated from 115 in 2011 to 227 in 1970. A similar number of days with precipitation occurred in the 1968 and 1985, respectively 225 and 224. An apparent downward trend became visible during the analysed multi-year period concerning the number of days with precipitation. Grajewski (2011) noticed a similar direction of changes in the number of days with precipitation while analysing the data for 1987-2008 period for Zielonka Forest.

Precipitation structure (Fig. 6) revealed that over 45% of days with precipitation referred to a daily total which did not exceed 1 mm. The number of days with precipitation ranging from 1 to 1.9 mm reached slightly below 15%. Percent of days in the subsequent precipitation fractions was decreasing systematically. Daily precipitation of over 19.9 mm was noted on slightly over 2% of days with precipitation. Burszta-Adamiak (2012) obtained similar dependencies for precipitation measured in 2009-2010 in Wrocław.

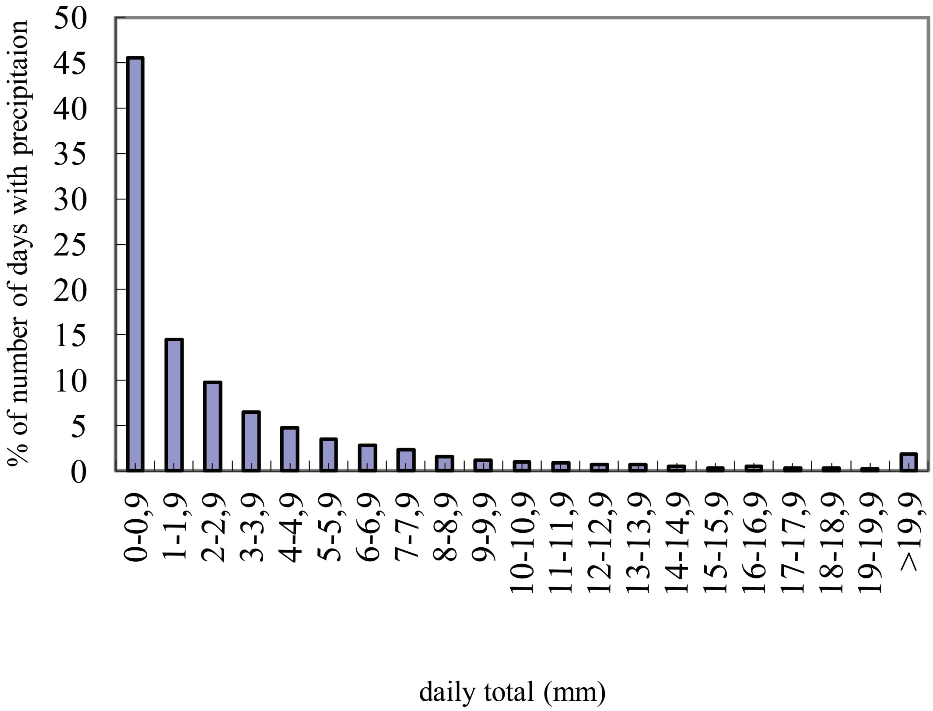

Figure 6. Structure of the days with precipitation over the period 1956-2012

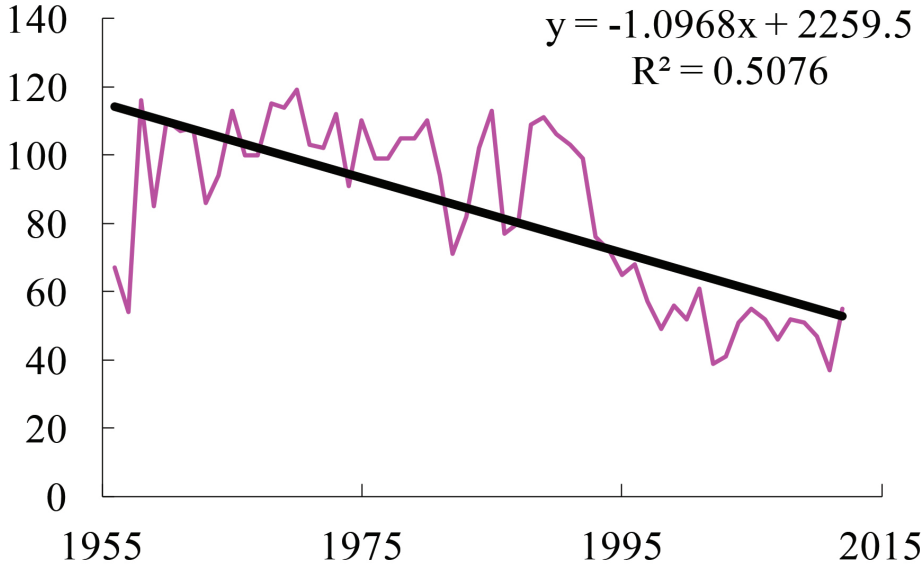

Figure 7. Number of days in a year with precipitation in the multi-year period 1956-2012

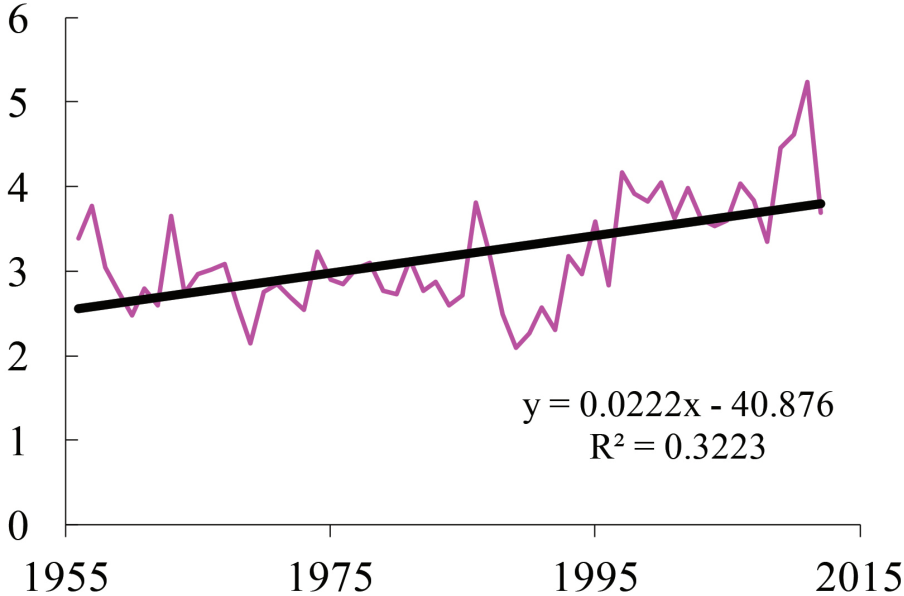

Figure 8. Average daily precipitation (mm) <1mm in the multi-year period

A decreasing trend occurred for the number of days with precipitation below 1 mm in the analysed multi-year period, which was even more pronounced than for the total number of days with precipitation (Fig. 7). The diagram showing average daily precipitation amounts, which are the ratio of annual precipitation total and the number of days with precipitation, revealed an upward trend (Fig. 8).

The highest daily precipitation totals in a year were greatly diversified (Fig. 9). The lowest maximum daily precipitation total in a year was only 14.6 mm, whereas the highest – 70.2 mm was registered on 2.09.1994. A minor increasing trend became visible for the highest in a year daily precipitation totals. Maximum daily precipitation totals occurred most frequently in the summer months. An unusual event in the multi-year period 1956-2012 was the lowest daily precipitation which occurred on 3 December 1992 (338th day of the year). In the same year, precipitation total, i.e. 403.5 mm was also one of the lowest over the analysed multi-year period.

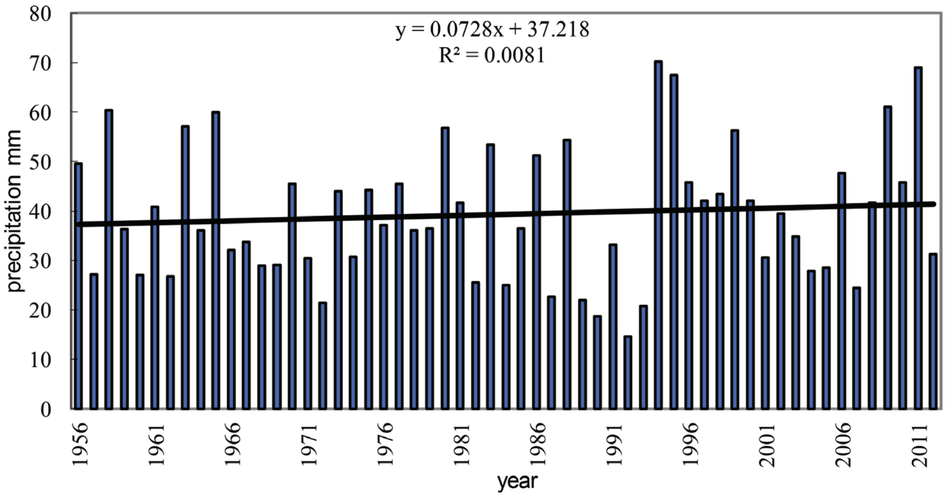

Figure 9. The highest in the year daily precipitation totals (mm) in the multi-year period 1956-2012

Extreme monthly precipitation totals over the analysed multi-year period were very strongly diversified (Fig. 10). The lowest ranged from 0 to 35 mm, whereas the highest monthly precipitation totals were within the range from 71 to 224mm. Despite a great spread between the extreme values, no apparent direction of changes was marked during the analysed period. A slight decreasing trend was visible for the number of days with precipitation in a month in the years 1956-2012 (Fig. 11), both for the lowest and highest amounts. All days of

November 2011 were without precipitation, whereas 29 days with precipitation were registered in December 1988.

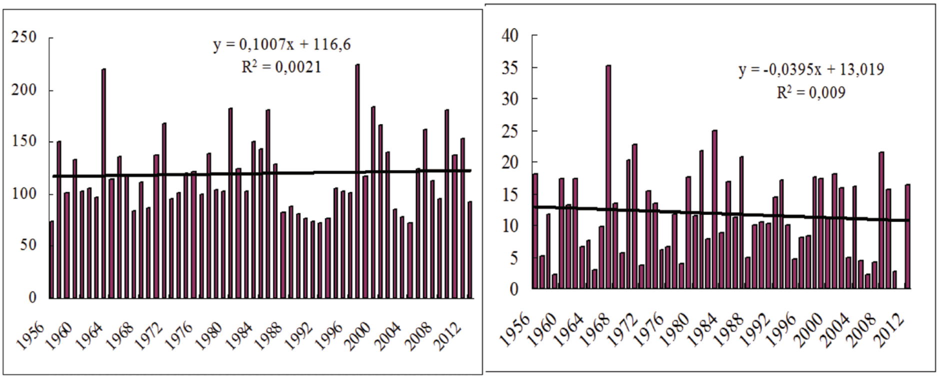

Figure 10. The lowest and highest in a year precipitation total over the multi-year period 1956-2012

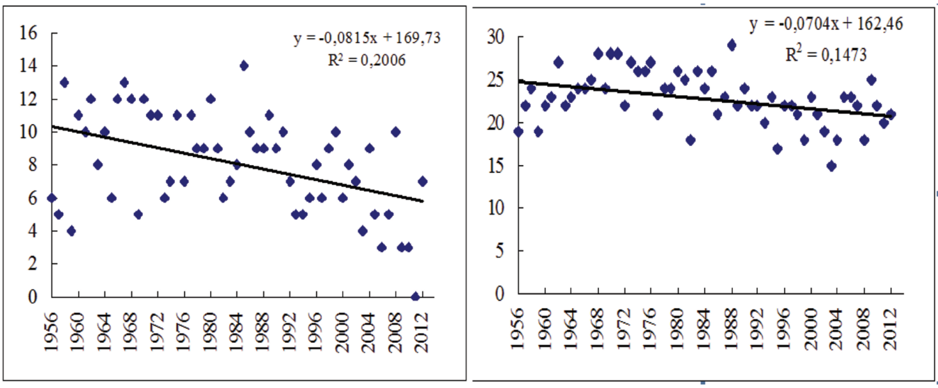

Figure 11. The lowest and highest in a year number of days with precipitation per month in the multi-year period 1956-2012

The highest monthly number of days with precipitation in a year registered for the analysed period most frequently occurred in December (12 times) whereas the lowest in May, September and October, respectively 11, 11 and 10 times.

Presented results revealed considerable time variability, like reported by (Kirschensztein 2005, Grajewski 2011)

CONCLUSIONS

Diversification of average annual precipitation totals in the Widawa River basin reached 20%. Precipitation amount was significantly correlated with the altitude of measurement point location above sea level.

Annual precipitation totals did not reveal an unanimous trend of changes, despite a big spread of results from 401.2 mm in 1969 to 794 mm in 2009.

Monthly precipitation totals, average for the multi-year period, ranged from 27.7 mm in February to 84.9 mm in July, at the extreme values from 0 in November 2011 to 224 mm in July 1997.

A decreasing trend for the number of days with precipitation, particularly <1mm, became apparent in the analysed multi-year period, whereas an upward trend was noted for average daily precipitation (annual precipitation total/number of days with precipitation).

Highest in monthly date, the sums of precipitation fluctuated from 14.6 mm on 3.12.1992 to 70.2 mm on 2.09.1994 and were noted most frequently during the summer half-year.

The lowest in a year maximum in a month daily precipitation totals ranged from 0 mm in November 2011 to 7.2 mm in July and August 1967 and did not reveal any trend of changes.

December was the month when the highest in a year number of days with precipitation occurred, while the lowest number of days with precipitation occurred in May, September and October.

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Received: 02.11.2016
Accepted: 29.12.2016