Environment Protection Engineering

Vol. 37 2011 No. 2

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ACCURACY OF MEASUREMENTS OF PRECIPITATION AMOUNT USING STANDARD AND TIPPING BUCKET PLUVIOGRAPHS IN COMPARISON TO HELLMANN RAIN GAUGES

Accuracy of measurements of the precipitation amount in function of time has been analysed using a traditional pluviograph and a new generation tipping bucket pluviograph (SEBA) in comparison to standard Hellmann's rain gauge. It was based on pluviographic material from IMGW meteorological station in Legnica (warm half-year from May to October 2009). The comparisons were made for 4 typical balance precipitation periods: May–October period, 1 month, 24 h, 360 min. For balance periods: season, month, 24 hours it was considered sufficiently accurate and approximately equal. However the analysis of short term precipitation (up to 360 min) showed that the biggest differences in precipitation amounts occur in the first 5 min of the rainfall time interval. Mutual differences between precipitation at definite time intervals for pluviograph and SEBA pluviograph are the lowest when they are used for interpreting pluviograms of changeable intervals of precipitation time. In the case of very intensive rainfalls, reaching the height of several millimeters during 5 min, it showed an underestimation of about 10–20% of the precipitation height by the SEBA pluviograph in comparison to the traditional pluviograph.

1. INTRODUCTION

In Poland, modelling of sewage systems, either existing or being designed, recommended by the standard PN-EN 752:2008, encounters a barrier of the lack of access to reliable and suitable precipitation databases [1–3]. As often as not, precipitation hietograms are essential as the input to hydrodynamic models with at least 5 min time resolution. In Poland, the access to source precipitation data (recorded on paper pluviographs until 2007) is managed by the Institute of Meteorology and Water Management (IMGW), the proprietor of the most meteorological stations in the country.

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It is possible to obtain a paid access to such databases at IMGW, however one can more often order a statistic analysis of precipitation (according to standard studies) for example with regard to the specification of local dependences of IDF or DDF type, that is, precipitation intensity or its amount with respect to time and frequency of occurrence.

Precipitation synthetic hietograms – randomly generated, but still in an experimental stage – can provide a solution, however, they also require high resolution source data [4–6]. The knowledge of recorded twenty four hours sums of precipitation amount, which are easily available, can be a starting point for their generation. A random generator is applied to carry out a classic down-scaling, that is, to isolate a twenty four hour precipitation into an equal time scale, a 5 min scale for example. In the case of short term data (few hours), the starting point for generation of synthetic hietograms also requires the knowledge of precipitation amount and duration for specific occurrence frequency, however the existing, local formulae of IDF or DDF type can be used here.

The paper is the authors' contribution to existing discussion on the choice of a new generation automatic pluviograph as the successor of the traditional float pluviograph (clock-driven and recording on a paper tape) for recording time dependences of precipitation. The most important criterion should be the most accurate recording of actual precipitation amounts, both (simultaneously) in long periods of time: a season, month or twenty four hours and particularly in shorter periods – from several minutes to a few hours. The problem concerns the assessment of accuracy, and thus, suitability of various types of commercially available automatic rain gauges: a tipping bucket type, such as the rain gauge RG 50 by SEBA (approved by *T*he World Meteorological Organization – WMO) applied since 2007 in the observation network of IMGW in Poland [7] but also a scale or laser type – all of practical time resolution of one minute. Furthermore, this paper refers to papers [8–10] describing and comparing the accuracy of various types of rain gauges, including state of art measurement devices such as an electronic scale rain gauge OTT Pluvio^2 or a laser disdrometer Parsivel.

2. RESEARCH MATERIAL AND RESULTS OF MEASUREMENT

2.1. THE RECORD OF SEASONAL AND MONTHLY PRECIPITATION AMOUNTS

The analysis of accuracy of recording by means of a traditional float pluviograph (clock-driven) and a new generation pluviograph of a tipping bucket type (SEBA) in comparison to traditional Hellmann's rain gauge was carried out based on data from the IMGW meteorological station in Legnica (the station coordinates: 51-12 N, 16-13 E; altitude: 122 m above sea level; normal precipitation: 515 mm). Simultaneous measurements of precipitation amounts by means of the three various rain gauges were carried out in the pluviometric season from May to October of 2009. The measurement devices were located on the site of the metrological station according to requirements in force that is, spaced in the distance of 2 ms between rain gauges. The measurements were taken on the height of 1 m above the ground (Fig. 1).

Fig. 1. Rain gauges in the IMGW meteorological station
in Legnica (from left): a float and tipping bucket SEBA type, pluviographs
and Hellmann's rain gauge (photo by J. Jadach)

In the entire measurement season from May to October of 2009, the total precipitation amount measured with rain gauges was similar (Table 1). However, the highest amount of precipitation of 472.3 mm was measured by means of Hellmann's rain gauge (the result was assumed to be 100%), average results of 469.9 mm (P/H = 99.5%) were obtained with the float pluviograph, while the lowest results of 467.3 mm (S/H = 98.9%) were given by the tipping bucket pluviograph SEBA. The highest absolute difference of measurement results amounted to 5.0 mm for the SEBA pluviograph, which differs by 1.1% from indications of Hellmann's rain gauge. The precipitation amount given by the float pluviograph was lower by 2.4 mm from indication of the traditional rain gauges, that is, was different by 0.5%.

The highest monthly precipitations occurred in June 2009, slightly exceeding 140 mm, while the lowest rainfall appeared in September, reaching slightly over 11 mm. By analyzing precipitation amounts measured in particular months, one can see a noticeable pattern in deviations of precipitation sums (Table 1). For example, Hellmann's rain gauge showed the highest precipitation amount sums in June – assumed being 100%, while the remaining devices indicated slightly lower values: 99.2% with the float pluviograph and 99.9% with SEBA. Only in May of 2009 for the float pluviograph and in August for both pluviographs, the measured precipitations were higher than for Hellmann's rain gauge (by the maximum of 2.3%). The highest percentage deviations of monthly sums of precipitation amounts for both compared pluviographs with respect to a traditional rain gauge did not exceed ±2.6%.

Table 1

Totals of monthly precipitations (in mm) and their deviations from Hellmann's rain gauge (100%) for the IMGW in Legnica from May to October of 2009

Month	Hellmann's rain gauge (*H*)	Float pluviograph (*P*)	*P*/*H* [%]	Pluviograph SEBA (*S*)	*S*/*H* [%]
May	81.5	82.1	100.7	79.7	97.8
June	141.4	140.3	99.2	141.3	99.9
July	126.3	124.9	98.9	124.0	98.2
August	52.3	53.5	102.3	52.4	100.2
September	11.5	11.2	97.4	11.2	97.4
October	59.3	57.9	97.6	58.7	99.0
Season May–October	472.3	469.9	99.5	467.3	98.9

Considering the nature of precipitation, especially its diversity of intensity in time and space, the analysis of operation of a device for recording precipitation amounts (with a constant recording) can be regarded equally accurate – equivalent.

2.2. RECORDING DAILY PRECIPITATION AMOUNTS

The number of days with precipitation (≥0.1 mm) indicated by the three rain gauges in the entire analyzed season was similar and amounted to 90 days according to the float pluviograph and 91 days according to the other rain gauges. The daily sums of precipitation amounts (in mm) recorded in June 2009 at the IMGW station in Legnica and their deviations (in %) in relation to Hellmann's rain gauge (whose indications were assumed to be 100%) were given in Table 2. The deviation of daily precipitation amounts for 16 rainy days in July for both pluviographs reached a similar level: $P/H \in [92.3; 166.7]\%$ and $S/H \in [88.9; 114.3]\%$, and on average for the entire month: $P/H = 98.9\%$ and $S/H = 98.2\%$. The highest values of relative differences concern mainly small precipitation amounts – within accuracy limits of the devices or the record readouts alone.

The maximum daily sum of precipitation amounts in the entire analyzed season occurred on 7 July 2009 and reached for particular rain gauges (Table 2): Hellmann's rain gauge – 45.2 mm (100%), the float pluviograph – 43.9 mm ($P/H = 97.1\%$) and the tipping bucket pluviograph SEBA – 42.2 mm ($S/H = 93.4\%$). These are deviations in the order of 3% and 7%, respectively – in relation to Hellmann's rain gauge. The

SEBA pluviograph is slightly less accurate in comparison to the traditional tipping bucket pluviograph for very high daily rainfall.

For example, the precipitation patterns for maximum daily rainfall on 7 July 2009 on both pluviograms are seemingly identical, however, those obtained with the SEBA pluviograph are understated by approximately 4% (43.9 mm and 42.2 mm). Considering all results of investigations – comparisons made so far for longer periods of time, the SEBA pluviograph can be recognized as sufficiently accurate and roughly equal to the traditional float pluviograph. It certainly falls into the accuracy class for the description of the investigated phenomenon, also for the period of twenty four hours (in relation to indications of Hellmann's rain gauge). However, the SEBA pluviograph shows significant inaccuracies for short durations (up to 6 h) of very intensive rainfall.

Table 2

Sums of daily precipitations (mm) in July 2009 and their deviations (%) in relation to Hellmann's rain gauge (100%) for the IMGW station in Legnica

Date	Hellmann's rain gauge (*H*)	Float pluviograph (*P*)	*P*/*H* [%]	SEBA pluviograph (*S*)	*S*/*H* [%]
2 July	0.7	0.8	114.3	0.8	114.3
4 July	18.6	18.6	100.0	19.3	103.8
5 July	0.9	1.1	122.2	0.8	88.9
7 July	45.2	43.9	97.1	42.2	93.4
8 July	2.5	2.4	96.0	2.3	92.0
10 July	9.3	8.7	93.5	8.5	91.4
11 July	2.6	2.4	92.3	2.7	103.8
15 July	2.8	2.8	100.0	2.8	100.0
18 July	19.4	19.2	99.0	19.4	100.0
19 July	0.3	0.5	166.7	0.3	100.0
20 July	2.8	2.8	100.0	2.9	103.6
21 July	1.0	1.0	100.0	1.0	100.0
23 July	10.6	11.1	104.7	11.3	106.6
24 July	5.5	5.5	100.0	5.5	100.0
25 July	3.1	3.1	100.0	3.1	100.0
28 July	1.0	1.0	100.0	1.1	110.0
Total in July	126.3	124.9	98.9	124.0	98.2
The share of the total in the May–October season [%]	26.7	26.5	–	26.6	–

It follows from the comparison of accuracy of other state rain gauges, that is, the electronic scale rain gauge OTT Pluvio^2 and laser disdrometer Parsivel, mutual discrepancies in recording daily precipitation sums can reach even 50%, which was demonstrated elsewhere [10].

2.3. THE RECORDING OF INTERVAL AMOUNTS OF SHORT TERM RAINFALLS

The development of traditional (paper) pluviographs to record precipitation patterns in short periods ranging from 1 min up to 360 min give raise to a number of difficulties. A basic scale of a pluviogram strip covers hour sections divided into six 10 min parts. Readouts of rainfall amounts in one hour intervals are applied in traditional pluviographic studies [11]. Such accuracy is unacceptable in the assessment of short term rainfall (especially including durations of 5, 10, 15, 30 or 45 min). The basic scale of a pluviogram strip allows isolation of rainfall fragments of durations shorter than 10 min. In practice, it is possible to determine precipitations (accurately enough) in the minimum 5 min intervals. Data for shorter periods would be burdened with high readout inaccuracy, both for precipitation amount and isolation of successive minutes of its duration. However, the development of 5 min intervals brings a certain inconvenience of forcing constant time intervals: 1–5, 6–10, 11–15, …, up to 56–60 min. Furthermore, such a manner of isolation and interpretation of interval precipitation amounts in constant 5 min intervals may make it impossible to capture the maximum rainfalls in specified (short) durations. Technically, the isolation of 5 min progressing-rolling intervals (changeable [12]), which begin and end on successive minutes is more difficult, even when using graphical enlargements of described pluviogram fragments. However, the latter method – in isolation from constant 5 min time intervals applied on the basic pluviogram scale – is more suitable for interpretation of measurement results (physically correct).

The situation is fundamentally changed in the case of the electronic recording of precipitation patterns in meteorology. In automatic pluviographs, such as SEBA (currently used in the IMGW network), the precipitation recording is carried out for each emptying of a tipping bucket of a small volume, whereas the tipping time is recorded with the accuracy of a second. Such a recording method makes it possible to specify precipitation amounts for any time intervals. Thus, two methods of the determination of the maximum 5 min rainfall sums can be used to develop precipitation patterns from SEBA pluviograms: the former – for constant 5 min time intervals and the other – for 5 min rolling intervals beginning in successive minutes of actual precipitation durations. As will be shown, the latter method yields more correct results, especially for shorter periods of time being analyzed.

The total of 40 days with precipitation of ≥5.0 mm, including 13 days with precipitation of ≥10.0 mm (according to Hellmann's rain gauge) were recorded in the Legnica station in the analyzed period from May to October 2009. The example of developed results for 10 selected cases of the highest rainfall – with the daily amount of

≥10.0 mm and duration up to 360 min is shown in Table 3. The development of pluviogram readouts for precipitations in 10 selected periods of time (5, 10, 15, 30, 45, 60, 90, 120, 180 and 360 min) was carried out separately for the float (clock) pluviograph and the tipping bucket pluviograph SEBA. Additional precipitation amounts in the interval of 1 min were specified for the SEBA electronic pluviograph, while the two mentioned methods for the development of pluviograms were used in the remaining time intervals, that is, readouts with constant time intervals (results: SEBA-1) and changeable intervals (results: SEBA-2).

The analysis of data presented in Table 3 allows formulation of the following conclusions – statements referring to the differences in recorded precipitations by comparing pluviographs:

- Mutual differences of interval precipitations for the developed rainfall durations from 5 to 360 min do not show a unique pattern, the advantage of precipitation amounts determined from the float pluviograph for the highest rainfall (on 7 July 2009) is only noticeable.
- Differences in interval precipitation amounts for the float pluviograph and the tipping bucket pluviograph SEBA at identical, constant durations reached the maximum of 3.3 mm (in minus) in the 5 min interval and the minimum of 1.5 mm in the 360 min interval (results: SEBA-1, Table 3, Fig. 3).
- Differences in interval precipitation amounts for the float pluviograph and the tipping bucket pluviograph SEBA at changeable intervals of rainfall durations were lower and reached the maximum of 2.3 mm (in minus) in the 5 min interval and the minimum of 1.5 mm in the 360 min interval (results: SEBA-2, Table 3, Fig. 3).
- Totals of short term precipitations determined based on digital records from the SEBA pluviograph at constant and changeable time intervals of rainfalls differed by the maximum of 2.4 mm in the 5 min interval, whereas the determined differences did not exceed ±1.0 mm (tab.Table 3) in the remaining time intervals.
- The maximum one minute precipitation amount read out from the SEBA pluviograph amounted to 3.6 mm (on 7 July 2009).

Figure 3 illustrates mutual quantitative differences of interval precipitation amounts for the float pluviograph and SEBA pluviograph – for results SEBA-1 and SEBA-2, developed from pluviograms from 7 July 2009.

As was stated above, the highest differences between results of measurements of precipitation amounts concern mostly the first interval of their duration –5 min (Table 3). In the case of a very intensive (high) rainfall reaching ca. f15 mm during 5 min (as on 7 July 2009), the difference of 2–3 mm indicates the underestimation of the precipitation amount of 10–20%. It should be emphasized that short and intensive rainfall pose a danger for functioning of sewage systems. Thus, the underestimation of 20% should be considered significant, hence further improvement of rainfall measurement instruments and methods is appropriate, especially for short durations, and essential for designing sewage systems.

Table 3

The breakdown of the highest precipitation amounts of durations from 1 to 360 min for the IMGW station in Legnica from May to October 2009[a]

Day	Rain gauge[b]	Rainfall sum [mm]	Rainfall occurrence		Duration [min]	Rainfall duration intervals [min]										
			Beginning	End		1	5	10	15	30	45	60	90	120	180	360
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
20–21 May	Hellmann's	15.5														
	pluviograph	15.7					2.8	4.3	4.6	5.8	5.9	5.9	5.9	7.3	9.8	15.4
	SEBA-1	15.3					2.5	3.6	4.4	5.4	5.6	5.6	5.6	7.2	9.7	14.8
	SEBA-2	15.3	01-50	06-16	266	1.2	3.4	3.9	4.4	5.5	5.6	5.6	5.6	7.3	9.8	14.8
15 June	Hellmann's	19.7														
	pluviograph	19.7					1.8	2.9	3.8	5.6	6.7	9.0	11.9	12.8	13.1	
	SEBA-1	20.5					1.6	3.0	4.0	6.0	7.1	9.4	12.0	13.1	13.4	
	SEBA-2	20.5	17-32	20-24	167	0.5	1.9	3.1	4.0	6.0	7.4	9.4	12.1	13.1	13.4	
24 June	Hellmann's	14.8														
	pluviograph	14.8					0.9	1.7	2.1	3.0	4.0	4.3	6.6	8.1	11.2	14.4
	SEBA-1	15.4					0.9	1.8	2.2	3.0	4.1	4.4	6.8	8.0	11.7	15.3
	SEBA-2	15.4	16-26	21-58	332	0.4	1.1	1.8	2.2	3.0	4.1	4.5	6.8	8.1	11.8	15.3
25 June	Hellmann's	18.1														
	pluviograph	17.8					5.0	6.9	7.0	7.2	7.3	7.3	8.3	8.5	13.0	16.1
	SEBA-1	18.4					4.6	6.8	7.3	7.3	7.3	7.3	8.6	8.6	13.5	16.8
	SEBA-2	18.4	11-26	17-50	384	1.3	4.6	7.0	7.3	7.3	7.3	7.3	8.6	8.6	13.5	16.8
04 July	Hellmann's	18.6														
	pluviograph	18.6					1.9	3.3	4.3	6.0	8.1	8.7	10.8	13.3	15.4	17.7
	SEBA-1	19.3					3.0	4.3	5.4	7.3	8.8	9.4	11.8	14.7	16.8	19.2
	SEBA-2	19.3	00-56	04-50	234	1.0	3.0	4.3	5.4	7.3	8.8	9.4	11.8	14.7	16.8	19.2
07 July	Hellmann's	45.2														
	pluviograph	43.9					16.7	25.8	28.8	31.8	33.9	34.5	36.3	37.2	38.6	40.2
	SEBA-1	42.2					13.4	23.2	25.9	29.4	31.4	32.1	34.3	35.2	36.8	38.7
	SEBA-2	42.2	18-20	22-55	275	3.6	14.4	23.5	26.8	29.5	31.7	32.4	34.3	35.2	36.9	38.7

Table 3 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18 July	Hellmann's	19.4														
	Pluviograph	19.2					2.8	5.0	6.1	7.1	8.3	8.9	10.9	13.1	15.1	17.9
	SEBA-1	19.4					4.1	5.3	6.1	7.2	8.3	8.9	11.3	13.3	15.3	18.2
	SEBA-2	19.4	14-25	19-21	296	0.9	4.1	5.4	6.4	7.3	8.4	9.0	11.3	13.4	15.4	18.2
23 July	Hellmann's	10.6														
	Pluviograph	11.1					6.1	8.7	9.6	10.1	10.2	10.2	10.2	10.2	10.4	11.1
	SEBA-1	11.3					3.5	6.8	9.2	10.4	10.5	10.5	10.5	10.5	10.7	11.3
	SEBA-2	11.3	16-51	21-45	294	2.0	5.9	7.8	9.5	10.4	10.5	10.5	10.5	10.5	10.7	11.3
02 August	Hellmann's	13.6														
	Pluviograph	13.3					0.8	1.5	2.1	4.0	5.7	7.1	9.2	9.9	10.2	
	SEBA-1	13.7					0.8	1.6	2.3	4.3	5.8	7.3	9.6	10.2	10.5	
	SEBA-2	13.7	00-10	03-29	199	0.2	0.8	1.6	2.4	4.3	5.8	7.3	9.6	10.2	10.5	
10 August	Hellmann's	11.5														
	Pluviograph	11.9					1.7	2.4	2.6	2.8	3.3	4.0	5.8	7.2	8.7	8.9
	SEBA-1	11.5					1.2	2.2	2.4	2.7	3.3	4.0	5.4	6.8	8.5	8.8
	SEBA-2	11.5	22-14	01-43	209	0.4	1.6	2.2	2.5	2.7	3.3	4.0	5.5	6.8	8.6	8.8

[a]The rainfall sum also covers precipitation occurring beyond the described period; the time of rainfall beginning and end is given according to indications of the SEBA rain gauge.

[b]SEBA-1 – for constant intervals of rainfall duration (1–5, 6–10, 11–-15, …, 56–60 min.), SEBA-2 – for progressing intervals.

Differences in recorded precipitations in the analyzed self-recording pluviographs are clearly visible in relation to indications of Hellmann's rain gauge, especially for short and intensive rainfalls, which occur rather seldom, but are essential in the process of dimensioning of sewage systems. The differences can be invoked by a number of causes. In the case of a float (clock) pluviometer during intensive rainfall, a certain part of precipitation is not recorded, when the storage container is emptied by means of a siphon. This results in a not entirely vertical diagram on a pluviogram, recording the moment of the float drop in the container which distorts measured total precipitations. In electronic recorders, precipitation losses may occur, when tipping buckets are dropped and water is splashed. Technical reasons such as irregularity of operation of a clockwork or voltage drops in a power supply battery, clogging of a beaker outlet, inaccurate placement of a pluviogram strip and a number of others (including the resolution of pluviogram scale and line thickness) may also deteriorate results of measurements.

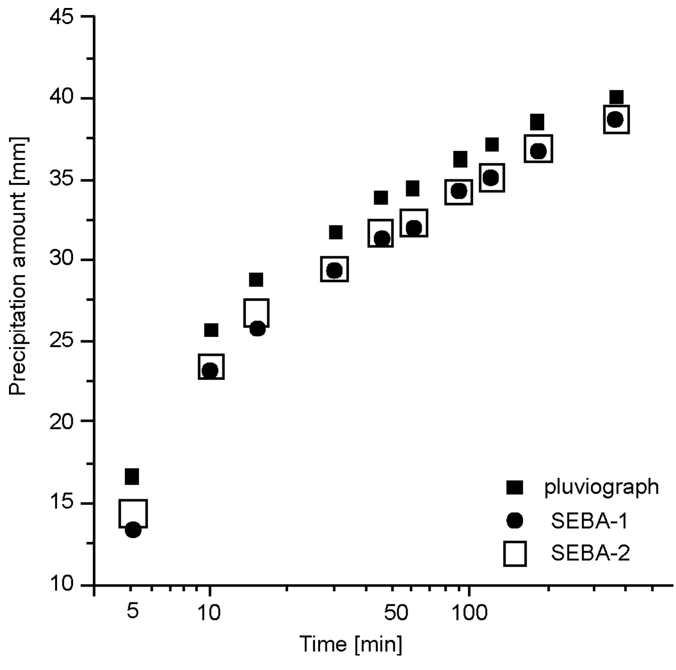

Fig. 2. Interval precipitation amounts for the float pluviograph and SEBA pluviograph; SEBA-1 and SEBA-2 results developed based on the pluviograms dated 7 July 2009

It should be noted that electronic recorders have also their drawbacks. In relation to traditional float pluviographs which may operate in a basically unchanged form for several dozen years and record relatively reliable rainfalls, automatic devices gradually lose adjustment and their indications become unreliable. The recommendation for carrying out periodical simultaneous rainfall measurements by traditional and electronic pluviographs seems noteworthy, since having switched one's measurement system to electronic recording only, one cannot neglect periodical inspections and calibrations of such instruments based on traditional methods. Thus, obtained results can be compared to previous obtained data.

3. SUMMARY AND CONCLUSIONS

The analysis of accuracy of precipitation measurements using a traditional float pluviograph and a new generation pluviograph of a tipping bucket type (SEBA), in comparison to traditional Hellmann's rain gauge, was based on pluviographic material from the IMGW meteorological station in Legnica from a warm half year (May–October) 2009. The comparison was made for four typical balance periods that is: the May–October season, 1 month, 1 day and 6 hours.

The total precipitation amounts in the entire pluviographic period measured by means of three rain gauges were very close. However, the highest precipitation sum was recorded with Hellmann's rain gauge (100%), medium sums – with a float pluviograph (99.5%), while the lowest values were recorded using a tipping bucket pluviograph SEBA (98.9%). The maximum difference of results (for the SEBA pluviograph) in relation to Hellmann's rain gauge amounted to –1.1%.

A similar deviation pattern of measured rainfall amounts can be noticed from the analysis of monthly precipitations. The highest sums were indicated with Hellmann's rain gauge, while the remaining devices noted slightly lower relative values as a rule. The percentage deviations of monthly precipitation did not exceed ±2.6% both for the SEBA pluviograph and float pluviograph with respect to Hellmann's rain gauge.

Relative average daily sums of precipitation amounts for 16 days with rainfall in July 2009 were characterized by a similar pattern. In a twenty four hour interval with the highest rainfall, the relative precipitation sum was: 97.1% for the float pluviograph and 93.4% for the tipping bucket pluviograph SEBA – with resprct to 100% (45.2 mm) for Hellmann's rain gauge. The added up rainfall amounts from self-recording pluviographs were different by approximately 4% to the disadvantage of the SEBA pluviograph for the highest daily rainfall during measurement season.

However, considering the nature of rainfall phenomenon, and especially the diversity of its intensity in time and space, the analyzed device for recording time dependences of precipitations can be recognized sufficiently accurate and approximately equivalent, certainly within the description accuracy class of the investigated phenomenon, especially for long periods of time, such as a season or a month, but also for a day. Nevertheless, the analysis of short term rainfalls – with durations ranging from 1 to 360 min – showed that the highest differences in precipitation amounts, recorded with compared pluviographs, occur mainly in the first 5 min of a rainfall. The mutual differences of interval precipitation amounts for the float pluviograph and SEBA pluviograph are the lowest, when changeable intervals of precipitation durations are applied to interpret the pluviograms. Mutual differences of the value of 2–3 mm were indicated in the case of very intensive rainfalls reaching ca. 15 mm during 5 min (as on 7 July 2009) which shows an underestimation of the precipitation amounts by 10–20% by the SEBA pluviograph in comparison to the traditional float pluviograph. Short lived and intensive rains are usually dangerous to proper functioning of a sewage system – described in the initial curve sections of the precipitation amount (DDF) or intensity (IDF).

From the analysis carried out and literature data it follows that further improvement of instruments and methods for measurement of precipitation amounts is necessary, since currently used rain gauges, including new generation ones, have a number of flaws.

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