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# Załącznik 3

## Summary of professional accomplishments

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## I. Education and degrees

In 2001, I graduated I High School of the name of Stefan Żeromski in Jelenia Gora and I started full-time studies at the faculty of Mathematics and Computer Science of the University of Wroclaw, which I graduated in 2005 with a bachelor's degree. In parallel, in 2002, I began second full-time studies – at the faculty of Environmental Engineering at the Wroclaw University of Science and Technology. I graduated in 2007 with honors, obtaining a master's degree in the specialty of Water supply and neutralization of sewage and waste (specialization: Waterworks and Sewerage).

In 2007, I started PhD studies under the supervision of Prof. Andrzej Kotowski. PhD thesis entitled „*Simulation studies of stormwater overflows and stormwater separators operation in the unsteady motion conditions to support the design of the drainage systems*", implemented as a part of the promotion grant, I defended with honors in 2011.

## II. Information on previous employment

In 2011, I started work as an assistant at the Faculty of Environmental Engineering at the Wroclaw University of Science and Technology, which is continuously the basic place of my employment until today. In 2012, I was promoted to the position of the scientific and teaching adjunct and simultaneously, I took the position of the deputy director for scientific Research and cooperation with the industry in the Institute of Environmental Protection Engineering at the Wroclaw University of Science and Technology, which I held until 2014. In 2016, I took the function of the vice-dean for student and organizational cases, which I have held to this day.

## III. Scientific achievement being the basis of the habilitation procedure

Title:
*Prediction of changes in maximum rainfall amounts in Wroclaw*
Author:
Bartosz Kaźmierczak
Publishing House:
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Publishing reviewers:
Prof. Andrzej Kotowski
Prof. Karol Kuś

Work description:

Urban drainage should protect against the effects of extreme rainfall, submerging and flooding, however, due to the stochastic nature of rainfall and their high spatial and temporal variability, it is not possible to achieve its fully reliable operation. The standard EN 752:2017 suggests to distinguish the allowable flooding frequency from sewers in a seven-step scale of the impact of threat on the environment – from $C = 1$ year (1 time per 1 year) for very low hazard areas, to $C = 50$ years (1 time per 50 years) for areas with very high risk.

Both progressive urbanization and climatic changes have a negative impact on the efficiency of the sewage systems operation, causing its increasingly frequent overloads, leading to local or urban flooding. The adaptation of the urban infrastructure, determined by the changing climate, will become more and more important so that our cities may be fit to live safely in the future.

Research on future rainfall scenarios and their impact on drainage infrastructure have been conducted for many years around the world. Also in Poland, there is an apparent trend in the rainfall structure change: longer periods without rainfall, followed by intense rainfall destroying crops, causing local flash-flooding, and even wide area floods. The increase in the extreme precipitation occurrence will undoubtedly result in the need to update the height (DDF) or rainfall intensity curves (IDF). The quantification of the problem, as well as appropriate remedial planning, in order to minimalize the negative effects of such events in the future are urgently needed today. The current legal status in Poland imposes an obligation on the sewage systems designers to safely dimension them, i.e. using the best available technique (BAT).

In the work, based on rainfall observations in Wroclaw, an attempt has been made to predict the future maximum rainfall, authoritative for drainage systems dimensioning (designing on the prospect of 50–100 years, i.e. 2100). Research material was represented by archival pluviographic records from the IMGW-PIB (pol. *Instytut Meteorologii i Gospodarki Wodnej – Państwowy Instytut Badawczy*) Wroclaw-Strachowice meteorological station, from the time span 1960–2018 (59 years of continuous observations).

Since rainfall models should be based on at least 30-year measurement period, and the principal purpose of the work was the forecast of the future rainfall based on observed trends, from the research material, a number of 30, 30–year measurement series were separated: 1960–1989, 1961–1990, …, 1989–2018. In this way, the 30 measurement series were created, which formed the basis for the development of probabilistic models of maximum rainfall. For statistical analyses, the maximum rainfalls were selected with the use of the peak-over-threshold (POT) method – above the own cut-off limit, for 16 durations, recommended for precipitation models formulation, i.e.: 5, 10, 15, 30, 45, 60, 90, 120, 180, 360, 720, 1080, 1440, 2160, 2880 and 4320 minutes. As a result, a number of 2018 rainfall were selected for analysis, of which for each of the 30 periods (from 1960–1989 to 1989–2018), the 30 highest rainfall heights (for each of the 16 rainfall durations) were selected and ranked non-increasing. For such prepared data, using the maximum likelihood method, an empirical probability of exceedance was attributed, followed by the identification of the parameters estimators of the generalized exponential distribution (GED) and Weibull distribution, by which the maximum rainfall amounts for each of the 30 analyzed periods were described.

In order to verify the compatibility between the assumed - theoretical and the empirical distributions, a λ-Kołmogorow test was carried out. Obtained results allowed to assume the null hypothesis about the GED and Weibull theoretical distributions compatibility with the empirical data. For comparison of the distributions, the Bayesian information criterion was applied, which allowed choosing the GED distribution as being qualitatively better for analyzed empirical data description. A very high agreement of the results obtained with formulated GED models with the measurement data was found, especially for rainfall lasting up to 1440 minutes.

High compliance of the results of calculations obtained with the use of formulated models with the measurement data allowed to consider the developed models as reliable and that could be the basis for generalization of research results. The applied Mann-Kendall test demonstrated the statistically relevant changes trends of all equations parameters describing the dependency the estimators of scale and location parameters on rainfall duration. As a result, the equations were obtained, which, after placing to GED quantile, allowed to determine the prediction model of maximum precipitation amounts, dependent on: the duration, probability of exceedance and a year, on which the rainfall is calculated.

The conducted research allowed to draw detailed final conclusions:

- For rainfalls with a frequency of occurrence of $C$ = 1 year, in the last three decades, i.e. in the years 1989–2018, an increase in the amount of precipitation with durations up to $t$ = 120 minutes and a decrease for longer durations was observed. The largest increases, at the level of 6–10%, were recorded for the most intense rainfall, with durations up to $t$ = 15 minutes. The biggest decreases, at the level of 3–6%, were recorded for rainfalls with a duration exceeding $t$ = 1080 minutes. A further increase in the amount of short-term rainfalls and a decrease in the amount of longer rainfalls are forecasted. The largest increases, at the level above 9% by 2050, are forecasted for rainfalls with a duration of $t$ = 5 minutes. In addition, increases of more than 6% in the same time horizon are forecasted for rainfalls with durations of $t$ = 10 and $t$ = 15 minutes. The reverse tendency is foreseen for rainfalls with a duration above $t$ = 120 minutes. The biggest decreases, at the level above 6% by 2050, are forecasted for rainfalls with the duration of one day and longer.
- For rainfalls with a frequency of occurrence of $C$ = 2 years, in 1989–2018 an increase in rainfall amounts was observed, with durations up to approximately $t$ = 60 minutes and a decrease for longer durations. The largest increases, ranging from 3 to even 15%, were recorded for the most intense rainfalls, with durations up to $t$ = 15 minutes. The biggest decreases, at the level of 5–8%, were recorded for rainfalls with a duration exceeding $t$ = 1080 minutes. A further increase in the amount of short-term rainfalls and a decrease in the amount of longer rainfalls are forecasted. The largest increases, at the level above 9% by 2050, are forecasted for rainfalls with a duration of $t$ = 5 minutes. In addition, increases of more than 3% in the same time horizon are forecasted for rainfalls with a duration of $t$ = 10 and $t$ = 15 minutes. The reverse tendency is foreseen for rainfalls with a duration above t = 60 minutes. The biggest decreases, at the level above 6–10% by 2050, are forecasted for rainfalls with the duration of one day and longer.
- For rainfalls with a frequency of occurrence of $C$ = 3 years, in 1989–2018 an increase in rainfall amounts was observed, with durations up to approximately $t$ = 30 minutes and a decrease for longer durations. The largest increases, at the level of 15%, were recorded for the most intense rainfalls, with durations up to $t$ = 15 minutes. The biggest decreases, at the level of 7–9%, were recorded for rainfalls with a duration exceeding $t$ = 1080 minutes. A further increase in the amount of short-term rainfalls and a decrease in the amount of longer rainfalls are forecasted. The largest increases, at the level of 8% by 2050, are forecasted for rainfalls with a duration of $t$ = 5 minutes. In addition, increases of more than 3% in the same time horizon are forecasted for rainfalls with a duration of $t$ = 10 minutes. The reverse tendency is foreseen for rainfalls with a duration above $t$ = 30 minutes. The biggest decreases, at the level of 7–8% by 2050, are forecasted for rainfalls with the duration of one day and longer.
- For rainfalls with a frequency of occurrence of $C$ = 5 years, in 1989–2018 an increase in rainfall amounts was observed, with durations up to approximately

$t$ = 15 minutes and a decrease for longer durations. The largest increases, at the level up to 15%, were recorded for the most intense rainfalls, with durations up to $t$ = 15 minutes. The biggest decreases, at the level of 8–10%, were recorded for rainfalls with a duration exceeding $t$ = 1080 minutes. A further increase in the amount of short-term rainfalls and a decrease in the amount of longer rainfalls are forecasted. The largest increases, at the level of 7% by 2050, are forecasted for rainfalls with a duration of $t$ = 5 minutes. In addition, increases of more than 3% in the same time horizon are forecasted for rainfalls with a duration of $t$ = 10 minutes. The reverse tendency is foreseen for rainfalls with a duration above $t$ = 15 minutes. The biggest decreases, at the level of 8–10% by 2050, are forecasted for rainfalls with the duration of one day and longer.

- For rainfalls with a frequency of occurrence of $C$ = 10, $C$ = 30 and $C$ = 50 years, in 1989–2018 an increase in rainfall amounts was observed, with durations up to approximately $t$ = 10 minutes and a decrease for longer durations. The largest increases, at the level up to 15%, were recorded for the most intense rainfalls (with durations of $t$ = 5 minutes). The biggest decreases, at the level of 9–13%, were recorded for rainfalls with a duration exceeding $t$ = 1080 minutes. A further increase in the amount of short-term rainfalls and a decrease in the amount of longer rainfalls are forecasted. The largest increases, at the level of 7% by 2050, are forecasted for rainfalls with a duration of $t$ = 5 minutes. The reverse tendency is foreseen for rainfalls with a duration above $t$ = 10 minutes. The biggest decreases, at the level of 9–12% by 2050, are forecasted for rainfalls with the duration of one day and longer.

Formulated in work the prediction model of maximum rainfall amount allows the urban drainage systems designers to take into account, in the design process, the forecasted increase in intensity of short-term rainfall, and therefore meet the requirements of the standard EN 752 regards the acceptable frequency of flooding occurrence from sewage systems – being currently designed, and having to safely operate in perspective of many decades.

## IV. Description of other scientific achievements

I published a total number of 82 works: 3 monographs, 14 chapters in monographs, 43 articles (including 16 with IF), 22 conference papers (including 9 indexed in Web of Science). In addition, I was a co-author of 3 monographs and 6 conference publishings, and co-author of 13 reports from Research works (PSR reports). In Appendix 4, entitled „*List of published scientific papers and information about the didactic achievements, scientific cooperation and promoting of science*", there is given a bibliographic description of my most relevant publications – from the total amount of 102 works over the whole period of employment in Wroclaw University of Science and Technology, including 13 individual works and 89 teamworks.

In the period before obtaining the PhD degree (2007–2011), I collected a total of 21 works (2 individual and 19 teamworks). Of these, I published a total of 15 works, including:

- 1 monograph,
- 3 chapters in monographs, including 1 discrete,
- 2 articles in IF journals,
- 5 publications in scored scientific journals without IF, including 1 discrete,
- 4 conference papers.

After obtaining PhD degree (2012–2019), I have assembled in my output a total number of 81 works (including 11 individual and 70 teamwork). I published 67 of them, including:

- 2 monographs, including 1 discrete (being the scientific achievement mentioned in point III),
- 11 chapters in monographs, including 2 discrete,
- 14 articles in IF journals, including 1 discrete,
- 22 publications in scored scientific journals without IF, including 3 discrete,
- 9 conference papers indexed in the Web of Science, including 2 discrete,
- 9 other conference papers, including 1 discrete.

In Table 1 there is presented the structure and numerical summary of my output divided into periods: before obtaining the PhD degree and after obtaining the PhD degree.

Table 1. A synthetic overview of research output

| Type of Publication | Prior to the Award of Doctoral Degree | | | After the Award of Doctoral Degree | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Individual | Co-authored | Total | Individual | Co-authored | Total | Individual | Co-authored | Total |
| Monographs | 0 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 3 |
| Chapters in monographs | 1 | 2 | 3 | 2 | 9 | 11 | 3 | 11 | 14 |
| IF journals | 0 | 2 | 2 | 1 | 13 | 14 | 1 | 15 | 16 |
| Other Journals | 0 | 5 | 5 | 3 | 19 | 22 | 3 | 24 | 27 |
| WoS conference papers | 0 | 0 | 0 | 2 | 7 | 9 | 2 | 7 | 9 |
| Other conference papers | 1 | 3 | 4 | 1 | 8 | 9 | 2 | 11 | 13 |
| Scientific editing | 0 | 0 | 0 | 0 | 7 | 7 | 0 | 7 | 7 |
| Reports | 0 | 6 | 6 | 1 | 6 | 7 | 1 | 12 | 13 |
| Total | 2 | 19 | 21 | 11 | 70 | 81 | 13 | 89 | 102 |

The total point achievements, after deducting the share of the work co-authors, amounts to 331.9 points, including 138.4 points for the articles in journals with IF. For the period after obtaining the PhD degree, there are 291.9 points, including 130.0 points for the articles in the journals with IF. The total IF amounts to 20.188, including 19.027 after obtaining the PhD degree.

Bibliometric indicators (number of works, citations, h-index) of my scientific output, depending on the base, amount to:

- Web of Science: number of works: 27, citations: 110, h-index: 7.
- Scopus: numer of works: 26, citations: 114, h-index: 8.
- Google Scholar: numer of works: 69, citations: 398, h-index: 11.

I have discussed below my interests and scientific achievements (in chronological order) with references to the list of scientific achievements – given in Appendix 4.

**Timespan before obtaining PhD degree (2007–2011)**

In the period before obtaining the PhD degree, my scientific interests included the following subjects:

1. Modeling of the stormwater overflows operation.
2. Modeling of operation of light liquid separators with internal by-pass channels.
3. Model studies of the hydrodynamic liquid flow regulators.
4. Modeling of reliable rainfall for sewage systems dimensioning.
5. Modeling of the sewage systems operation.

**Ad 1.** The simulation studies of the impact of operational assumptions on the construction and operational parameters of the improved storm overflows with the choke pipe on the combined sewage system were the first scientific issues that I dealt with. The research carried out in 2007–2011 showed, among others, that the most important parameter affecting the operation of storm overflows (and, at the same time, construction costs) is the height of the overflow edge (*p*). The discrete replacement of the parameter *p*, in the area of its permissible variability, proved that the shortest overflow edge occurs in the case of its highest altitude, regardless of the outflow stream volume to the wastewater treatment plant. These studies were published in a scoring journal (Appendix 4, position E43) and conference papers (L10, L12, L13). I received a promotion grant for Research, entitled "*Simulation studies of stormwater overflows and stormwater separators operation in the unsteady motion conditions to support the design of the drainage* ", implemented in 2009–2011.

**Ad 2.** At the same time, in the years 2007–2009, I participated in the modeling of sewage flows in light liquid separators, especially with the so-called internal by-pass channels of a coalescent or lamella filter. The results of the undertaken research (reports: J12, J13) provided the basis for their correct dimensioning and subsequently receipt by the manufacturer of these devices of technical approvals, issued by the Institute for Environmental Protection in Warsaw.

**Ad 3.** In the years 2007–2010, I participated in studies that were aimed to determine the hydraulic characteristics of hydrodynamic flow regulators for practical applications in waterworks (for clean liquids) and in sewage (for liquids with varying degrees of pollution) and to formulate on this basis their design and dimensioning principles (report: J10).

**Ad 4.** In the years 2007–2011, I participated in research aimed at determining the maximum rainfall amounts with given duration and probability of exceedance – reliable for dimensioning of drainage systems. The performed research allowed to formulate a precipitation model for Wroclaw – reliable for the safe design of drainage systems. In addition, it has been shown that it is appropriate to create models for the maximum rainfall amount of local range, because universal models for the whole Poland are characterized by low accuracy and, therefore, little utility for design. The results of the work were published in articles with IF (A15, A16), the monograph "*Precipitation modeling for sewerage measuring*" (E2), chapters of monographs (E15, E16), articles without IF (E40, E41), and reports (J9, J11). The interest in local rainfall models contributed to the publication on the safe dimensioning of sewage systems based on reliable rainfall data. In 2009–2011, I published in this regard two articles (E39, E42), a conference paper (L11) and a report (J8).

**Ad 5.** The last of the areas I became interested in before obtaining a PhD degree was hydrodynamic modeling of sewer systems. In 2011, I published a chapter in a monograph (E14) on the use of the Storm Water Management Model (SWMM) package to verify the hydraulic capacity of a stormwater sewage system.

## Timespan after obtaining PhD degree (2012–2019)

After obtaining the PhD degree, I continued some of the previously started research subjects (1, 4 and 5), and also undertook new problems concerning topics (6-11), i.e.:

6. Stormwater retention.
7. The technology of biochemical remediation and storage of surface water in underground hydrogeological structures.
8. Trends in the rainfall amount changes.
9. The impact of climate change on the functioning of sewage systems.
10. Complementarity of renewable energy sources.
11. Modeling of the water supply systems operation.

**Ad 1.** In 2013–2014, I have been dealing with the use of hydrodynamic regulators in modern stormwater overflows (A12, E9, E50) and the problem of the annual number of storm discharge prediction and their pollution load (E27, E30, J3). In addition, I was the co-author of the expert opinion on technical solutions for stormwater overflow on the sewer channel of the "Garbary" sewage pumping station in Poznan, with the selection of the construction parameters of the overflow (B3).

**Ad 4.** The subject of rainfall modeling I have been constantly dealing with since the beginning of PhD studies to the present day. The greatest achievements in this respect are the probabilistic precipitation model for Legnica (A5, L5), the development of, a unique in the country scale, equation for maximum rainfall in Wroclaw, occurring more often than once a year (A14) and the use of generalized exponential distribution for describing the maximum rainfall – published among others in the Journal of Hydrology (A6, E38). Other works, published, among others in the Journal of Hydrometeorology, concerned the methodological bases for precipitation models formulation and methods for selecting the best of distributions (A13, E13, E20, E23, E46, E47, E49, E51, E52) as well as analysis of spatial variability of precipitation (E10).

**Ad 5.** Parallel to the subject of rainfall modeling, I constantly deal with hydrodynamic modeling of the sewage systems operation. The research undertaken so far concerned, inter alia, verification of dimensioning methods (E17, E31, E33, E37) and clarifying of methods for drainage systems modeling (E11, E32, E34, E35, E36). On this basis, the method of delay coefficient was recognized as a safe method for dimensioning stormwater drainage – with the local maximum rainfall models (A10, E28) and the rules for identification the hydrological and hydraulic parameters of hydrodynamic models in the course of their calibration and validation were proposed (A4, E8). I am also a co-author of the works considered as case studies (E6, E19, E25), valuable from an academic point of view. In addition, I am the co-author of the monograph "*Verification of stormwater sewer capacity in hydrodynamic modeling*" (E1), and also published in this area 2 conference papers (L4, L9) and 2 reports (J2, J4).

**Ad 6.** Since 2012, I have been dealing with the problem of retention of stormwater retention. I have published numerous works related to dimensioning (E4, E21), modeling (E5, E24, L1) and infiltration (E12) of stormwater. In addition, I was the author of the study *Estimation of the retention reservoirs volume for retention of wet weather combined sewage from the Port Północ and Port Południe nodes necessary to limit the number of storm discharges to the Oder* (B1) and co-author of the *Concept of technical solutions for stormwater retention* (B2).

**Ad 7.** In 2013–2014, I participated in two tasks – *The concept of water discharge installation and design assumptions for their construction at the Kłodzko Waterworks* and *The concept of conversion of the pumping station in the Kłodzko Waterworks and design assumptions* – implemented under the research and development grant "*Biochemical remediation and surface water storage technology in underground hydrogeological structures for municipal water intakes in river valleys*". On this subject, I published an article (E29), a conference paper (L8), and also co-authored two reports (J6, J7).

**Ad 8.** Since 2013, I have been dealing with trends in rainfall amount changes. The results of the analyses of trends in precipitation rates in the Upper Odra basin were published in the journal with IF (A8). In this subject I started the cooperation with scientists from the Institute of Meteorology and Water Management and the Czech Hydrometeorological Institute, which resulted in the publication of papers indexed in Web of Science (E22, E44, E45) and in conference materials (L2, L6, L7).

**Ad 9.** In parallel with the mathematical description of changes in rainfall amounts, in 2013 I took care of the impact of these changes on the sewage systems operation. I published articles on dimensioning (A7) and modeling (A1, A9, A11) of drainage systems in journals with IF, in the case of a forecasted increase in the frequency and intensity of rainfalls due to climate change. In addition, I published 2 chapters in monographs (E3, E7), an article (E26) and a conference paper (L3).

**Ad 10.** In 2017, I started cooperation with scientists from the Goethe University Frankfurt and native AGH and University of Life Sciences in Wroclaw, which resulted in articles (among others in Energy), presenting the concept of temporal and spatial complementarity of wind and solar resources in Lower Silesia (A3, E48).

**Ad 11.** The last of the topics, undertaken in 2018 as a part of the scientific internship at the Bialystok University of Technology, concerns the modeling of the water supply systems operation. Until now, I have been able to publish articles on forecasting water consumption (A2) indexed in the Web of Science and the analysis of loss and frequency of failures in water supply networks (E18). In addition, I was a co-author of the report on the impact of the size and variability of water cutting on the unevenness of sewage outflow (J1). In addition, I was a co-author of the report on the impact of the amount and variability of water discharge on the irregularity of sewage outflow (J1).

In addition to the scientific interests mentioned above, I participated in the development of recommendations and guidelines for the design, modernization and operation of networks, sewage devices and laterals in the field of safe dimensioning of sewage systems and designing of sewage pumping stations (J5).

In the years 2014–2016, I was a scientific co-editor of books in the series *Interdisciplinary Problems in Environmental Protection and Engineering* (F5, F6, F7), and then, in 2017–2018, in conference materials from the series *Interdisciplinary Problems in Environmental Protection and Engineering* (F1, F3), indexed in the Web of Science.

In 2017, I was a co-editor of the conference materials from the series *Advances in Energy Systems and Environmental Engineering* (F4), indexed in the Web of Science, and in 2018 from the *Seminar of Applied Mathematics* (F2).

From 2018, I am an editor with the right to decide on accepting papers for publication in the journal SN Applied Sciences (Springer).