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Appendix 2A

SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

including information about achievement in research, didactic, expert and organisational activities

Wrocław, 16.03.2015 r.

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1 Degrees held

2 March 2000 **Bachelor of Science** in Water and Sanitary Engineering of Rural Areas, Faculty of Land Reclamation and Environmental Engineering, Agricultural Academy of Wrocław (currently Wrocław University of Environmental and Life Sciences).

30 June 2001 **Master of Science** in Water and Sanitary Engineering; Faculty of Environmental Engineering and Geodesy, Agricultural Academy of Wrocław. Diploma with distinction (overall grade: very good).

28 September 2005 **Ph.D. in Technical Sciences** in Environmental Engineering. Dissertation defended before the Scientific Council of the Institute of Environmental Engineering, Wrocław University of Technology. Doctoral dissertation title: *Research on the Use of Geotextiles to Prevent Clogging in the Infiltration Process (Badania nad zastosowaniem geowłóknin do przeciwdziałania kolmatacji w procesie infiltracji)*. PhD Supervisor: prof. dr hab. inż. Janusz Łomotowski. The doctoral dissertation was awarded a distinction.

2 Information about employment in academic institutions

From 01.12.2005 to 31.12.2009 Researcher and lecturer at the Division of Infrastructure and Sanitary Technology, Institute of Building Engineering and Landscape Architecture, Agricultural Academy of Wrocław (currently Wrocław University of Environmental and Life Sciences).

From 01.01.2010 to date Researcher and lecturer at the Division of Infrastructure and Sanitary Technology, Institute of Environmental Engineering, Wrocław University of Environmental and Life Sciences.

From 15.09.2009 to 15.09.2013 Expert co-ordinator of a project implemented at the Wrocław University of Environmental and Life Sciences under the Human Capital Operational Programme (Sub-measure 4.1.2).

3 Identification of scientific accomplishment

At the outset of procedure for the award of the degree of *Habilitated Doctor of Technical Sciences*, in accordance with Article 16(2) of the Act of 14 March 2003 on academic degrees and title and on degrees and title in art, habilitation dissertation was identified (work published in full in a series of Monographs no. CLXXV by Publisher Wrocław University of Environmental and Life Sciences, Wroclaw, 2014 (ISBN 978-83-7717-187-5) entitled:

GREEN ROOF AS AN ELEMENT OF SUSTAINABLE URBAN DRAINAGE SYSTEMS IN URBAN AREAS

3.1 Introduction, presentation of the scientific objectives and results

The ongoing urbanisation process entails changes in hydrological conditions caused by an increasing amount of impermeable surface, which results in a decreased retention and infiltration of rainwater into the ground. Natural water retention in the cities is often reduced to an extent that affects the groundwater level or soil and ground moisture content; there is also an increase in surface run-off during torrential rains that, as a consequence, leads to local flooding or urban floods.

This ongoing urbanisation requires that traditional urban drainage systems be equipped with technical solutions affecting the reduction of peak flow discharged into rainwater drains or natural waterbodies. This issue was noticed in many countries. In the 1990s, sustainable development strategies started to be implemented with a view to reinstating hydrological conditions in urban areas to their original status prior to land development, and reducing the amount of pollutants transported into water ecosystems with surface runoff. One of the best known strategies is the Low Impact Development (LID) strategy, widespread in the United States, and the strategy of Water Sensitive Urban Design (WSUD), implemented in Australia. Those strategies are applied in practice through the implementation of Sustainable Urban Drainage Systems (SUDS) or Integrated Management Practices (IMPs). These solutions encompass both surface and underground stormwater storage tank systems with infiltration of water into the ground. With the right soil, hydrological and field conditions, the various surface storage tank solutions are preferable. Finding free space for storage and infiltration facilities such as basins, reservoirs or trenches in the urban "tissue" may be difficult, given the high-density housing, complex underground infrastructure systems

and high prices of land. Under such conditions, however, it is possible to use systems that slow down rainwater runoff, while at the same time causing minimum interference with the existing housing or technical infrastructure in cities. Such solutions include green roofs.

Green roofs are used more and more frequently. They are installed on rooftops of residential buildings, public utility facilities, garages, terraces or parking areas. The investors' interests in those structures stem from legal requirements relating to the necessity of restoring biologically active areas while implementing an investment project, and from an increased social awareness of the need to improve stormwater management in urban areas. The multi-layered structure of green roofs allows stormwater to be largely retained and evapotranspirated. During rainfall, water drains into the sewage system only after the green roof's retention capacity is exceeded. A large number of factors affecting green roof retention properties (rainfall distribution over the year, rainfall intensity, outdoor air temperature, plant species used, thickness of the substrate layer, etc.) result in the fact that the research results presented in the literature frequently differ. For those reasons, it is not recommended to transpose the results of research relating to retention capabilities of green roofs conducted in different climatic conditions.

My green roof research was prompted by a noticeable scarcity of results of studies on the transformation of runoff wave and its influence on runoff quality conducted in the national climate conditions. The need for more research on green roofs was frequently communicated by the representatives of local governments, sewage system administrators, designers and contractors during discussions held at scientific conferences, trade seminars, or during meetings organised as part of operations of the Polish Green Roof Association that I chaired in the years 2009-2011. Previously, there had been no systematic or comprehensive research conducted into the operation and performance of green roofs in Polish conditions.

In the course of experiments, periods with both shortage and excess of rainfall were recorded, which enabled a statistical evaluation of green roof performance under changing weather conditions.

Pilot-scale research (on extensive green roof models of varying design) has been conducted at the Wrocław University of Environmental and Life Sciences since 2009 in the "Green Roof Laboratory" situated on the roof of the Science and Education Center located near Grunwaldzki Square in the centre of Wrocław. Green roof models have a shape of rectangular boxes (roof platforms) with outer dimensions of 2.40 m in length; 1.20 m in width, 0.35 m in height, placed at a slope angle of 4^{o} (Fig.1).

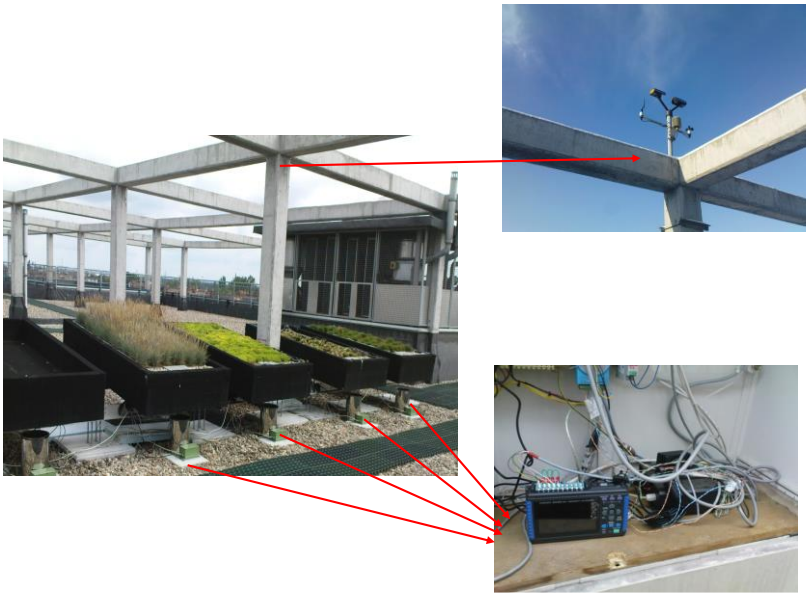

Fig. 1 Green roof models on the roof of the Science and Education Center, Wrocław University of Environmental and Life Sciences, with the precipitation measuring system (distrometer - laser precipitation sensor) and runoff measuring system (electronic devices placed under the roof platforms to continuously measure the amount of runoff from test plots, connected to Memory Hilogger 8430-20 by HIOKI)

One of the roof platforms serves as a conventional (reference) roof (deprived of vegetation and other green roof layers). The detailed methodology of research is presented in the publications. Later in the text, an DR abbreviation is used for the reference roof, with DZ being used to describe extensive green roofs, including in particular DZ-1 for a roof with drainage system (non-systemic solution); DZ-2 for a roof with gravel layer (system solution); DZ-3 for a roof using internal drainage in substrate solutions; and DZ-4 for a roof using a drainage and storage system.

The main scientific objectives of the original green roof research, the results of which are presented in the above-mentioned hablilitation dissertation, include the following:

a) determining green roof retention capacity and its impact on the delay and volume of peak runoff under the conditions of random, natural and dynamic volatility of rainfall depth in urban areas;
b) determining green roof influence on the quality of runoff water;
c) identification of needs taking into account the safe management of rainwater runoff discharged from green roofs, which should be taken into account in the design and operation of green roofs.

Ad a)

The hydrological performance of green roofs is often compared to that of detention reservoirs. Some of the rainfall is discharged into the atmosphere in the process of evapotranspiration from the part of the roof covered with plants. Excess rainfall is discharged from the multi-layered structure of green roofs later than in the case of conventional roofs, and at a lower runoff volume. Water retention capacity of green roofs has shown dynamic changes due to environmental factors.

The tests conducted on extensive green roof models and on the reference roof in Wrocław conditions have shown a significant effectiveness of green roofs as sustainable drainage systems in urban areas in respect of runoff dynamics and volume reduction. The analysis of rainfall-runoff relationship for each of the test plots has shown that the water retention on green roofs was higher than that on the reference roof. It was found that for rainfall events of a daily depth not exceeding 1 mm, i.e. those that occurred most frequently during the tests, the retention amounted to nearly 100% for green roof models, and to approximately 90% for the conventional reference roof. From the point of view of the sewage system operation, however, rainfall events of a bigger depth are more important. Test results show that the retention capacity decreases gradually with the increase of daily rain depth, but the difference between rainwater retention capacity of the conventional roof and that of the green roof increases (Fig. 2). It has been found that the rainfall depth affects runoff from the reference roof to a larger extent than it affects runoff from green roofs which, owing to their structure, are able to retain more rainwater.

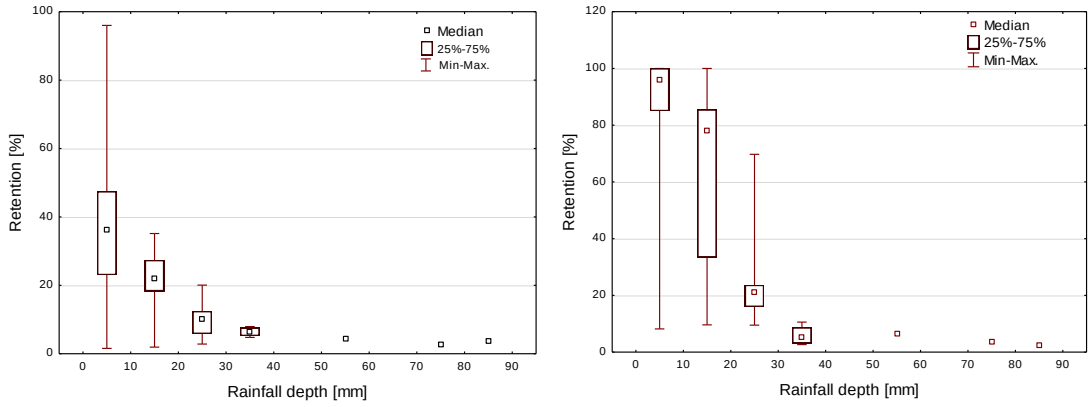

Fig. 2 Water retention volume in relation to rainfall depth on a conventional roof (on the left), and a green roof (on the right)

In the case of a single rainfall event, the degree of water saturation in the substrate prior to rainfall was of crucial importance. Several rainfall events occurring at short intervals

prevented the recovery of the roof's retention capacity, as a result of which the runoff was only slightly reduced during the next rainfall event. An improvement of retention capabilities was observed in cases where the antecedent dry weather period was longer than 24 hours. (Fig.3). The identified antecedent dry weather period is short when compared with other reports in the literature, which is indicative of a quick "recovery" of retention capacity by the green roof structures concerned. In the case of the reference roof, the length of the antecedent dry weather period did not significantly affect the runoff coefficient values calculated.

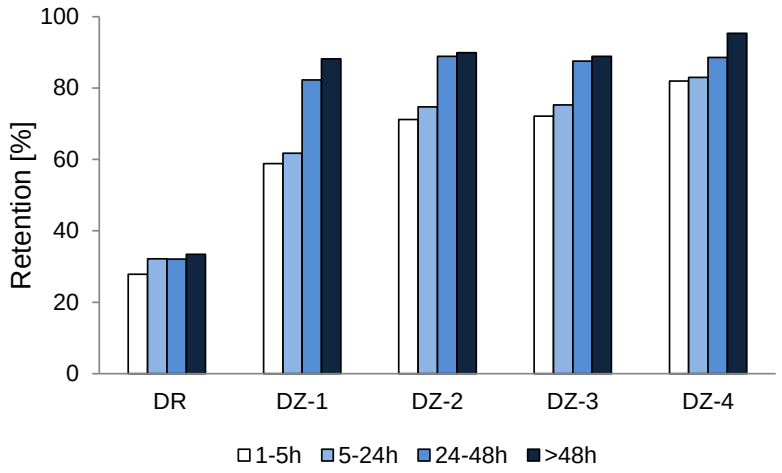

Fig. 3 Water retention volume in relation to the length of antecedent dry weather periods (DR – reference roof; DZ-1÷DZ-4 – green roofs)

Research shows that the retention capacity of green roofs changes over time. When comparing the retention on two green roof models tested (green roof with gravel drainage layer (system solution), and green roof using internal drainage in substrate solutions) in the first two years of their operation with that in the next two years, an increase of 4% in the water retention median values for those periods was noted. This phenomenon may be caused by an increase in root weight, as well as by changes taking place in the substrate structure. The leaching of organic matter, influence of external factors, tunnelling through roots, soil fauna and flora all affect the general porosity of the substrate layer and increase water retention. An increase in water retention capacity of green roofs during their operation is a favourable phenomenon from the viewpoint of rainwater management in urban areas.

Green roofs affect the runoff wave transformation. The author's own research shows that there is a reduction in peak flow and an increase in runoff delay time when compared with conventional roofs (Fig.4). When referred to peak runoff, the reduction ranged from 54% to 99% for green roofs. In comparison, the peak flow reduction on the reference roof was

within the range from 23% to 73%. The water retention volume decreased along with the increase in rainfall depth, which was related to the limited retention capacity of the green roof.

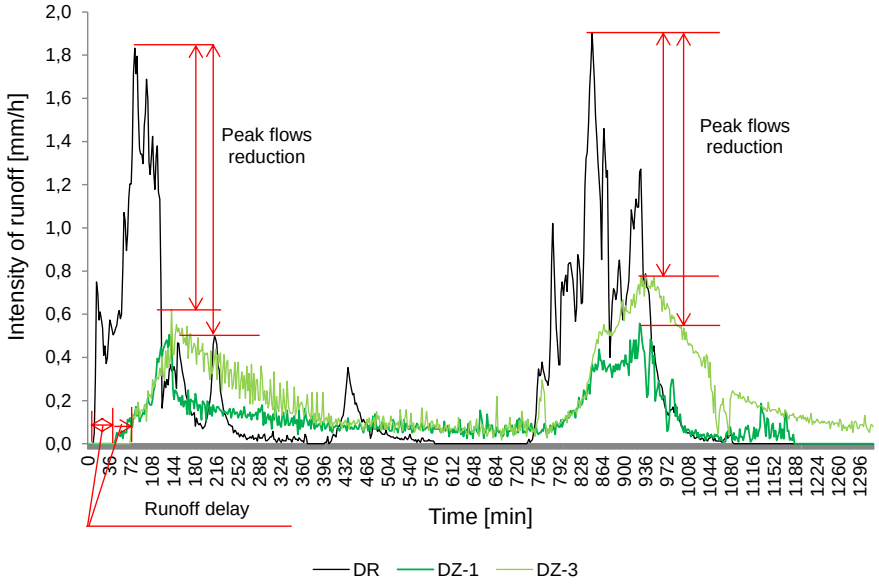

Fig. 4 Delays and peak flow reductions on the reference roof (DR) and on green roofs (DZ-1 and DZ-3) during one of the recorded rainfall events

Green roofs affected the runoff hydrograph also by slowing down the outflow of rainwater. On the majority of days with rainfall events, runoff from green roof models started after a dozen or so minutes, although cases where runoff took place after several hours from the start of the rainfall event were also recorded. The highest runoff delay times were noted on extensive green roof models with internal drainage in the substrate and with gravel drainage. By comparison, runoff from the reference roof usually started after several or a dozen or so minutes. The runoff delay time was affected by the length of antecedent dry weather period, duration of the rainfall event, and rainfall intensity fluctuations over time (rainfall hyetograph). The influence of daily rain depth was much smaller.

It has been found that the retention capacity of green roof models is affected by seasons. A lower water retention was noted in autumn when compared with summer or spring. Research shows that green roof water retention capacity depends on the duration of the rainfall event, its intensity and depth changes over time. With intense rainfall, differences between water retention on green roofs and the reference roof were marginal. This conclusion has been drawn on the basis of observation of green roof models' performance during rainfall events of high intensity that occurred in Wrocław, among other things, between 14 and 18 May, 1 and 2 June, and 23 and 30 June 2010, i.e. when the 1st and the 2nd

flood waves moved through Wrocław**.** The results of measurements conducted prove that the retention capacity of green roofs during intense rainfall is limited (Fig.5).

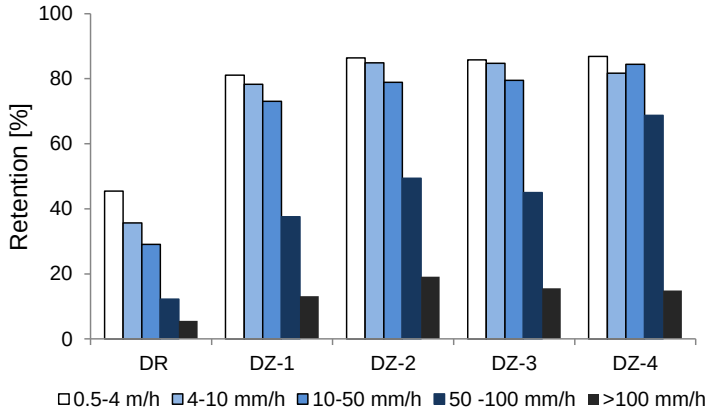

Fig. 5 Water retention volume in relation to rainfall intensity (mean values)

The recorded green-roof water retention value should not be associated with one factor only. Statistical analyses show that water retention on green roofs is significantly affected by rain depth, changes in intensity, duration of antecedent dry weather period, and air temperatures. It has been found that the most significant factors include rain depth and the number of days between subsequent rainfall events.

Statistical research results show that water retention may decrease by 1% when rainfall depth increases by 0.8 mm for the reference roof, and by almost 2 mm for green roofs. An increase in air temperature by 0.5^{o}C for the reference roof, and by approx. 1^{o}C for green roofs, results in an increase in rainwater retention capacity by 1%.

Ad b)

At the outset of green roof research, attention was paid mainly to hydrological aspects, while disregarding green roof influence on the quality of runoff water. This probably resulted from a common belief that green roofs, owing to their structure and vegetation, reduce the amount of pollutants that enter their surface with dry and wet atmospheric deposition. It was widely believed that a reduction in rainwater runoff from green roofs, when compared to conventional roofs, decreased the load of pollutants discharged into the atmosphere. Research on the quality of runoff water from green roofs was undertaken to increase knowledge in that respect. Research on this issue was initiated at the time when there were no publications relating to this topic. At the present moment, there is quite a significant

number of articles published in that respect, which proves the importance of the undertaken course of experiments.

The research shows that green roofs affect the quality of runoff water. It has been found that rainwater contact with green roof substrates results in an increase in pH value when compared with pH values of rainfall or runoff from the reference roof (Fig.6).

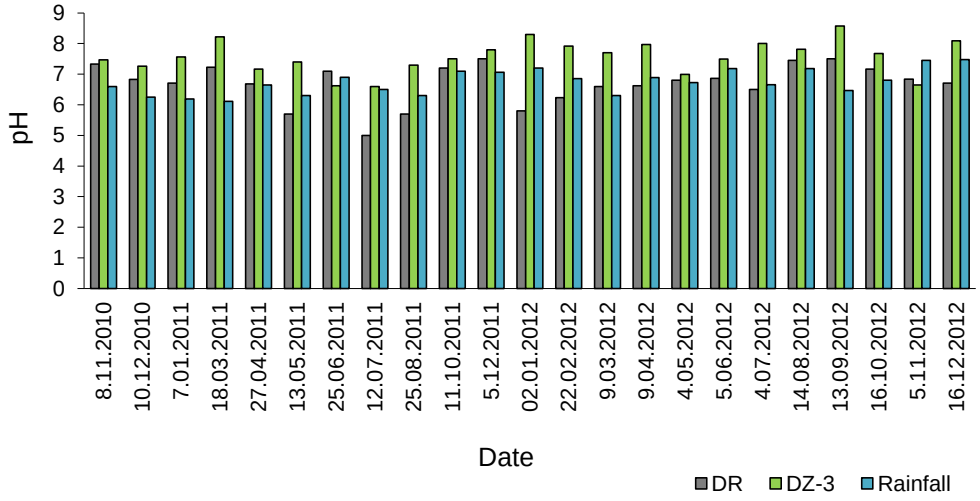

Fig. 6 Results of pH tests in selected months during the analysed period

A stabilisation of ammonia nitrogen and sulphate concentrations, as well as COD (chemical oxygen demand) values in runoff from green roofs has been observed in seasons other than winter. The values of those water quality indicators in runoff from green roofs were lower than the values determined in runoff from the reference roof, but higher than those recorded in rainfall. This proves that mineral and organic compounds leach from the growing media. It has been demonstrated that green roofs reduce the runoff of pollutants from dry deposition, when compared with conventional roofs, because the highest concentrations of analysed indicators were noted in the runoff from the reference roof (Fig. 7).

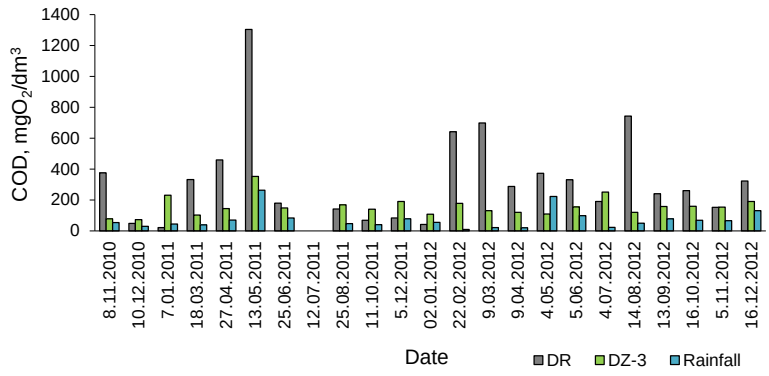

Fig. 7 Chemical oxygen demand values in selected months during the analysed period

When monitoring the experimental sites, the leaching of pollutants, mainly nutrients and salts, was observed in the initial period of green roofs' operation. Despite the fact that no fertilisers were used in the research concerned, higher concentrations of nitrates, nitrites and phosphates were noted in the runoff from green roofs than in the runoff from the reference roof or in the rainfall. These compounds were most probably leached from the compost or fertilisers added to substrates by their manufacturers to ensure the proper growth of plants. Other, equally probable reasons for such compounds' presence in the runoff from green roofs include the decomposition (mineralisation) of plant remains, and atmospheric deposition. It was noted that the values of the analysed runoff water quality indicators were decreasing with the age of the roof. In the research concerned, the values of green-roof runoff water quality indicators decreased after approximately three years of operation. In the case of electrolytic conductivity, the said changes were noticeable as soon as six months after green roof models had been put into operation (Fig. 8).

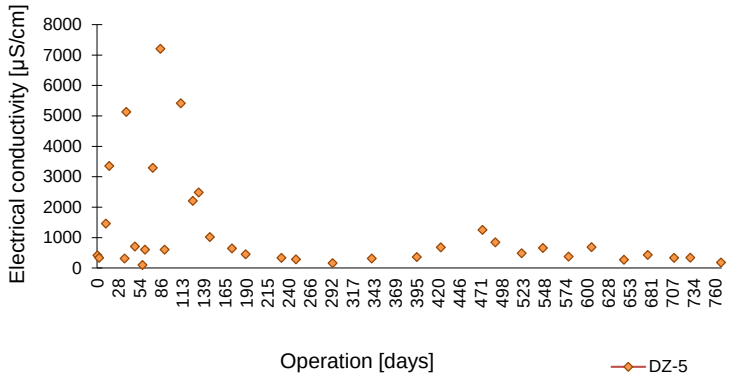

Fig. 8 Changes in electrolytic conductivity values in relation to the age of the roof

In Poland, as in other countries, no standards defining pollution concentration thresholds relating to rainwater drainage from green roofs have been developed so far. To be able to compare the pollution level of runoff from green roofs, the research results obtained were referred to the quality of rainwater drained from other types of land use. The said analysis was made on the basis of research results published in the national and foreign literature presenting the values of pollution indicators relating to rainwater runoff from conventional roofs (covered with various materials), streets and expressways, as well as runoff from housing developments or industrial zones. Average pH values in the analysed runoff from green roofs were higher than those in runoff from conventional roofs studied

by Chang et al.[1] and Lee et al.[2]. Average electrolytic conductivity values obtained in the recorded runoff from GR-2 and GR-3 green roofs (of a longer period of operation) were at the level of maximum values obtained in their research by Chui[3] in runoff from urban watersheds and by Vialle et al. [4,5] in runoff from a tile roof. Average COD values determined in runoff water from green roofs (at 200 mgO_2/dm^3) were similar to the values obtained by Thomson et al.[6]. Maximum values of this pollution indicator were lower that those obtained by Legret and Pagotto[7] in runoff from expressways, but higher than the values noted by Chui[3] in runoff water from urban watersheds.

The concentration of nitrates in runoff from green roofs was many times higher than the concentration reported in the literature for runoff from conventional roofs by Chang et al.[1]; Tsakovski et al.[8]; Lee et al.[2], Vialle et al.[5], or in runoff from expressways presented by Polkowska[9]. Average values of ammonia nitrogen concentration were almost three times lower than those in runoff from urban watersheds obtained by Polkowska in her research[9].

The content of chlorides in runoff water from motorways and expressways is many times higher than the concentration determined in runoff from green roofs [Thomson[6]; Polkowska[9]]. In turn, the runoff from conventional roofs [Tsakovski et al.[8]; Vialle et al.[4,5]] contained lower concentrations of chlorides than those determined in runoff water from analysed green roofs.

It was proven that green roofs were not a source of pollution of runoff water with lead or cadmium. The concentration values of those metals in runoff waters were below the limit of qualification. The content of manganese, as well as that of iron, copper or chromium, was

[1] Chang M., McBroom M.W., Beasley R.S., 2004. *Roofing as a source of nonpoint water pollution*. Journal of Environmental Management 73: 307-315.
[2] Lee J. Y., Bak G., Han M., 2012. *Quality of roof-harvested rainwater-comparison of different roofing materials*. Environmental Pollution 162: 422-429.
[3] Chui P.C., 1997. *Characteristics of stormwater quality from two urban watersheds in Singapore*. Environmental Monitoring and Assessment. 44: 173-181.
[4] Vialle C., Sablayrolles C., Lovera M., Jacob S., Huau M.C., Montrejaud-Vignoles M., 2011. *Monitoring of water quality from roof runoff: Interpretation using multivariate analysis*. Water Research 45: 3765-3775.
[5] Vialle C., Sablayrolles C., Lovera M., Huau M-C., Jacob S., Montrejaud-Vignoles M., 2012. *Water quality monitoring and hydraulic evaluation of a household roof runoff harvesting system in France*. Water Resources Management 26: 2233-2241.
[6] Thomson N., 1997. *Highway stormwater runoff quality: development of surrogate parameter relationships*. Water air soil pollution, 94: 307-347.
[7] Legret M., Pagotto C., 1999. *Evaluation of pollutant loadings in the runoff waters from a major rural highway.* The Science of the Total Environment, 235: 143-150.
[8] Tsakovski S., Tobiszewski M., Simeonov V., Polkowska Z., Namieśnik J., 2010. *Chemical composition of water from roofs in Gdansk*, Poland. Environmental Pollution 158: 84–91.

low. From among the entire scope of metal determination performed as part of the research, only an increased concentration of zinc was noted in green roof runoff. An elevated zinc concentration was also noted in runoff from the reference roof, which would make it possible to conclude that green roofs are not a source of this metal. The results of research presented in the literature in respect of runoff quality from conventional roofs do not confirm this assumption. Concentrations of zinc, as determined in runoff from conventional roofs covered with different materials [Chang et al.[1]; Mendez et al.[10]; Lee et al. 2012[2]], are distinctly lower. On the other hand, the results of zinc content in the runoff water from motorways and expressways [Thomson, 1997[6]; Ball et al. 1998[11]; Barbossa and Hvitved-Jacobsen[12]; Dierkers and Geiger[13] Legret and Pagotto 1999[7]], as encountered in the literature, are many times higher than those observed in the analysed runoff from green roofs.

Summing up, one may state that the author's own results of research into the influence of green roofs on the quality of runoff are similar to the results of publications discussing this topic that have been published in recent years. The green roof runoff is much less polluted than the rainwater discharged from traffic arteries or from housing developments, but it may be a source of pollution, as indicated by the comparison of concentrations of the parameters measured with literature data relating to the quality of runoff from conventional roofs. The largest differences between runoff waters from green roofs and from the various land use types occur in the case of organic pollutants and chlorides.

Observed increased in interest in the implementation of green roofs in Poland shows that it is need to continue the research which has been started. Future research should be aimed at the evaluation of the performance of green roofs for extended periods of use. The analyzes carried out showed variability retention properties and the quality of runoff

[9] Polkowska Ż., 2006. *Jakość wód spływających z powierzchni arterii komunikacyjnych na terenie aglomeracji wielkomiejskiej*. Chemia i Inżynieria Ekologiczna. 13 (S2): 305-322.
[1] Chang M., McBroom M.W., Beasley R.S., 2004. *Roofing* ….Art.cit. s.14
[2] Lee J. Y., Bak G., Han M., 2012. *Quality*…. Art.cit. s.14
[6] Thomson N., 1997. *Highway…* Art.cit. s.14
[7] Legret M., Pagotto C., 1999. *Evaluation…* Art.cit. s.14
[8] Tsakovski S., Tobiszewski M., Simeonov V., Polkowska Z., Namieśnik J., 2010. *Chemical….* Art.cit. s.14
[10] Mendez C.B., Afshar B.R., Kinney K., Barrett M.E., Kirisits M.J., 2010. *Effect of roof material on water quality for rainwater harvesting systems.* Raport. Wyd. Texas. (http://www.twdb.state.tx.us/innovativewater/rainwater/projects/rainquality/2011_02_rainquality_final_rpt.pdf)
[11] Ball J.E., Jenks R., Aubourg D.: *An assessment of the availability of pollutant constituents on road surfaces*. The Science of the Total Environment, 1998, 209: 243-254.
[12] Jacobson C.R., 2011. *Identification and quantification of the hydrological impacts of imperviousness in urban catchments: A Review*. Journal of Environmental Management 92: 1438-1448.
[13] Dierkes C., Geiger W.F., 1999. *Pollution retention capabilities of roadside soils.* Water Science and Technology. 39 (2): 201-208.

over time, suggesting that these changes will continue to be progressed in the long term. There is a suspicion, based on published papers, that the ability of green roofs to neutralize rainfall will decrease in the long term operation of the roof, which would be a negative phenomenon. On the other hand, in the case of nutrients and organic, the situation may be improving as the number of this type of leaching of pollutants, may be sometimes reduced to a safe minimum. It is not without significance, for the quality of runoff in the long term, it may be stability of other elements of green roofs. Without testing at the mature green roofs, we won't get the answers to these assumptions.

Ad c)

The results obtained should point to the need for more attention to be paid to the quality of runoff from the point of view of its later management or the necessity of selecting "safe" substrate components. Bearing in mind the impact that green roofs have on the quality of runoff, the current method of management consisting in the direct runoff discharge into the sewage system or receiving waterbody should be limited. Discharging water from green roofs into stormwater drainage or combined sewage system may have an adverse effect on the performance of sewage systems (on a local rather than regional scale), and, consequently, on wastewater receiving bodies. The more urban areas are greened this way, the greater this effect will be. In the case of single green roofs located in cities, the impact on sewage systems' performance may be unnoticeable and limited solely to local problems (relating to the sewage system or fittings). Looking prospectively, however, the number of investment projects involving green roofs will increase. In the event of larger investments, e.g., the greening of roofs of an entire housing estate, the management of roof runoff should be taken into account. The presence of organic matter in substrates may lead to mineralisation processes in the course of intermittent watering and drying during dry weather periods. These processes result in the deterioration of colour and opacity of runoff. These parameters limit the use of runoff from green roofs, e.g., for the purpose of toilet flushing. For those reasons, the use of such runoff for irrigation of the neighbouring green areas or for water recirculation to be used in dry periods to water the plants growing on the roof, seems to be a better option. Another proposal could involve the discharge of runoff into the constructed wetlands, stormwater storage tank systems with infiltration of water into the ground or other sustainable stormwater management systems, e.g., rain gardens, infiltration trenches, vegetated channels, etc. The purpose of such solutions is to ensure runoff management through retention and pre-treatment prior to its discharge into the ground or waterbody.

In places where it is impossible, even on a small scale, to install a system to pre-treat the runoff, it is recommended that preventive measures be applied. One of such measures includes the use of long-lasting fertilisers that are insoluble in water in the place of traditional fertilisers. Fertilising should be limited to the necessary minimum in order to reduce runoff pollution. The use of readily soluble fertilisers on green roofs should be prohibited.

According to the fact that there is the potential risk of metal pollution from green roofs runoff it should be taken into account when installing green roofs near the sources of pollution. It is also important to the performance of green roofs use such components of substrates that can help minimize runoff pollution discharged from green roofs, while providing adequate physical and chemical properties necessary for plant growth. The use of substrates, without affecting the outflow, it is important not only from the point of view of limiting pollution inputs to the receivers, but also because of the plans of many investors use outflows from green roofs to flush toilet or as a surface water supply for retention reservoirs, which can perform the aesthetic functions in the cities.

3.2 Application potential of research results

The implementation of technical solutions, including green roofs, which are aimed at reducing the volume and rate of rainwater runoff, requires that reliable data relating to the performance thereof be in place. The complex nature of the problem makes the issues raised in this research to be of interest both to sanitary engineers, hydrologists, urban planners, architects, landscape architects, as well as green roof designers, contractors and manufacturers of component elements. Undoubtedly, the development of green roofs in Poland has been hindered so far by such factors as no knowledge of the role of green roofs in stormwater management; low ecological awareness in the society; gap in the professional literature in the Polish language; or shortage of specialists in that area. Another problem that was frequently encountered in practice involved a difficulty in estimating the volume of water that, while running off a green roof, was to be managed locally via the system of retention/infiltration into the ground or was to be discharged directly into the sewage system. The research conducted on green roof models located on the roof of the Science and Education Center of the Wrocław University of Environmental and Life Sciences in respect of rainwater retention, changes in the intensity and volume of runoff during and after the rainfall event, and changes in the rainfall and runoff quality, affords a new approach to the issue of green roof installation in Poland.

The effects of volume and peak flow reduction will directly affect the performance of the sewage system. Mitigating the hydraulic impact on the distribution system may help prevent the necessity of building retention reservoirs or increasing the diameter of ducts. For catchment areas with combined sewage systems, the reduction in the volume and rate of runoff water flowing into the receiving waterbody will translate into a decreased frequency of raw sewage discharge into the waterbody due to stormwater overflows. Attention needs to be drawn, however, to the fact that, as the research results show, during intense rainfall events the reduction in the total runoff volume, expressed as a percentage, is small, which, however, does not permit it to be disregarded. Therefore, the knowledge about reduction in runoff volume and rate may be used by urban drainage system designers and contractors, as well as by local authorities when developing anti-flood strategies taking account of the sustainable stormwater management principles.

Knowledge of water retention on green roofs on the basis of local precipitation characteristics may also become important for municipalities whose aim in the process of stormwater drainage cost distribution is to lower that cost for owners of living roofs. Moreover, runoff modelling results may also be taken into account as a criterion for provision of financial support to individuals who wish to have such a roof installed. The system of financial motivation to encourage the installation of sustainable drainage systems is commonly used abroad (e.g., in Germany or the United States). Its purpose is to motivate the inhabitants, entrepreneurs and local government units to build facilities to increase water retention in cities and, on a larger scale, to implement flood control measures. The first programmes to fund pro-environmental investments relating to on-site stormwater management, as implemented in the Polish cities in 2011, give hope that this form of subsidising will also be adopted country-wide. Today, such programmes are offered, among others, in Sopot, Kraków, Gdańsk and Warsaw.

It seems impossible to conduct long-term field studies in every given region. Thus, there are still more attempts at the application of other tools that would allow us to evaluate the retention capacity of green roofs in a much quicker way and, usually, at a lower cost than is required for field study. An alternative method of obtaining practical information on this subject is the application of computer software.

The research results collected during measurements carried out at green roof experimental sites could be used as input data to run hydrodynamic simulations to assess the effectiveness of green roof hydrological performance. The use of computer tools required

each time that local precipitation values and parameters relating to the structural characteristics of green roofs be defined in advance. The testing and verification of the model's correctness were based on the data obtained directly from the measurements.

The prediction of rainwater runoff from green roofs under different conditions of their operation may then be used in programs dedicated to dynamic modelling of stormwater drainage performance in urban areas.

The effective use of green roofs was analysed not only in quantitative but also in qualitative terms. On the one hand, the analyses of runoff quality show a positive impact of green roofs on pH reaction of water (they increase the pH value), but, on the other hand, an undesirable phenomenon has been observed that consists in the leaching of organic substances from the substrate layers, which may adversely affect the performance of sewage systems or receiving waterbodies in the event of runoff discharged into traditional infrastructure systems. These phenomena were of a seasonal nature. In the winter, elevated values of electrolytic conductivity, sulphates, phosphates, organic substances (expressed as COD and UV_{254}), and chlorides were noted in the runoff from green roofs. In the spring, in turn, the runoff contained elevated concentrations of nitrates and nitrites. Substrate properties, including the content of organic substances or substances enriching the substrate with nutrients that are added by manufacturers to facilitate the growth of plants on green roofs, as well as dry and wet atmospheric deposition, are among the most probable factors that affect the quality of runoff from green roofs.

The results of runoff quality analyses may be of material importance to the operators of sustainable stormwater management systems and sewage networks, as well as to designers, contractors and manufacturers of materials for green roofs. It is especially this latter group of stakeholders that frequently underlines the need to conduct this type of research in order for the Polish edition of green roof design guidelines to be published in the nearest future. In the absence of comprehensive and uniform national standards, the only thing remaining would be to rely on the FLL guidelines developed by the German Research Society for Landscape Development and Landscape Design (*German: Forschungsgesellschaft Lischaftsentwicklung Lischaftsbau e.V.*) in German conditions, entitled "The Guidelines for Planning, Installing and Maintaining Green Roofs." The situation gradually improves. The work on the Polish edition of green roof guidelines developed on the basis of translation of the FLL publication and taking account of the formal and legal requirements relating to Polish conditions commenced in December 2013. I use the knowledge and experience gained

in the course of my research during working meetings of the GREEN ROOF expert group appointed by the DAFA Association of Flat Roof and Facade Contractors, wherein I act as a content editor of the aforementioned guidelines. The group's efforts should result in the development and publication of the Polish edition of those guidelines in 2015.

4 Achievements and topics of other research projects conducted by the Candidate

I started my research-related work in 2001, simultaneously with the commencement of my doctoral studies at the Faculty of Environmental Engineering and Geodesy, Agricultural Academy of Wrocław (currently the Wrocław University of Environmental and Life Sciences). My research relates to the following issues:

4.1 Research on the clogging process during surface water and rainwater infiltration into the ground

During the surface water and rainwater infiltration into the ground via infiltration facilities, the ground becomes clogged. The clogging process is caused by the deposition of mineral and organic pollutants in the bottom layer of the ground and on the surface of infiltration sources. Clogging is the major factor that affects the operation period of natural water infiltration facilities. Taking account of the clogging phenomenon is particularly important when designing underground systems for rainwater infiltration, since any work relating to their repair or declogging is expensive and difficult to perform.

In order to reduce the undesirable clogging process, the use is made of geotextiles which are spread on the ground surface. In the research conducted thus far, attention had been paid only to the changes in hydraulic properties of geotextiles in the ground-geotextile system. The issue of protective efficiency of geotextiles in the suspended solid-geotextile-ground configuration (that takes place in the case of natural water infiltration) had not been widely analysed. This scarcity of information prompted research aimed at determining to what extent geotextiles contributed to the reduction of clogging in the bottom layers of the ground in infiltration facilities. The said research was conducted during the preparation of my doctoral dissertation. The results of tests conducted in a laboratory and on the newly designed infiltration water intake in Bydgoszcz-Czyżkówek show a practical usability of geotextiles as a microfiltration membrane, on the surface of which particles suspended in the infiltrating water are trapped.

Geotextiles provided protection by limiting the penetration of suspended solids into the ground, but, as a result of trapping solids in the filtration process, they themselves became clogged, which directly affected the infiltration rate. I used the experience gained during

laboratory and field studies in my further research work conducted as part of my doctoral studies. Using pilot-scale test sites and open-work elements applied in practice, I conducted measurements to determine dynamic changes in filtration coefficients caused by clogging. The effects of that research enabled me to develop original models that make it possible to determine the resistance of the clogging layer during the filling and emptying of underground systems for rainwater infiltration. The empirical models developed as part of my dissertation may be used in engineering practice, among other things, to design systems used in the processes of artificial infiltration of rainwater or to estimate ground infiltration capabilities and the degree of ground clogging in the areas to be used for the construction of infiltration facilities. The research results were presented in my doctoral dissertation entitled *Research on the use of geotextiles to prevent clogging in the infiltration process* (manuscript), and in the following publications:

4.1.1 **Burszta-Adamiak E.**, Łomotowski J., 2005: *Prognozowanie zmian poziomu wody w czasie infiltracji z podziemnych zbiorników chłonnych*. (Forecasting changes in water level during the infiltration from underground infiltration tanks). Proceedings of the VII International Scientific and Technical Conference "Effectiveness of information technology implementation" in the series "Computer in environmental protection", Gniezno, pp.31-37 (measurements, compilation of research results, co-editing, contribution 70%).

4.1.2 **Burszta-Adamiak E.**, Łomotowski J., 2006: *Badania oporu hydraulicznego warstwy zakolmatowanej przy okresowej infiltracji wody do gruntu*. (Head loss in silted-up laser during periodic water infiltration into the ground). Ochrona Środowiska, Vol. 28, No. 1, pp. 29-32 (measurements, co-editing, compilation of research results, contribution 70%).

4.1.3 **Burszta-Adamiak E.**, 2007: *Ocena zjawiska kolmatacji w urządzeniach do sztucznej infiltracji wód.* (Estimation of clogging process in artificial infiltration systems). Gaz Woda i Technika Sanitarna, No. 7-8, pp.43-47. (contribution 100%).

4.1.4 **Burszta-Adamiak E.**, 2007: *Ocena przydatności geowłóknin do ochrony przed kolmatacją przy infiltracji wód (*Evaluation of the geotextiles usefulness for protection against clogging during water infiltration into a ground). Przegląd Naukowy Inżynieria i Kształtowanie Środowiska. Yearbook XVI, Issue 3(37), pp.90-98. (contribution 100%).

4.1.5 **Burszta-Adamiak E.**, Łomotowski J., 2007: *Badania kolmatacji gruntu w urządzeniach do infiltracji wód opadowych*. (Research of clogging of ground in stormwater infiltration systems). [in:] Monograph of the Committee of Environmental Engineering Polish Academy of Science (PAN), Vol. 46, pp.75-84. (measurements, co-editing, compilation of research results, contribution 50%).

4.1.6 **Burszta-Adamiak E.**, 2008: *Ryzyko zanieczyszczenia wód gruntowych w czasie eksploatacji systemów do infiltracji wód opadowych*. (The risk of groundwater contamination during the operation of systems for rainwater infiltration). Forum Eksploatatora. No. 3, pp. 39-42 (contribution 100%).

4.1.7 **Burszta-Adamiak E.,** 2008: *Zanieczyszczenie wód opadowych a urządzenia chłonne*. (Contamination of rainwater vs. infiltration facilities). Wodociągi i Kanalizacje no. 4 (50), pp.64-65 (contribution 100%).

4.1.8 **Burszta-Adamiak E.**, Polewka P., 2009: *Wpływ czynników naturalnych na pracę urządzeń do infiltracji wód opadowych*. (Natural factors impact on operation of stormwater infiltration systems). Gaz Woda i Technika Sanitarna, No.12, pp. 16-20. (co-editing, compilation of research results, contribution 50%).

4.1.9 **Burszta-Adamiak E.**, Łomotowski J., 2013: *Skuteczność geowłóknin w ograniczaniu kolmatacji w systemach do infiltracji wód opadowych. (Effectiveness of geotextiles in reducing clogging in facilities to rainwater infiltration*) Inżynieria Morska i Geotechnika, No. 2, pp.144-148. (measurements, co-editing, compilation of research results, contribution 80%).

4.1.10 **Burszta-Adamiak E.**, Łomotowski J., 2013: *Modelling of percolation rate of stormwater from underground infiltration systems*. Water Science and Technology. Vol. 68, No. 10, pp.2144–2150 (measurements, co-editing, compilation of research results, contribution 70%).

4.2 Testing of suspended solids present in water and sewage using a laser particle size analyzer

Research into the use of geotextiles to reduce ground clogging during surface water or rainwater infiltration required knowledge of the particle size distribution of suspended solids that penetrate into the ground along with the infiltrating water. By working together with the staff of the Institute of Geography and Regional Development at the Faculty of Earth Science and Environmental Management of the University of Wrocław, where the particle size analyzer was available, I was able to start making such determinations. The volume of suspended solids and their particle size distribution were measured using rainfall and roof runoff samples collected in selected cities in the Lower Silesian region, i.e., in Bielawa, Strzelin and Wrocław, and in the Brda River waters. In the years 2003-2006, the said research was conducted under the 3 P04G 051 25 grant entitled "The use of Malvern particle size analyzer to monitor surface water quality," wherein I was the project contractor. Following the award of my doctoral degree and conclusion of the grant, the said research was continued and further developed. Since 2008, an extended research team has analysed particle size distribution of suspended solids in rainwater and roof runoff samples collected, among others, in Kietrz and Racibórz (Upper Silesia), and in the Odra River waters, as well as in municipal and industrial sewage samples and backwash effluent from filters used for groundwater treatment. The determination of particle size and content of suspended solids based on particle size distribution testing using the laser diffraction method on these samples was relatively innovative. Previously, tests using this device had been used to identify the origin of dust

in the atmosphere, or to meet the needs of pharmaceutical, chemical or food industries. The research results have provided new information to evaluate the status of water and sewage quality.

The results of the said studies may be found in the following publications:

4.2.1. **Burszta-Adamiak E**., Łomotowski J., 2003: *Możliwości wykorzystania granulometru laserowego do badań procesu infiltracji wody*. (Possibilities of using laser particle size analyzer to infiltration process research) Ochrona Środowiska no. 3, pp. 45-48. (measurements, compilation of research results, co-editing, compilation: 50%).

4.2.2. **Burszta-Adamiak E.**, Łomotowski J., Stodolak R., 2004: *Analiza zanieczyszczeń w opadach atmosferycznych (*Analysis of pollutants in precipitation). Series: Research System. Supporting information for socio-economic development and environmental protection., Vol. 36, Warsaw; pp. 281-289. (co-editing, interpretation of results, contribution 30%).

4.2.3. **Burszta-Adamiak E.**, Łomotowski J., 2005: *Badania składu granulometrycznego wód opadowych i powierzchniowych z zastosowaniem granulometru laserowego*. (Research granulometric composition of rainwater and surface water using a laser partcle size analyzer). [in:] Monograph of the Committee of Environmental Engineering Polish Academy of Science (PAN), Vol.33, pp. 331-338 (measurements, co-editing, compilation of research results, contribution 50%)

4.2.4 Łomotowski J., **Burszta-Adamiak E.**, Kęszycka M., 2006: *Badania zawiesin występujących w wodach powierzchniowych z wykorzystaniem granulometru laserowego* (Study of suspensions occurring in surface waters using laser particle size analyzer). Gaz Woda i Technika Sanitarna, No. 11, pp. 26-28. (measurements, co-editing, compilation of research results, contribution 30%).

4.2.5. **Burszta-Adamiak E.**, Kęszycka M., Szwed J., 2007: *Ocena przydatności granulometru laserowego do analizy zanieczyszczeń wód opadowych odprowadzanych z terenów zurbanizowanych*. Woda – Środowisko – Obszary Wiejskie. Wyd. IMUZ, t.7, z.2b (21) ss.33-42. (Wykonanie pomiarów, współredakcja tekstu, opracowanie wyników badań, udział 30%).

4.2.6. **Burszta-Adamiak E.**, Stodolak R., 2007: *Ocena składu granulometrycznego zawiesiny w mokrym opadzie atmosferycznym na tle jego składu fizykochemicznego*. (Assessment of suspension grain composition occurring in precipitation against a background of its physico-chemical composition). Woda – Środowisko – Obszary Wiejskie, IMUZ, Vol. 7, Issue 2a (20), pp.83-94. (co-editing, compilation of research results, contribution 40%).

4.2.7. **Burszta-Adamiak E.**, Kęszycka M., Łomotowski J., 2008: *Skład granulometryczny zawiesin występujących w wodach opadowych*. (Granular composition of suspensions occuring in rain water). Proceedings of the XX National Jubilee and VIII International Scientific and Technical Conference "Water supply, water quality and protection", 15-18 June 2008, Poznań-Gniezno, pp. 137-147. (co-editing, compilation of research results, contribution 30%).

4.2.8. **Burszta-Adamiak E.**, Kuśnierz M., Łomotowski J., Wiercik P.,2012: *Badania składu granulometrycznego zawiesin zawartych w ściekach komunalnych i przemysłowych*. (*The research on grain size distribution In suspension occurring in municipal and industrial*

wastewater). Infrastruktura i Ekologia Terenów Wiejskich. No. 3/III, pp. 43–54. (co-editing, compilation of research results, contribution 20 %).

4.2.9. Łomotowski J., Wiercik P., **Burszta-Adamiak E.**, 2013: *Wpływ zawartości związków żelaza i manganu na skład granulometryczny zawiesin w popłuczynach z filtrów do oczyszczania wód podziemnych*. (Effect of iron and manganese content on granulometric composition of suspensions in backwash effluent from filters used for groundwater treatment. Ochrona Środowiska (ISBN 1230-6169), Vol.35, No. 4, pp. 43-46 (co-editing, contribution 15%).

4.2.10. **Burszta-Adamiak E.,** Kuśnierz M., Domańska M., Wiercik P., Łomotowski J., 2014: *Metody stosowane w badaniach zawiesin w wodach opadowych*. (The methods used in suspension research in the stormwater). Journal of Civil Engineering, Environment and Architecture. Vol. XXXI, No. 61 (3/I/14), July-September 2014, pp. 23-32 (co-editing, compilation of research results, contribution 20%).

The diversity of probability distributions of particle sizes in the samples collected necessitated further research to be initiated with a view to systematising those results. To this end, a statistical method of cluster analysis was applied, which is a classification technique used for grouping observations or properties by analysing similarities in the areas explored. A hierarchical clustering method was applied, which consists in the sequential clustering of objects into homogeneous groups. The hierarchical clustering results are represented in a tree diagram, or the so-called dendrogram, that presents distances between clustered objects.

The cluster analysis results made it possible to determine that despite samples having been taken at various experimental sites and at varying intervals, it was still possible to identify particle size distribution that was characteristic of surface water, rainwater, runoff, raw sewage, treated sewage, activated sludge and backwash effluent. This proves that the particle size of suspended solids present in a given medium is a property that enables sample type identification.

The use of statistical tools to process large quantities of data collected improved the possibilities of analysing particle size distribution of suspended solids in natural waters and sewage. The results of this research are presented in the following publications:

4.2.11. **Burszta-Adamiak E.**, Łomotowski J., 2006: *Cluster analysis use for processing of the results of suspension's grain composition occurring in rainfall and snowfall*. "Land-und Ernährungswirtschaft im Wandel. 6-8 March, Poczdam, Germany, pp. 49-52. (measurements, compilation of research results, co-editing, contribution 50%).

4.2.12. **Burszta-Adamiak E.**, Kęszycka M., Łomotowski J., 2006: *Zastosowanie analizy skupień do uporządkowania danych o wielkości zawiesin występujących w wodach i ściekach.*(Cluster analysis use for sorting of the data of suspension's grain composition occurring in the water and wastewater). Studies & proceedings of polish association for knowledge management.

Bydgoszcz-Ciechocinek, pp.39-44. (measurements, compilation of research results, co-editing, contribution 30%).

4.2.13. **Burszta-Adamiak E.**, Kęszycka M., Adamska K., 2006: *Zastosowanie analizy skupień do klasyfikacji danych o składzie granulometrycznym zawiesin występujących w wodach powierzchniowych i ściekach.* (Cluster analysis use to classify of the data of suspension's grain composition occurring in the surface water and wastewater). Proceedings of XXXVI Seminar of mathematics applications, Kobyla Góra 2006, pp. 73-76. (compilation of research results, co-editing, contribution 30%).

Another stage of research work that I undertook in order to identify suspended solids present in natural waters and sewage was to learn their spatial structure. Reports found in the literature proved that suspended solids present in water formed polydisperse systems and were usually made up of particles of irregular structure and a wide range of sizes. The spatial structure of suspended solids particles was identified using fractal geometry, wherein the fractal dimension is the basic parameter. The particle size analyzer made it possible to determine the optical fractal dimension. For those reasons, in parallel to particle size distribution tests, the spatial structure of particles in suspended solids was identified. Once the fractal dimension was known, one could estimate, among other things, the "packing degree" of irregular particles in suspended solids. A low value of fractal dimension showed that there was a large number of open spaces that may absorb high quantities of pollutants. On the other hand, the sediment characterised by a high "degree of packing" of particles has better draining properties.

The results of these studies were published in *Ochrona Środowiska* (Environmental Protection) journal and in the monograph entitled "Environmental Engineering III":

4.2.14. **Burszta-Adamiak E.**, Łomotowski J., Kęszycka M., 2009: *Analiza budowy przestrzennej zawiesin występujących w wodach naturalnych*. (Analysis of the spatial structure of suspensions occurring in natural waters). Ochrona Środowiska (ISBN 1230-6169), No. 3, pp. 65-68. (measurements, co-editing, compilation of research results, contribution 35%).

4.2.15. **Burszta-Adamiak, E.**, Kęszycka, M., Łomotowski J., 2010: *Structure and granulometric composition of suspensions in sewage sludge and activated sludge.* [in:] The monograph "Environmental Engineering III" edited by Artur Pawlowski, pp.161-166. Paper ISBN: 978-0-415-54882-3, eBook ISBN: 978-0-203-84666-7, DOI: 10.1201/b10566-28 (measurements, co-editing, compilation of research results, contribution 35%).

The research using laser diffraction method to analyse suspended solids in natural waters was summarised in a collective monograph that I co-authored entitled:

4.2.16. Łomotowski J., **Burszta-Adamiak E.,** Kęszycka M., Jary Z., 2008: *Metody i techniki optyczne w badaniach zawiesin*. (Optical methods and techniques in the study of suspensions). Monographs of the Systems Research Institute Polish Academy of Science (PAN), Series:

Research system , Vol. 58, Warsaw, pp.1-150. (measurements, co-editing, compilation of research results, contribution 30%).

4.3 Studies on the possibility of stormwater management via Sustainable Urban Drainage Systems (SUDSs)

The problem of rainwater drainage into sustainable urban drainage systems has accompanied me since the moment of initiation of my research work, the only difference being that after the award of my doctoral degree both literature studies and research work in this field have intensified. I was motivated to explore this topic, on the one hand, by a growing interest in this type of facilities and, on the other hand, by the scarcity of information about the type of systems, their design, installation and operation under the Polish conditions. My first publications in that respect were more of an overview nature. The topics that they discussed were focused on the identification of needs for the application of sustainable drainage systems, description of the facilities' structural solutions, as well as formal and legal conditions for their use in Poland. Over the years, as I dealt with these topics and gained practical experience through co-operation with designers and contractors, my publications additionally addressed issues relating to the design and operation of systems that enable on-site stormwater management. The results of these studies may be found in the following publications:

4.3.1 **Burszta-Adamiak E.**, Kozłowska E., Łomotowski J., 2003: Wybrane zagadnienia związane z odprowadzeniem wód opadowych. (Selected issues related to the discharge of rainwater). Przegląd Komunalny, no. 5, pp. 127-129. (co-editing, contribution 40%).

4.3.2 **Burszta-Adamiak E.**, Łomotowski J., 2004: *Problemy infiltracji wód opadowych do gruntu* (Problems of rainwater infiltration into the ground). Przegląd Komunalny, no. 11, pp.123-125. (co-editing, contribution 50%).

4.3.3 **Burszta-Adamiak E.**, Łomotowski J., 2006: *Odprowadzanie wód opadowych na terenach o rozproszonej zabudowie*. (Drainage of rainwater in areas with dispersed development). Infrastruktura i Ekologia Terenów Wiejskich. Polish Academy of Sciences, Branch in Krakow, Krakow, pp.141-152. (co-editing, contribution 50%).

4.3.4 Licznar P., Łomotowski J., **Burszta-Adamiak E.**, Kuczewski K., 2007: *Pierwszy krok w budowie bazy danych o opadach dla inżynierów sanitarnyc*h. (The first step in building a database of rainfall for sanitary engineers). Forum Eksploatatora No. 2 (29), pp. 38-40 (co-editing, contribution 20%).

4.3.5 **Burszta-Adamiak E.**, 2008: *Eksploatacja urządzeń do infiltracji wód opadowych*. (Maintenance of the rainwater infiltration facilities). Gaz Woda i Technika Sanitarna, no 3, pp.24-28. (contribution 100%).

4.3.6 **Burszta-Adamiak E.**, 2008: *Alternatywne sposoby zagospodarowania wód opadowych w warunkach miejskich*. (Alternative methods for storm water management in urban area). Ekologia i Technika Vol XVI, no. 6, pp. 271-275. (contribution 100%).

4.3.7 **Burszta-Adamiak E.**, 2008: *Możliwości gospodarowania wodami opadowymi w warunkach miejskich* (Possibilities of storm water management in urban areas). Municipal infrastructure and sustainable development in urban areas „INFRAEKO 2008", Rzeszów, pp. 35-42. (contribution 100%).

4.3.8 **Burszta-Adamiak E.,** 2008: *Sposób na wodę deszczową*. (The way to stormwater management). Dom i zagroda. No. 3, pp.32-34 (contribution 100%).

4.3.9 **Burszta-Adamiak E.**, Kęszycka M., Ryglewska B., 2008: *Użytkowe i estetyczne walory oczyszczalni hydrofitowych* (Usable and aesthetical amenities of wetlands). Architektura Krajobrazu no. 2 (19), pp. 56-60. (co-editing, compilation of research results, contribution 30%).

4.3.10 **Burszta-Adamiak E.**, 2010: *Zrównoważone gospodarowanie wodami opadowymi.* (Sustainable stormwater management). Rynek Instalacyjny No. 9, pp. 56-58. (contribution 100%).

4.3.11 **Burszta-Adamiak E.**, Sylwester A., 2010: *Projektowanie dachów zielonych.* (Green roof design). Rynek Instalacyjny no 12, pp. 81-83. (co-editing, contribution 70%).

4.3.12 **Burszta-Adamiak E.**, Sylwester A., 2010: *Zielone dachy – alternatywne rozwiązanie dla problemów urbanizacji.* (Green roofs - an alternative to the problems of urbanization). Inżynier Budownictwa No. 7/8, pp. 64-67 (co-editing, contribution 70%)

4.3.13 **Burszta-Adamiak E.**, Antosz K., 2011: *Gospodarowanie wodami opadowymi na prywatnych posesjach.* (Stormwater management on private properties). Ekologia i Technika, Vol. XIX, No. 3, pp. 153-158. (compilation of research results, co-editing, contribution 70%).

4.3.14 **Burszta-Adamiak E.,** 2011: *Wybrane zagadnienia związane z projektowaniem i eksploatacją systemów alternatywnych*. (Selected issues related to the design and operation of alternative systems). [in:] The monograph edited by prof. Janusz Łomotowski "Rainwater and extreme events," Published by Seidel-Przywecki Ltp., pp.147-155 (contribution 100%).

4.3.15 **Burszta-Adamiak E.**, Kuśnierz M.: Łomotowski J., 2011: *Retencja i oczyszczanie wód w systemach hydrofitowych*. (Retention and treatment of water in wetlands). [in:] The monograph edited by prof. Janusz Łomotowski "Rainwater and extreme events," Published by Seidel-Przywecki Ltp., pp.157-162. (co-editing, contribution 30%).

4.3.16 **Burszta-Adamiak E.**, Łomotowski J., Kuśnierz M., Smolińska B., 2011: *Oczyszczanie wód z zawiesin w systemach hydrofitowych (Purification of suspensions from water in wetlands).* Gaz Woda i Technika Sanitarna, No. 12, pp.483-485. (compilation of research results, co-editing, contribution 25%).

4.3.17 **Burszta-Adamiak E.**, 2011: *Zagospodarowanie spływów opadowych za pomocą systemów bioretencji.* (Management of stormwater runoff through bioretention systems.) Rynek Instalacyjny no. 3, pp.91-93. (contribution 100%).

4.3.18 **Burszta-Adamiak E.**, 2011: *Odprowadzanie wód opadowych systemami do podziemnej retencji i infiltracji.* (Drainage of stormwater systems for underground retention and infiltration). Rynek Instalacyjny No. 5, pp. 48-51. (contribution 100%).

4.3.19 **Burszta-Adamiak E.**, 2012: *Wody opadowe w miastach* (Stormwater in urban areas). Rynek Instalacyjny No. 5, pp. 35-38. (contribution 100%).

4.3.20 **Burszta-Adamiak E.**, 2012: *Polskie doświadczenia. Gospodarowanie wodami opadowymi na dachu zielonym.* (Polish experiences. Stormwater management on green roof). Wodociągi i Kanalizacje No. 7-8, pp. 28-31. (contribution 100%).

4.3.21 **Burszta-Adamiak E.**, 2013: *Perspektywy rozwoju zielonych dachów.* (Prospects for the development of green roofs). Wodociągi i kanalizacja. No. 5(111), pp.58-60. (contribution 100%).

4.3.22 **Burszta-Adamiak E.**, 2014: *Identyfikacja problemów i potrzeb w zagospodarowaniu wód opadowych w polskich miastach.* (Identification of problems and needs in stormwater management in polish cities). Proceedings of the IX National Conference on "Stormwater-legal, economic and technical aspects". 15-16 May, Iława, pp. 99-105. (contribution 100%)

4.3.23 **Burszta-Adamiak E.**, Zygmunt-Rubaszek J., 2014: *Projektowanie systemów zrównoważonego gospodarowania wodami opadowymi.* (Designing of sustainable stormwater systems). Rynek Instalacyjny, No. 10, pp.2-5. (co-editing, contribution 50%).

My further scientific development was undoubtedly influenced by two events. One of them was the organisation of the National Scientific and Technical Conference on Stormwater Management Problems in Wrocław with the participation of foreign guests, including Dusty Gedge, Chairman of the European Federation of Green Roof Associations (EFB). At the conference, a need was identified for the Polish scientific and technical organisation to be formed in order to take actions to build a platform for co-operation between entities engaged in planning, designing, installing, operating, repairing, manufacturing and supplying materials, as well as studying and promoting green roofs. Several months later (in April 2009), the Polish Green Roof Association was formed. I was the co-founder and Chairman of the Association in the years 2009-2011.

The other important event involved the extension of research facilities in the Urban Hydrology Laboratory formed in 2006 on the initiative of prof. dr hab. inż. Janusz Łomotowski and located on the roof of the Science and Education Center of the Wrocław University of Environmental and Life Sciences. As part of the extension, in November 2008 green roof experimental sites were built, and I took part in their installation. In subsequent months, those sites were additionally provided with the required test equipment. Since June 2009, I have been conducting continuous research on those experimental sites to determine water retention capabilities of green roofs and the quantity of pollutant loads trapped in the roof's structure and leached therefrom depending on weather conditions, green roof structure, growing media used, condition of plants or period of operation. The results of those studies

are discussed in detail in the monograph being the basis for the application for the initiation of the habilitation procedure and in the following publications:

4.3.24 **Burszta-Adamiak E.**, 2010: *Retencja wód opadowych na dachach zielonych w warunkach wrocławskich.* (Stormwater retention on green roofs in Wroclaw conditions) Gaz Woda i Technika Sanitarna, No. 3, pp. 21-24. (contribution 100%).

4.3.25 **Burszta-Adamiak E.**, 2012: *Analysis of stormwater retention on green roofs*. Archives of Environmental Protection, Vol. 38, no.4, pp. 3 – 13. (contribution 100%).

4.3.26 **Burszta-Adamiak E.**, 2012: *Analysis of the retention capacity of green roofs.* Journal of Water and Land Development No.16 (I-VI), pp. 3-9. (contribution 100%).

4.3.27 Bogacz A., Woźniczka P., **Burszta-Adamiak E.**, Kolasińska K., 2013: *Metody zwiększanie retencji wodnej na terenach zurbanizowanych.* (*Methods of enhancing water retention on urbanized areas*). Przegląd Naukowy Inżynieria i Kształtowanie Środowiska. Vol.22 (1), No. 59, pp. 27-35. (co-editing, performing part of the research, contribution 25%).

4.3.28 **Burszta-Adamiak E.**, 2013: *Zielone dachy - sposób na retencję rozproszoną w miastach*. (Green roofs - a way of distracted retention in cities). Dachy Płaskie, No. 2 (19), pp. 23-24. (contribution 100%).

4.3.29 **Burszta-Adamiak E.,** Łomotowski J., Wiercik P., 2014: *Zielone dachy jako rozwiązania poprawiające gospodarkę wodami opadowymi w miastach.* (Green roofs as a tool for improvement the stormwater management in urban areas). Inżynieria Ekologiczna, Vol. 39, pp. 26–32, DOI: 10.12912/2081139X.47 (measurements, co-editing, compilation of research results, contribution 70%)

4.4 Evaluating the possibility of using the existing numerical models to simulate runoff from green roofs

The investment activities undertaken in respect of rainwater drainage in cities based on sustainable drainage systems require that analyses relating to the performance of local retention systems be conducted using computer simulation models adapted to local conditions. Such programs are currently becoming more and more available, which enables their widespread use in practice. Like many hydrologic and hydraulic models that contain empirical parameters, the simulation models used require calibration and verification. The model may be calibrated, if measurement databases are available. According to numerous specialists, it is exactly the current lack of available data to be used for the calibration of models that is the cause of their limited use. For those reasons, efforts were initiated to find models which, due to their simplicity and good representation of experimental data, may be used in practice to determine the volume of runoff from green roofs in a situation where the structural properties of the roof and meteorological parameters are known.

The use of computer programs (numerical models) for this type of analyses is recommended by the FLL guideline which is the most important guideline for planning, designing and maintaining green roofs.

In the research conducted so far, the EPA SWMM (Storm Water Management Model) and GARDENIA programs have been used. In the first case, the work has been done using the latest version (5.0.022) of SWMM program which has been extended to include a possibility of hydrological modelling of LID devices (bioretention facilities, drainage ditches, rainwater storage tanks, porous surface, as well as grass ditches and basins). The second program was developed by Dominique Thiery at a research institution in France (BRGM to Bureau de Recherches Géologiques et Minières). It is a global model. So far, it has been used to simulate the relationship between the runoff from the catchment or the level of underground water and the volume of supply in the form of rainfall. The efforts to model runoff from green roofs yielded more satisfactory results in the GARDENIA program than in the SWMM program. For that reason, attempts were made in the publication at presenting not only the research results obtained but also the needs for improvement of the hydraulic model embedded in the SWMM program in order to improve the modelling results obtained. This work is being continued and further developed, all the more so since the extensive database containing information from more than five years of experimental sites' monitoring makes it possible to use the measurement data to simulate green roof performance not only for single rainfall events but also for continuous rainfall data.

The results of those studies were presented in the following publications:

4.4.1. **Burszta-Adamiak E.**, Mrowiec M., 2013: *Modelling of green roofs hydrologic performance using EPA's SWMM*. Water Science and Technology, Vol. 68, No 1, pp. 36–42 (preparation of input data for the model, co-editing, compilation in part of research results, contribution 50%)

4.4.2. **Burszta-Adamiak E.**, Fiałkiewicz W., 2014: *Modelowanie odpływu wód opadowych z dachów zielonych.* (Modeling of storm water runoff from green roofs). Inżynieria Ekologiczna, Vol. 39, pp. 15–25, DOI: 10.12912/2081139X.46 (preparation of input data for the model, interpretation of results, co-editing, contribution 50%)

4.5 Modelling hydraulic conditions of water supply network operation

The computer-aided network management using Geographic Information Systems (GIS) in water and sewage companies is another focus of my scientific interest. I made my first hydraulic model of the water supply network in 2001 while working on my Master's thesis entitled *Hydraulic Model of the Water Supply Network in Strzelin*. Prof. dr hab. inż. Janusz Łomotowski was the supervisor of my thesis. I made hydraulic

calculations (having entered the information about the water supply network in Strzelin (Dolnośląskie Province)) in the EPANET program that was developed by the US-EPA (United States Government Environmental Protection Agency). As part of my co-operation with dr hab. inż. Jan Studziński from the Systems Research Institute, Polish Academy of Sciences in Warsaw, I made comparative calculations for the same network in the OHiO (Hydraulic and Optimisation Calculations) program that was developed by the Systems Research Institute, Polish Academy of Sciences in Warsaw to model water distribution systems and at that time was undergoing final testing.

A little later, in 2003, I helped with tasks aimed at using the EPANET program to make hydraulic calculations for the "Bychowo" joint water supply system covering 66 villages and hamlets of the Dolnośląskie Province, located within the area of the following municipalities: Prusie, Żmigród, Trzebnica and Wołów.

The results of those studies were presented in the following publications:

4.5.1. **Burszta-Adamiak E.**, Łomotowski J., 2003: *Wybrane zagadnienia związane z wykorzystaniem GIS w przedsiębiorstwach wodociągowych* (Selected issues connected with using GIS in waterworks*)*. Agricultural Engineering, No. 3 (45), Vol. II, pp.261-269. (development of a hydraulic model, co-editing, contribution 50%).

4.5.2. **Burszta-Adamiak E**., Krasuski R., Łomotowski J., 2003: *Wykorzystanie programu EPANET do symulacji hydraulicznej pracy systemu wodociągowego*. (The use of EPANET software for hydraulic simulation of a water supply system work). Proceedings of the VI National Scientific and Technical Conference "Computer in Environmental Protection" Poznan, Chalin, September 24-27, pp.47-52. (participation in the development of hydraulic model, co-editing, contribution 30%).

In later years I familiarised myself with other computer programs for analysing, designing and optimising water distribution systems and for designing and operating sewage and stormwater drainage systems, i.e., WaterCAD, SewerCAD and StormCAD by Bentley.

I shared my experience gained while working with those programs, as well as knowledge relating to the use of the Geographic Information Systems to manage water and sewage companies, in the teaching process, among other things, while lecturing on Modelling of Water Drainage Systems and on Sanitary Systems as part of the Environmental Engineering study programme (Stormwater Management and Sanitary Technology specialisations, respectively), and on Water Supply and Sewage Networks as part

of the Hydraulic Engineering and Water Management and the Environmental Engineering study programmes.

In the years 2012 – 2013, as part of my co-operation with Świdnickie Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o.o. (Water and Sewage Company) in Świdnica, I was able to assess the usability of WaterCAD V8i program for the simulation of hydraulic performance of a real water supply network. The results of those studies, as referred to the measurements of flow and pressure conducted on the water supply network and accompanied by the description of problems encountered while creating the numerical map and the hydraulic model of the analysed network in that program, were presented in the following publications:

4.5.3. **Burszta-Adamiak E.**, Synowiecka J., Przerwa A., 2013: *Zastosowanie programu WaterCAD do analizy pracy sieci wodociągowej na przykładzie systemu zaopatrzenia w wodę w Świdnicy*. (Application of the WaterCAD software for analysis of water supply system on the example of the water supply system of Świdnica). Instal, No. 11, pp. 78-81. (development the concept of the article, compilation of research results, co-editing, contribution 30%).

4.5.4. **Burszta-Adamiak E.**, Synowiecka J., Przerwa A., 2013: *Zastosowanie programu WaterCAD do modelowania i symulacji sieci wodociągowej.* (Application of the WaterCAD software for modeling and simulation of water supply system). Inżynieria i Ochrona Środowiska, Vol. 16, No. 4, pp. 537-549. (development the concept of the article, compilation of research results, co-editing, contribution 30%).

Based on the data obtained from Świdnickie Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o.o. (Water and Sewage Company) in Świdnica, a hydraulic model of one of the seven water supply zones in Świdnica was developed. The results of those efforts were presented in the Master's thesis that I supervised, entitled *The Application of Geographic Information Systems to Design Water Supply and Sewage Networks*. The said thesis won an award as the best diploma thesis in a contest entitled "Write about Świdnica" organised by the Municipal Office in Świdnica. The developed model has a chance to be implemented and used by Świdnickie Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o.o. (Water and Sewage Company) in Świdnica as part of its ongoing operation of the water supply network.

4.6 Stormwater management funding

My scientific interests are also focused on the issue of funding investment projects relating to stormwater management in urban areas.

The implementation of efficient and effective solutions that improve stormwater management in cities requires considerable financial expenses. The fee for discharging rainwater and melt-water into the sewage system is a relatively new source of funding

for investments aimed at ensuring effective stormwater management. Although the charging of such fees becomes a must (necessitated both by EU directives, according to which "the polluter pays," and by the Polish law, including, among other things, the prohibition of cross-subsidies, as well as by the technical condition of facilities), until the present moment only a small fraction (approx. 20%) of water and sewage companies in Poland have decided to charge such fees. This topic is still highly controversial and raises many objections among the general public, therefore looking for ways to improve this situation is an extremely important issue as far as stormwater management in urban areas is concerned.

The major topics of my research in that respect included analyses aimed at identifying the needs and changes that would have to be made when implementing the fees for the discharge of rainwater into rainwater sewer systems in Poland; methods for calculating rainwater and melt-water fees applicable both domestically and abroad (in the United States, Canada, Germany); as well as the identification of financial support opportunities for projects relating to stormwater management, both domestically and abroad. The results of that research may be found in the articles that I authored and in a chapter of the following monograph:

4.6.1. **Burszta-Adamiak E.**, 2008: *Opłaty za wody opadowe - doświadczenia polskie i zagraniczne*.(Stormwater fees – national and foreign experiences) [in:] The monograph edited by prof. Janusz Łomotowski "Problems of rainwater management " Published by Seidel-Przywecki Ltp., pp.115-123 (contribution 100%).

4.6.2. **Burszta-Adamiak E.**, 2009: *Opłaty za wody opadowe w kraju i za granicą.* (Stormwater fees in Poland and abroad). Wodociągi i kanalizacja. No. 4(62), pp. 25-26. (contribution 100%).

4.6.3. **Burszta-Adamiak E.**, 2009: *Opłaty za wody opadowe –doświadczenia polskie i zagraniczne*.(Stormwater fees - national and foreign experiences). Gaz, Woda i Technika Sanitarna, no. 3, pp. 15-18. (contribution 100%).

4.6.4. **Burszta-Adamiak E.**, 2010: *Narzędzia motywacyjne dla poprawy gospodarki wodami opadowymi.* (Incentives for improving of stormwater management). Przegląd Komunalny No. 4(223), pp. 79-81 (contribution 100%).

4.6.5. **Burszta-Adamiak E.**, 2011: *Wody opadowe - edukacja i motywacja społeczeństwa.* (Rainwater - education and motivation of society). Wodociągi i Kanalizacja, No. 5 (87), pp. 84-88 (contribution 100%).

4.6.6. **Burszta-Adamiak E.**, 2011: *Naliczanie opłat za wody opadowe w warunkach krajowych i zagranicznych.* (Calculation of stormwater fees in national and foreign conditions). Proceedings of Nationwide symposium "Hydroprezentacje XIV" - Water protection, water management, water supply and sewerage, 14-16 June, Ustroń, pp. 69 – 82. (contribution 100%)

4.6.7. **Burszta-Adamiak E.**, 2014: *The financial mechanisms of urban stormwater management.* [in:] The monograph edited by Tomasz Bergier, Jakub Kronenberg and Paweł Lisicki , published in the series Sustainable Development Applications no. 5 "Water in the city". Published by The Sendzimir Foundation, pp.57-69. (contribution 100%).

4.7 Water Footprint evaluation

While recognising water to be the core element of sustainable development of its member states, the European Union has enacted numerous directives (Water Framework Directive, Drinking Water Directive, Urban Waste Water Directive) and regulations to support better water use and management, as well as promote green technologies and practices that are aimed at protecting water resources. In recent years, the special focus of the European Union's attention has been on providing access to fresh water resources to its inhabitants, since the decrease in the infiltration rate value in urban areas and high use of chemical fertilisers in agriculture cause an increased groundwater salinity in the upper aquifiers which form one of the more significant sources of water supply. In addition, an increased content of mineral additives in surface waters is noted, which results from higher loads of those compounds being discharged with sewage or surface runoff. Modern municipal sewage treatment systems are designed to remove organic compounds, as well as nitrogen and phosphorus, but do not ensure the removal of dissolved salts.

The adverse effect of the growth of civilisation on natural waters prompted actions to be taken in cities with a view to implementing a systemic solution to problems relating to water quality, water consumption, flood risk or water distribution network management.

To this end, an attempt was made to use the Water Footprint (WFTP) indicator as a tool facilitating the decision-making process in order to improve water management in urban areas.

The identification of Water Footprint (WFTP) values in cities and comparison of the data between various urban areas is to enable the development of optimum long-term strategies for the modification of water treatment and distribution systems, as well as sewage treatment and disposal systems depending on the city's characteristics in order to improve the efficiency of those systems. This will also enable a rationalisation of water resource management in urban areas, and may support the development and implementation of new technologies and alternative solutions relating to natural water cycle.

Research in that respect was conducted under an international project entitled *Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use (URBAN_WFTP),* that was co-funded by the European Regional

Development Fund under the Central Europe Programme. I was the project contractor. One of the major objectives of the project was to develop a joint strategy for Central Europe based on the Water Footprint approach. The proposed methodology of WFTP calculation was applied in Innsbruck (Austria), Vicenza (Italy) and Wrocław. The results for Wrocław are presented in the following publication:

4.7.1. Fiałkiewicz W., **Burszta-Adamiak E.**, Malinowski P., Kolonko A., 2013: *Urban Water Footprint – system monitorowania i oceny gospodarowania wodą w miastach* (Urban Water Footprint – city water management monitoring and evaluation system). Ochrona Środowiska (ISBN 1230-6169), Vol.35, No. 3, pp. 9-12. (co-editing, compilation in part of research results, contribution 25%).

In order to promote and disseminate the project's results, a network of experts of the URBAN_WFP project was formed. I was included in the said network as an expert in November 2014. The task of the appointed experts is to help stakeholders understand the water footprint methodology and provide advice in respect of practical application of the best solutions, procedures and technologies for a better use of water at municipality, company and housing community levels.

5 Research output summary

My current research output encompasses 109 items in total, including 87 published research papers, 21 manuscripts (reports and expert opinions) and 1 patent (Table 1). My published research output includes 29 independently authored papers and 57 co-authored papers. The total number of points calculated in accordance with the Ministry of Science and Higher Education guidelines is 414. (Table 2).

Prior to the award of my doctoral degree, my output encompassed 13 published papers, including 2 co-authored original research papers, 1 peer-reviewed article, 1 chapter in a monograph, 2 popular science articles, and 1 individual and 6 co-authored conference papers.

Following the award of my doctoral degree, my research output has significantly increased. In the years 2005-2014, the total of 55 original research papers were published, including 6 impact factor papers, 2 monographs, 7 chapters in monographs, 35 articles published in journals listed by the Ministry of Science and Higher Education in its current lists, and 5 articles in peer-reviewed non-serial publications. Out of the total number of research papers published after the award of my doctoral degree, 28 publications are individually authored papers (1 publication in an impact factor journal, 1 monograph,

11 original papers published in journals indexed in databases other than the *Journal Citation Reports* (JCR), 3 chapters in monographs, 1 peer-reviewed article in a non-serial publication, 9 popular science articles and 2 conference papers).

The scientific articles that I authored or co-authored were cited 4 times in journals listed in the Web of Science (WoS) database. In addition, my papers were cited 51 times in the Polish and foreign literature (based on the data from the database Google Scholar, this number does not include autocitations). The Hirsh Index according to the Web of Science is 1. The total Impact Factor of scientific publications as per the *Journal Citation Reports* (JCR) according to the year of publication is 4.768 (Appendix 3A).

A synthetic overview of my research and implementation output, and its score based on the current list of journals of the Ministry of Science and Higher Education, is presented in Tables 1 and 2, respectively. The detailed list of articles in presented in Appendix 3A.

Table 1

Synthetic overview of research output
(situation as at 15.03. 2015)

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
Original Research Papers									
In impact factor journals				1	5	6	1	5	6
Original papers published in peer-reviewed journals		3	3	12	27	39	12	30	42
Monographs				1	1	2	1	1	2
Chapters in monographs		1	1	3	4	7	3	5	8
Other									
Chapters in textbooks					2	2		2	2
Conference papers and popular science articles	1	8	9	12	6	18	12	14	27
Non-published reports and expert opinions		5	5		16	16		21	21
Patents					1	1		1	1
Total	**1**	**17**	**18**	**29**	**62**	**91**	**30**	**79**	**109**

Table 2

The overview of output by score based on the current list of journals of the Ministry of Science and Higher Education of 31 December 2014 (situation as at 15.03.2015)

Title of the Journal	Score	Number of Papers		Total Number of Papers	Total Score
		Prior to the Award of Doctoral Degree	After the Award of Doctoral Degree		
IF Journals					
Archives of Environmental Protection	15		1	1	15
Water Science and Technology	20		2	2	40
Ochrona Środowiska (*Environmental Protection*)[1]	15		3	3	45
Other Peer-Reviewed Journals					
Journal of Water and Land Development	6		3	3	18
Ochrona Środowiska[2]	15	1	1	2	30
Gaz Woda i Technika Sanitarna (*Gas, Water and Sanitary Technology*)	5		7	7	35
Infrastruktura i Ekologia Terenów Wiejskich (*Infrastructure and Ecology of Rural Areas*)	5		2	2	10
Inżynieria Rolnicza (*Agricultural Engineering*)	5	1		1	5
Przegląd Naukowy Inżynieria i Kształtowanie Środowiska (*Scientific Review: Environmental Engineering and Development*)	5		2	2	10
Woda – Środowisko – Obszary Wiejskie (*Water – Environment – Rural Areas*)	5		2	2	10
Ekologia i Technika (*Ecology and Technology*)	5		2	2	10
Architektura Krajobrazu (*Landscape Architecture*)	4		1	1	4
Rynek Instalacyjny (*Installation Market*)	5		7	7	35
Zeszyty Problemowe Postępów Nauk Rolniczych (*Problem Papers on the Developments in Agricultural Sciences*)	9		1	1	9
Instal	6		2	2	12
Inżynieria Morska i Geotechnika (*Maritime and Geotechnical Engineering*)	3		1	1	3
Inżynieria i Ochrona Środowiska (*Environmental Engineering and Protection*)	5		1	1	5
Inżynieria Ekologiczna (*Ecological Engineering*)	5		3	3	15

Czasopismo Inżynierii Lądowej, Środowiska i Architektury (Journal of Civil Engineering, Environment and Architecture)	5		1	1	5
Monographs and Textbooks					
Monographs	20		2	2	40
Chapters in monographs in Polish	4	1	6	7	28
Chapters in monographs in English	5		1	1	5
Chapters in textbooks	0		2	2	0
Other Published Research Papers					
Peer-reviewed papers in non-serial publications	0	1	3	4	0
Papers included in conference proceedings	0	7	7	14	0
Popular science articles	0	2	11	13	0
Patents	25		1	1	25
Non-published Papers					
Reports and expert opinions	0	5	16	21	0
TOTAL		**18**	**91**	**109**	**414**

[1] includes articles of 2009 and 2013, when the journal had an IF
[2] includes articles of 2003 and 2006, when the journal did not have an IF

6 Participation in research projects

6.1 European projects

1. Contractor in the project entitled *Water Absorbing Geocomposites – Innovative Technologies to Support Plant Vegetation* co-funded by the European Regional Development Fund under the Innovative Economy Operational Programme 2007-2013. Priority 1. Research and development of modern technologies, Measure 1.3. Support for R&D projects for entrepreneurs carried out by scientific entities, Sub-measure 1.3.1. Development projects. Project implementation period: 2009-2014.
2. Contractor in an international project entitled *Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use* (URBAN_WFTP), co-funded by the European Regional Development Fund under the Central Europe Programme. The project was implemented in the years 2012-2014.
3. Contractor in an international project entitled *A garden over your head – Swiss green roofs and living walls as a model and inspiration for innovative activities of Polish self-governments in the field of energy conservation and climate protection*. Project partners included the Association of Municipalities Polish Network ”Energie Cités”, Green Roof Competence Centre at the Zurich University of Applied Sciences and the Polish Green Roof Association (PSDZ). The project was co-funded by Switzerland under the Swiss

Programme for Co-operation with New EU Member States. The project was implemented in the years 2012-2014.

4. Contractor in an international project entitled *A garden over your head 2 – Promoting the concept of green roofs and living walls as an innovative activity in municipalities to be included in the Low Emission Economy Plans (LEEP),* implemented by the Association of Municipalities Polish Network ”Energie Cités.” The project was co-funded by Switzerland under the Swiss Programme for Co-operation with New EU Member States. The project was implemented in January-February 2015.

6.2 National projects

1. Contractor in a research project 3 PO4G 05125 entitled *The use of Malvern particle size analyzer to monitor surface water quality*. The project was implemented in the years 2003-2006.

6.3 Research work for business entities

1. Łomotowski J. Łoniewski P., Jędrusik M., Kolcuń O., Gromada O., Ferenc L., **Burszta E.,** *Koncepcja modernizacji i rozbudowy ujęć infiltracyjnych dla miasta Wrocławia*. (The concept of modernisation and extension of infiltration intakes for Wrocław) IMS sp. z o.o. Wrocław. A study ordered by the Municipal Water and Sewage Company in Wrocław, June 2001.

2. Łomotowski J., **Burszta E.**: *Badania na doświadczalnych układach infiltracyjnych na terenie ujęcia wody z rzeki Brdy dla Bydgoszczy.* (Research on experimental infiltration systems in the area of water intake from the Brda River for Bydgoszcz.) A study prepared for the Municipal Water and Sewage Company in Bydgoszcz, September 2002.

3. Łomotowski J., Licznar P. **Burszta-Adamiak E.**: *Sprawozdanie z nadzoru i opracowanie wyników z eksploatacji stawów doświadczalnych na terenie komunalnego ujęcia wody w Bydgoszczy-Czyżkówku wraz z opracowaniem wytycznych do projektowania i eksploatacji infiltracyjnego ujęcia wody dla miasta Bydgoszczy*. (Supervision report and analysis of results obtained from the operation of experimental basins in the area of municipal water intake in Bydgoszcz-Czyżkówek together with the preparation of guidelines for designing and operating an infiltration water intake for the city of Bydgoszcz.) A study prepared for the Municipal Water and Sewage Company in Bydgoszcz, December 2002.

4. Łomotowski J., **Burszta-Adamiak E.**: *Koncepcja modernizacji z rozbudową istniejącej oczyszczalni ścieków w Wołczynie*. (The concept of modernisation and extension of the existing sewage treatment plant in Wołczyn.) A study ordered by the Municipal Office in Wołczyn, Wrocław, September 2005.

5. Łomotowski J., **Burszta-Adamiak E.**: *Opinia o układzie technologicznym podczyszczania gnojówki na terenie PIW w Puławach.* (Opinion on the technological

system for liquid manure pre-treatment at the National Veterinary Research Institute in Puławy.) A study prepared for the National Veterinary Research Institute in Puławy, February 2006.

6. Licznar P., **Burszta-Adamiak E.**, Łomotowski J.: *Separatory koalescencyjno-lamelowe BEWA, typoszereg dla przepustowości nominalnych NG=10, 20, 30, 40, 60, 80 i 100 $dm^3 \cdot s^{-1}$*. (BEWA lamella and coalescing separators, product range for nominal capacities of NG=10, 20, 30, 40, 60, 80 and 100 $dm^3 \cdot s^{-1}$.) A study prepared for Bewa Systemy Oczyszczania Ścieków (Sewage Treatment Systems), April 2006.

7. Licznar P., **Burszta-Adamiak E**., Łomotowski J.: *Separatory koalescencyjne BEWA-KA, typoszereg dla przepustowości nominalnych NG=60, 80 i 100 $dm^3 \cdot s^{-1}$* (BEWA-KA coalescing separators, product range for nominal capacities of NG=60, 80 and 100 $dm^3 \cdot s^{-1}$.) A study prepared for Bewa Systemy Oczyszczania Ścieków (Sewage Treatment Systems), April 2006.

8. Łomotowski J., **Burszta-Adamiak E.**, Licznar P, Kęszycka M.: *Określenie przyczyn zmian jakości wody w sieci wodociągowej w dzielnicach Błędów, Łęka i Okradzionów eksploatowanej przez Przedsiębiorstwo Wodociągów i Kanalizacji w Dąbrowie Górniczej*. Etap I. (Identification of reasons for water quality changes in the water supply network operated by the Water and Sewage Company in Dąbrowa Górnicza in Błędów, Łęka and Okradzinów districts. Stage I.) A study prepared for the Water and Sewage Company in Dąbrowa Górnicza, January 2006.

9. Łomotowski J., **Burszta-Adamiak E.**, Licznar P, Kęszycka M.: *Określenie przyczyn zmian jakości wody w sieci wodociągowej w dzielnicach Błędów, Łęka i Okradzionów eksploatowanej przez Przedsiębiorstwo Wodociągów i Kanalizacji w Dąbrowie Górniczej. Etap II.* (Identification of reasons for water quality changes in the water supply network operated by the Water and Sewage Company in Dąbrowa Górnicza in Błędów, Łęka and Okradzinów districts. Stage II.) A study prepared for the Water and Sewage Company in Dąbrowa Górnicza, March 2006.

10. Łomotowski J., **Burszta-Adamiak E.**: *Ekspertyza nt.: Studium hydrologiczne ekosystemu znajdującego się na obszarze oczyszczalni ścieków pola osobowickie, określające zakres i charakter zmian tego terenu w przypadku zaprzestania odprowadzania ścieków na ten teren., Część I. Synteza*. (Expert opinion on: Hydrological study of the ecosystem located within the area of "Osobowice Fields" Sewage Treatment Plant, identifying the scope and nature of changes in this land in the event of discontinuation of sewage discharge therein. Part I. Synthesis.) A study prepared for the Municipal Water and Sewage Company in Wrocław, December 2009.

11. Łomotowski J., Fiałkiewicz W., **Burszta-Adamiak E.**, Pływaczyk L., Łyczko W., Pęczkowski G., Klaus R.: *Studium rekultywacji terenu znajdującego się na obszarze oczyszczalni ścieków Pola Osobowickie (Etap II A)", Raport końcowy* (A study of reclamation of land located within the area of "Osobowice Fields" Sewage Treatment Plant (Stage II A), Final Report.) A study prepared for the Municipal Water and Sewage Company in Wrocław, August 2012.

12. Łomotowski J., Fiałkiewicz W., **Burszta-Adamiak E.**, Wiercik P., Domańska M., Synowiecka J., Ciecirko M., Bawiec A., , Pływaczyk L., Łyczko W., Pęczkowski G.,

Klaus R., Woźniakowska K., Szczypta J.: *Budowa modelu hydrogeologicznego pól irygowanych Osobowice. Zadanie II. Wykonanie badań ilościowych i jakościowych ścieków odpływających z pól irygowanych oraz określenie potencjału terenu do oczyszczania ścieków nadmiarowych pogody deszczowej*. (Construction of a hydrogeological model of Osobowice irrigation fields. Task II. Quantitative and qualitative testing of sewage flowing out of the irrigated fields and identification of the land's potential to treat overflow sewage caused by stormwater.). A study prepared for the Municipal Water and Sewage Company in Wrocław, March 2014.

7 Internships and scientific missions

1. Czech Republic (Prague) – Scientific internship at the Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University in Prague (September-November 2011)
2. Ukraine (Odessa), 2003 – Participation in the 4th International Olympiad in Hydraulics, 22-26 September.
3. Austria (Innsbruck) – Technical meeting: drafting of urban water footprint model, organised under the project entitled *Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use*, 15 February 2013.
4. Germany (Dresden) – Partner meeting (WP 3.6), organised under the project entitled *Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use*, 25 April 2013.
5. Germany (Nuremberg) – Steering Committee Meeting and Technical Board Meeting, organised under the EU project entitled *Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use*, 6-7 June 2013.
6. Hungary (Debrecen) – A meeting to conclude the project entitled *Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use*, 21 November 2014.

8 Scientific workshops and training courses

In order to extend my knowledge relating to the topics of my research, I have completed the following training courses, both domestically and abroad:

1. Hungary (Pésc) – 2nd Image Train Advanced Study Course entitled *Groundwater management in mining areas*. This training course, combined with workshops, was organised under the "Innovate management of groundwater resources in Europe-training and RTD co-operation" project on 23-27 June 2003.

2. Germany (Münchenberg) – German and Polish scientific workshop entitled *Modelling of environmental processes*. 25-27 May 2004.
3. Poland (Wrocław) – *Green Inspirations* on plant landscaping on roofs, organised by Bauder on 28 February 2008.
4. Poland (Warsaw) – *ZinCo green roof systems*, 17 January 2009.

In 2011 I also participated in an intensive e-learning course conducted in English and comprised of two levels: Level 1: *Introduction to sustainable development*, Level 2: *Applications of sustainable development*, organised in the period from 8 April to 29 May. Having successfully completed all tasks to be performed as part of the course, I was admitted to attend the 14th *International Summer Academy – Challenges of Sustainable Development in Poland 2011* held on 3 - 21 July 2011 in Łódź. Like in the case of the e-learning course, all lectures, discussions and tasks during the Summer Academy were in English due to the international nature of this event.

9 Practical professional training

In the period from 1 August to 31 October 2014 I underwent professional training at Wroterm Sp z.o.o. in Wrocław, a company engaged in a comprehensive implementation of investment projects relating to heating, water and sewage, ventilation, air-conditioning systems, as well as control and measurement instruments and automation.

10 Co-operation with other institutions

The major institutions that I have co-operated with so far include the following:

1. Systems Research Institute, Polish Academy of Sciences in Warsaw.
2. Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e. V. (Centre for Agricultural Landscape Research), Germany
3. Dipartimento di Ingegneria Industriale dell'Università degli Studi di Padova (Department of Industrial Engineering, University of Padova), Italy
4. Arbeitsbereich Umwelttechnik, Universität Innsbruck (Department of Environmental Engineering, University of Innsbruck), Austria
5. Zürcher Hochschule für Angewandte Wissenschaften - ZHAW (University of Applied Sciences in Zurich, and in particular the Green Roof Competence Centre), Switzerland
6. INNOVA Észak-Alföld Regionális Fejlesztési és Innovációs Ügynökség Nonprofit Kft. (Agency for Regional Development and Innovation INNOVA Észak-Alföld), Hungary

7. Industrie- und Handelskammer Nürnberg für Mittelfranken IHK (Nuremberg Chamber of Commerce and Industry for Middle Franconia IHK), Germany
8. Giacomo Rumor Foundation Veneto Productivity Center, Italy
9. The Sendzimir Foundation in Warsaw
10. alpS GmbH, Austria
11. Comune di Vicenza (Vicenza Town Hall), Italy
12. Municipal Office in Wołczyn
13. Municipal Water and Sewage Company in Wrocław
14. Miejskie Wodociągi i Kanalizacja w Bydgoszczy Sp. z o.o. (Municipal Water and Sewage Company in Bydgoszcz)
15. Świdnickie Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o. o. (Municipal Water and Sewage Company in Świdnica)
16. Dąbrowskie Wodociągi Sp. z o.o.(Municipal Water and Sewage Company in Dąbrowa Górnicza)
17. Polish Green Roof Association
18. Association of Municipalities Polish Network ”Energie Cités”
19. DAFA Association of Flat Roof and Facade Contractors
20. Green roof designers, contractors and distributors of green roof components, including, among other things, Optigrün International AG, GCL Sp. z o.o., APK DACHY, Laboratorium dachów zielonych (Green Roof Laboratory), KiK KRAJEWSCY, CALLA S. C. Jolanta Gryczyńska, Bauder GmbH & Co. KG, SWISSPOR Polska sp. z o.o and BÜSSCHER&HOFFMANN.
21. BEWA Sp. z o.o. – manufacturer of environmental protection systems.

By working with the above-mentioned institutions and research organisations, as well as with the representatives of designers and contractors, municipalities and technical associations, I was able to pursue national and international research projects, co-organise conferences and training courses relating to my research, prepare publications, and conduct research work and perform industry-specific analyses for business entities.

Since February 2015 I am a member of the scientific committee “retencja.pl” - portal dedicated professional, scientific and technical exchange of views, experiences and good practices in the field of rainwater management.

11 Reviews of articles published in foreign journals and content editing

I reviewed 16 articles intended to be published in *Water Science and Technology* journal, 1 article classified to be published in *Landscape and Urban Planning* journal and 1 article intended for publication in *Environment Protection Engineering* journal and 1 to the journal *Desalination and Water Treatment*. All those journals are entered in the "A" list of the Ministry of Science and Higher Education that encompasses scientific journals indexed in the Journal Citation Reports (JCR). In 2011, I reviewed an article addressed to Rynek Instalacyjny journal and in 2012, I also reviewed 2 articles that were published as part of the proceedings of the 9th International Conference on Urban Drainage Modelling (UDM) organised on 3-7 September 2012 in Belgrade (Serbia).

Currently, I am the content editor of the Polish edition of green roof guidelines developed on the basis of translation of the publication of the FLL – German Research Society for Landscape Development and Landscape Design (*German: Forschungsgesellschaft Lischaftsentwicklung Lischaftsbau e.V.*), entitled *The Guidelines for Planning, Installing and Maintaining Green Roofs*. (*German: Richtlinie für die Planung, Ausführung und Pflege von Dachbegrünungen*). It is anticipated that the work on the Polish edition of the guidelines will be completed in the 2nd quarter of 2015.

12 Patents

2012: Burszta-Adamiak E., Łomotowski J., Licznar P.: Patent no. 214917 for an invention called the Coalescing separator. Decision of the Polish Patent Office of 17.12.2012. Date of patent application filing: 4.06.2009.

13 Teaching and educational activities

I started teaching in the 2001-2002 academic year at the Agricultural Academy in Wrocław (Wrocław University of Environmental and Life Sciences). At the present moment, I teach courses as part of full-time and part-time Bachelor's degree and supplementary Master's degree studies in the following fields: Environmental Engineering; Hydraulic Engineering and Water Management; Spatial Planning; Environmental Protection; and Geodesy and Cartography. In the years 2004-2008 I also taught courses as part of Landscape Architecture programme. The courses that I teach are related to the areas of my scientific interests. In terms of topics, they include issues relating to: water supply and sewage systems design, planning and operation; stormwater management; water and sewage treatment technologies; and environmental monitoring. Some of the classes are taught at a computer lab, where students learn and use specialist engineering programs, such as: Microstation, AutoCAD, EPANET, WaterCAD, SewerCAD, StormCAD, PHREEQC simulators of ionic composition of water, or a program for calculations relating to activated sludge treatment plants: *Ekspert osadu czynnego (Activated sludge expert)*.

The courses that I taught included the following: Water Supply and Sewage Systems – Selected Issues; Infrastructure; Technical Infrastructure Planning; Water Supply and Sewage Networks; Modelling Stormwater Drainage Systems; Water Management; Sanitary Systems; Unit Processes; Water Treatment; Sewage Treatment Technology; Information Technologies; and Air Pollution and Protection of the Atmosphere.

In the 2006-2007 and 2008-2009 academic years I was responsible for organising individual classes for foreign students from Portugal, Spain and Turkey. The said work was performed under the Erasmus programme in respect of the following courses: Water and Wastewater, Technology Use in Air Protection, and Technologies in Environmental Protection.

I am responsible for teaching the following courses: Stormwater Management as part of full-time second-cycle (graduate) studies in the field of Environmental Protection; Sanitary Systems as part of full-time second-cycle (graduate) studies in the field of Environmental Engineering; and Engineering Graphics as part of full-time first-cycle (undergraduate) studies in the field of Geodesy and Cartography.

In the years 2006-2014 I supervised 22 Master's theses and 17 Bachelor's theses in the following fields of study: Environmental Engineering, Spatial Planning, and Environmental Protection. I acted as a scientific supervisor for 4 Bachelor's degree projects

prepared by groups of 4-5 students at the end of their B.Sc. studies in the field of Environmental Engineering.

In 2013 I was appointed an auxiliary supervisor of a doctoral student Karolina Kolasińska – her dissertation relates to changes in the properties of substrates in the course of their use on green roofs.

While working at the Wrocław University of Environmental and Life Sciences, I have fulfilled many roles relating to the teaching process. The major ones are as follows:

- Expert co-ordinator for the Environmental Engineering programme under the EU project entitled "Programme of the Wrocław University of Environmental and Life Sciences for the increase of the number of graduates from technical and natural science faculties of key importance for knowledge-based economy" (contest no. 1/POKL/4.1.2/2009). The project was funded by the European Social Fund under the Human Capital Operational Programme, Priority IV: Higher Education and Science, Measure 4.1: Strengthening and development of didactic potential of universities and increasing the number of graduates from faculties of key importance for knowledge-based economy. The project was implemented in the years 2009-2013;
- Year tutor for the Environmental Engineering programme in the years 2006-2010;
- Secretary of the Recruitment Committee for the admissions procedure for Civil Engineering programme candidates, full-time and part-time studies, in the 2005-2006 academic year;
- Member of the Recruitment Committee for the admissions procedure for Environmental Engineering programme candidates, full-time and part-time studies, in the academic years of 2006-2007 and 2009-2010;
- Member of the Recruitment Committee for Ph.D. candidates in the 2007-2008 academic year.

Every year since 2007 I have been appointed to be a reviewer of examination tasks and other materials selected by the Regional Examination Board in Wrocław for the written and practical parts of examination confirming professional qualifications of an Environmental Engineering and Land Reclamation Technician, and since 2008 also to be the judge competent to express opinions on planned tasks selected by the Regional Examination Board in Wrocław for the written part of examination in that profession. On December 31, 2014. Decision No 297/2014 I was entered in the register of examiners Regional Examination Board

in Wrocław in terms of the qualification examination in the profession Technician Environmental Engineering and Land Reclamation (No. 311208 / R.23, R.24 / 2014).

Since 2012 I have been a member of the Programme Committee for Environmental Engineering. On numerous occasions I have been the member of Master's and Bachelor's degree examination boards for Environmental Engineering and Environmental Protection programmes.

14 Organisational activities

In the course of my doctoral studies and employment with the Wrocław University of Environmental and Life Sciences I have fulfilled the following roles:

1. Member of the Dean's Committee for Environmental Engineering programme self-assessment report in 2008;
2. Member of the Dean's Committee that was appointed to prepare prospects for the Faculty's development in respect of didactics, science and organisational structure entitled *The Path of the Faculty of Environmental Engineering and Geodesy from 2015 to 2020* (2009);
3. Secretary of the organisational committee for the National Scientific and Technical Conference with the participation of foreign guests on Stormwater Management Problems in the "Modelling of Hydrological Processes" series organised at the Wrocław University of Environmental and Life Sciences on 20-21 November 2008;
4. Organiser of a training course entitled "Green roofs – a challenge to environmental problems of the 21st century?", Wrocław, 28 October 2009;
5. Member of the organisational committee for the 2nd International Scientific and Technical Conference on Technical and Environmental Conditions of Stormwater Management, Tuchola-Tleń, 21-23 October 2010;
6. Member of the organisational committee for the 2nd National Scientific and Technical Conference in the series entitled "Modelling of Hydrological Processes – Extreme Phenomena in Municipal Infrastructure Operation," Zegrze near Warsaw, 1-2 February 2011;
7. Organiser of workshop entitled "What is my Water Footprint, i.e. students' awareness of the consumption of the Earth's resources," organised under

the Introduction of Water Footprint (WFTP) approach in urban area to monitor, evaluate and improve the water use project, Wrocław, 20 March 2014.

15 Activities relating to dissemination of knowledge

Since the time that I commenced my research work at the Wrocław University of Environmental and Life Sciences, I have participated in over 50 conferences, symposia and scientific congresses, presenting my research results. The most important of those are specified below.

15.1 Participation in national scientific meetings

1. 18th National Scientific and Technical Conference in the "Technological Progress in Water Supply Systems" series, Wrocław 23-25 October 2003;
2. 6th Scientific and Technical Conference on Application of Information Technologies in Water Supply and Sewage Systems Management, Wągrowiec, 30 November - 2 December 2003;
3. 5th Congress of Polish Sewage System Operators "POLKAN 2003", Łódź, 20-21 November 2003,
4. 10th Scientific and Technical Conference on Infrastructure and Ecology of Rural Areas – Development and New Technologies, Dobczyce, 23-25 June 2003;
5. 8th National Training Symposium on Designing, Building and Operating Household Sewage Treatment Plants, Kiekrz, 19-21 February 2003;
6. Symposium on Sewage Management Problems in Municipalities on the Eve of Poland's Accession to the EU, Poznań, 18 November 2003;
7. 10th Conference in the "Multiple-access Computer Systems" series entitled "IT and Communication Methods and Techniques in Management," Ciechocinek, 13-15 September 2004;
8. 2nd National Environmental Engineering Congress, Lublin, 4-7 September 2005;
9. 19th National Scientific and Technical Conference in the "Technological Progress in Water Supply Systems" series, Wrocław, 20-22 October 2005;
10. Scientific Conference on Environmental Engineering and Development of Non-Urbanised Areas – Water in Landscape Engineering. Warsaw, 29-30 June 2006;
11. 6th Congress of Polish Sewage System Operators "POLKAN 2003", Łódź, 6-7 December 2007;
12. 3rd National Training Conference on Stormwater: Legal, Economic and Technical Aspects, organised by Abrys Sp. zo.o. Toruń, 10-11 April 2008.

13. 1st National Scientific and Technical Conference under the auspices of the Committee on Environmental Engineering of the Polish Academy of Sciences ”INFRAEKO 2008” Municipal Infrastructure vs. Sustainable Development of Urban Areas. Rzeszów-Paczółtowice, 26-27 June 2008;
14. Symposium on Water Supply and Sewage Systems – Modern Plastic Solutions in European Research Programmes. The Possibility of Using Research Results in Teaching. Szczepowice, Buk, 13-14 February 2008;
15. 4th National Training Conference on Stormwater: Legal, Economic and Technical Aspects, Włocławek, 6-7 April 2009;
16. National Scientific Conference on Problems of Plant Protection in Urban Areas. Wrocław, 15-17 September 2010;
17. Symposium on Stormwater: Aspects of Stormwater Management Based on the Example of Selected Polish Cities, Katowice, 24 March 2010;
18. 2nd National Scientific and Technical Conference in the series entitled “Modelling of Hydrological Processes – Extreme Phenomena in Municipal Infrastructure Operation,” organised by the Faculty of Environmental Engineering and Geodesy in collaboration with the Centre for Hydrological Processes Modelling of the Wrocław University of Environmental and Life Sciences, Polish Green Roof Association, Offices of Polish Cities and Publishing House Seidel-Przywecki Sp. z o.o. , Zegrze near Warsaw, 1-2 February 2011;
19. 6th National Training Conference on Stormwater: Legal, Economic and Technical Aspects, Toruń, 4-5 April 2011;
20. National Symposium HYDROPREZENTACJE XIV’2011., Ustroń, 14-16 June 2011;
21. 7th National Training Conference on Stormwater: Legal, Economic and Technical Aspects, Active Measures Taken by Cities to Control Rainwater Runoff. Łódź, 23-24 April 2012;
22. Conference entitled “A garden over your head – Swiss green roofs” and “Living walls as a model and inspiration for innovative activities of Polish self-governments in the field of energy conservation and climate protection”. Kraków, 18 January 2013;
23. Environmental Conference organised by the Marshal’s Office of Świętokrzyskie Voivodeship in Kielce entitled “Retaining Water in the Catchment,” Kielce, 26 February 2013;

24. Conference entitled "A garden over your head – Swiss green roofs" and "Living walls as a model and inspiration for innovative activities of Polish self-governments in the field of energy conservation and climate protection". Bydgoszcz, 13-14 May 2014;
25. 9th National Training Conference on Stormwater: Legal, Economic and Technical Aspects. Iława, 15-16 May 2014;
26. Scientific Conference with the participation of foreign guests entitled "Water Management in Environmental Development and Protection," Wrocław-Pierwoszów, 28-30 May 2014;
27. 17th Scientific and Technical Congress WOD-KAN-EKO 2014, Łódź, 6-7 November 2014.
28. Seminar on "Green roofs and living walls as an innovative action plans included in local low-carbon economy", Bialystok (12 February 2015), Lublin (13 February 2015), Czestochowa (23 February 2015) and Słupsk (26 February 2015).

15.2 Participation in international scientific meetings

1. International Conference on Natural Waters and Water Technology, Acquafredda di Maratea, Italy, 4-9 October 2003.
2. 6th International Scientific and Technical Conference on Application of Computing Methods in Water Supply and Sewage Systems Management in the "Computer in Environmental Protection" series. Poznań 2003;
3. International Scientific and Technical Conference organised by the Ukrainian Ministry of Education and Science and the Kiev University of Civil Engineering and Architecture entitled "Проблеми водопостачання водовидведення та гидравлики. (English: Problems of Water Distribution and Flow Hydraulics), Kiev, Ukraine, 20-22 April 2004.
4. 7th International Scientific and Technical Conference on Effective Implementation of Information Technologies, Gniezno, 16-18 September 2005;
5. 7th International Scientific and Technical Conference on Effective Implementation of Information Technologies in the "Computer in Environmental Protection" series, Gniezno 2005;
6. The World Green Roof Congress, London, England, 17-18 September 2008.
7. The International Conference "Networking event in the field of water management and sanitation Europe-Africa-EECA," Vienna (Austria), 16-17 September 2009.
8. 2nd International Scientific and Technical Conference AQUAEDUCTUS 2010. "Problems of Water Supply and Sewage Disposal in Urban Agglomerations in Poland and in Europe." Warsaw, 18-19 March 2010;

9. 2nd International Scientific and Technical Conference on Technical and Environmental Conditions of Stormwater Management. Tuchola – Tleń, 21-23 October 2010;
10. 2nd German – Polish Forum on Eco-Innovation: Fostering R&D collaboration for a change, Poznań, 24-25 November 2010;
11. 9th International Conference on Urban Drainage Modelling (UDM), Serbia, Belgrade, 4-7 September 2012.
12. International Conference "URBAN Water Footprint: an innovative approach to manage water in urban areas", 20 November 2014.

15.3 Acting as trainer or expert

In the years 2009-2015 I acted in my capacity as trainer or expert on topics relating to my research at the following meetings:

1. Warsaw, 26 March 2009 – trainer in the subject of "*Green Roof Impact on Environmental Parameters*". Training course entitled "Green roofs – a challenge to environmental problems of the 21st century?";
2. Łódź, 21 May 2009 – trainer in the subject of "*Motivational Tools in the Charging of Stormwater Fees Abroad*" at the Symposium on Stormwater: Aspects of Stormwater Management Based on the Example of Selected Polish Cities;
3. Wrocław, 28 October 2009 – trainer in the subject of "*Possibilities of Rainwater Retention on Green Roofs*". Training course entitled "Green roofs – a challenge to environmental problems of the 21st century?";
4. Białystok, 18 November 2009 – trainer in the subject of "*The Role of Green Roofs in Stormwater Management in Urban Areas*". Training course entitled "Green Inspirations";
5. Opole, 10 November 2012 – trainer in the subject of "*Sustainable Stormwater Management in Urban Areas*". Training course entitled "Stormwater in Cities" organised by the Regional Chamber of Civil Engineers in Opole;
6. Warsaw, 8-9 May 2013 – expert in the following section: "*Analyses of Proposals of Model Green Roof and Living Wall Investments in Municipalities – Discussion*" during the workshop organised for the representatives of cities and municipalities entitled "Green Roofs and Living Walls in Local Action Plans for Sustainable Energy";
7. Kraków, 17 January 2013 – expert in the following section: "*Evaluation of Municipal Potential for CO_2 Reduction and Rainwater Retention – Discussion with the Participation of Experts and Representatives of Municipalities*" during the workshop

organised for the representatives of cities and municipalities entitled "Green Roofs and Living Walls in Local Action Plans for Sustainable Energy";

8. Wrocław, 29 September – 1 October 2014 and 5 November 2014, trainer in the subject of "*Strategies and Technological Solutions Affecting Water Footprint Reduction and Examples of Good Practices in Cities*". Training course organised by the Water and Sewage Company (MPWiK S.A.) in Wrocław for local government representatives under the project entitled "Urban Water Footprint – a System for Monitoring and Assessing Urban Water Management".
9. Poznań, 11 March 2015, expert in the subject of "*Green Roofs - Space for Stormwater Retention*". The International Conference organized by DAFA Association "Roofs and facades - green future for urban construction", BUDMA 2015.

16 Participation in the operations of technical associations

- Member of the Founding Committee of the Polish Green Roof Association;
- Chairperson of the Polish Green Roof Association in the years 2009-2011;
- Member of the Audit Committee of the Polish Green Roof Association in the 2011-2014 term of office;
- Member of the International Water Association (IWA) since 2009;
- Member of the Association of Water and Land Reclamation Engineers and Technicians (*Polish: Stowarzyszenia Inżynierów i Techników Wodnych i Melioracyjnych, SITWM*) since 2008;
- Secretary of the Management Board of SITWM Branch in Wrocław in the years 2009-2012;
- Member of the Young Technical Staff Commission of the Wrocław Council of FSNT NOT (Polish Federation of Engineering Associations) since 2012.
- Member of the DAFA (Association of Flat Roof and Facade Contractors) Conference Content Team since 2014.

17 Awards and distinctions

1. 1997 – 2001: merit scholarship each year during my studies in the field of Environmental Engineering;
2. 2005 – Distinction awarded to my doctoral dissertation entitled *Research on the Use of Geotextiles to Prevent Clogging in the Infiltration Process (Badania nad*

zastosowaniem geowłóknin do przeciwdziałania kolmatacji w procesie infiltracji), Institute of Environmental Engineering, Wrocław University of Technology;

3. 2008 – Wrocław University of Environmental and Life Sciences Rector's Level 3 Individual Award in the field of research for the series of publications relating to ground clogging phenomena;
4. 2009 – Wrocław University of Environmental and Life Sciences Rector's Level 3 Team Award in an organisational field, in particular for the organisation of the 1st National Scientific and Technical Conference on Stormwater Management Problems with the participation of foreign guests that was held on 20-21 November 2008 in Wrocław;
5. 2009 – Wrocław University of Environmental and Life Sciences Rector's Level 1 Team Award in the field of research, in particular for the series of publications relating to studies of suspended solids using a laser particle size analyzer;
6. 2010 – AQUAEDUCTUS Award for the best paper presented at the 2nd International Scientific and Technical Conference AQUAEDUCTUS 2010: Problems of Water Supply and Sewage Disposal in Urban Agglomerations in Poland and in Europe. Warsaw, NOT, 18-19 March 2010 (awarded for the paper entitled *Stormwater Retention on Green Roofs in Wrocław Conditions*).
7. 2012 – Wrocław University of Environmental and Life Sciences Rector's Level 3 Individual Award for scientific accomplishments, in particular for the series of publications relating to the problem of stormwater in urban areas.

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