Dr. Robert Banasiak
Institute of Meteorology and Water Management
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SELF REPORT

1. Name

Robert Banasiak

2. Education and degrees

- Doctor of Philosophy,

December 1999, Agricultural University of Wrocław, Poland, the Faculty of Environmental Engineering and Geodesy.

Thesis title: *'Investigation of suspended load in open channels.'* (in Polish). Supervisor prof. Włodzimierz Parzonka,

- MSc, land reclamation

September 1994, Agricultural University of Wrocław, Poland, the Faculty of Environmental Engineering and Geodesy /Uniwersytet w Hanowerze (in the frame of TEMPUS programme).

Thesis title: „*Hydraulische Problemen der naturnahen Regelung von Fliessgewässern*" (*Hydraulic problems of the nature-friendly river training*, in German). Supervisors: prof. Włodzimierz Parzonka and prof. Klaus Rickert.

3. Information on previous employment:

od 07.2010–present – Institute of Meteorology and Water Management National Research Institute (IMGW-PIB) Wrocław Branch, specialist, since 06.2012 – deputy head of the Centre for Flood and Drought Modelling.

12.2008–09.2009 – Technical University of Wrocław, the Faculty of Environmental Engineering (part time - 0.5).

2008–06.2010 – consultancy and construction sector (Studiebureau Verhoeven c.b.v.a., NAVIGA-STAL sp. z o.o., SETEC Engineering GmbH).

05.2000–12.2007 – Hydraulics Laboratory of the Ghent University, 'post-doc' research fellow and project engineer.

12.1994–04.2000 – Agricultural University of Wrocław, Poland, the Faculty of Environmental Engineering and Geodesy Uniwersytet Przyrodniczy, PhD student, teaching assistant, project engineer.

4. Scientific achievement being the basis of the habilitation procedure

a) The scientific achievement, in accordance with the art. 16 paragraph 2 of the Act of March 14th 2003, concerning degrees and titles (Dz. U. nr 65, item 595, as amended) is the series of publications entitled:

Hydraulics and sediment processes in closed and open channels with free surface flows

b) The list of publications constituting the scientific achievement:

b1. Banasiak, R., Verhoeven, R. (2004). *ADV measurements of turbulence over an eroded sediment bed in a semicircular flume*. 12th International Conference on Transport & Sedimentation of Solid Particles, 20-24 September 2004, Prague, Czech Republic. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu, 481, 113-124.

Own contribution – 80%

b2. Banasiak, R., Verhoeven, R., De Sutter, R., Tait, S. (2005). *The erosion behavior of biologically active sewer sediment deposits: Observations from a laboratory study.* Water Research 39, 5221-5231.

Own contribution – 70%

b3 Banasiak, R., Verhoeven, R. (2006). *Influence of bed structure on the erosion of a cohesive sediment bed.* Zeszyty Naukowe Akademii Rolniczej we Wrocławiu, XV, 536, 9-18.

Own contribution – 80%

b4. Banasiak R., Verhoeven R. (2006). *Quantification of the erosion resistance of undisturbed and remoulded cohesive sediment beds.* Water, Air and Soil Pollution: Focus 6, 381-391.

Own contribution – 80%

b5. Banasiak, R., Verhoeven, R. (2008). *Transport of sand and partly cohesive sediments in a circular pipe run partially full.* Journal of Hydraulic Engineering (ASCE), Vol. 134, No. 2, 216-224.

Own contribution – 80%

b6. Banasiak, R., Verhoeven, R. (2006). *Flow resistance in pipes with noncohesive and partly cohesive sediment deposits.* 13th International Conference on Transport & Sedimentation of Solid Particles, September 2006, Tbilisi, Georgia, Eds. Gochitashvili & Sobota, ISBN 83-60574-00-6, 29-38.

Own contribution – 80%

b7. Banasiak R. (2008). *Hydraulic performance of sewer pipes with deposited sediments.* Water, Science and Technology, WST 57:11, 1743-1748.

Own contribution – 100%

b8. Banasiak R, Tait S. (2008). *The reliability of sediment transport predictions in sewers – the influence of hydraulic and morphological uncertainties.* Water, Science and Technology, WST 57:9, 1317-1327.

Own contribution – 80%

b9. Banasiak R., Krzyżanowski M., Gierczak J., Wdowikowski M. (2014). *Bathymetric changes, roughness and conveyance of a compound, regulated by groynes river channel during low and high water conditions.* RiverFlow2014 – Shleiss et al. (Eds) Taylor&Francis Group, London, ISBN 978-1-138-02674-2, 369-374.

Own contribution – 60%

b10. Banasiak R, Krzyżanowski M. (2015). *Assessment of the morphologic regime and flow resistance during floods in the Middle Odra River (in Polish).* Acta Sci. Pol., Formatio Circumiectus, 14(2), 25-38. *Own contribution – 70%*

c) Description of the scientific goal and the obtained results contained in a monographic list.

When dealing with sediment transport processes the response of the top layer of a deposit to particular flow conditions is very important. A key aspect associated with the mobility of sediment is the bed topography of a deposit as it affects the flow resistance, the discharge-water level relationship, and the applied bed-shear stress and thus the sediment transport rate causing morphologic changes. Its importance has also been recognized in terms of ecological implications of mobilizing pollutants, thereby affecting streambed organisms' mortality and modification.

This dynamic response of the surface is related to the type of sediment within a deposit. A sediment deposit can be categorized according to its grain size composition and the degree of cohesion. Fine particles less than 0.063 mm are commonly assumed to be of a cohesive character. These grain sizes are predominant in mud deposits found in lakes, estuaries, reservoirs, and lowland rivers, where the sedimentation of suspended sediment takes place, or when natural soils form channel boundaries. Larger particles of sand and gravel form loose beds mostly found in steeper alluvial channels. A third type of the bed is the semicohesive sediment, which consists of granular fractions and a certain amount of fines and/or organic matter. Such mixed deposits can also be found in some stream bottoms, estuaries, or in sewer pipes. It has been recognized that the presence of even a small amount of a fine grain size fraction has the potential to modify considerably the mobility of the sediment mixture. The terms "cohesive-like" or "partly cohesive" have also been used to describe a sediment deposit that has a greater resistance to erosion than would be anticipated from purely granular deposits of similar grain size.

However in cohesive deposits not only is an increased resistance to erosion expected but the geometry of the bed surface will develop in a different fashion and this has a substantial influence on the flow resistance. Bed forms for noncohesive sediments have been widely investigated and described both in rivers and sewer pipes; much less information on bed form development is available regarding sediments exhibiting cohesive strength. In the past, several researchers investigated the influence of cohesion on the erodibility of such deposits. This research was focused on determining the conditions for incipient motion and establishing relationships linking erosion rates or transport intensity with flow induced shear stress and relating them with more specific parameters describing deposit characteristics. Artificial cohesive sediment mixtures were selected as a test material in many studies as they produce more consistent and reproducible results than natural sediments. Artificial mixtures were typically made from sand and a cohesive binder in different proportions.

It has been observed that a sediment mixture displays cohesive properties when the cohesive fraction reaches a certain level of concentration. The properties of the cohesion depend more on the type of cohesive binder than on the grain size of the granular fraction. Before reaching this limit, sediment mixtures were reported to behave as a noncohesive bed soon after the fines are washed out from the deposit surface. There is a transition between noncohesive and cohesive sediments or partly cohesive sediments. However, no clear quantification defines limits between these modes of transport, except some vague relationships between flow rate and bed-load transport intensity. Using these relationships may result in different answers due to an incomplete understanding of the processes which control the mobility of partly cohesive sediments.

My investigations investigation dealt with the transport behavior of both noncohesive, cohesive sediments and sediments in transition between them. The morphologic development, parameters of hydraulic resistance and sediment transport capacity were addressed. The detailed and comprehensive approach aimed also to enhance knowledge on the transport of sediment mixtures that are encountered in a wide range of natural or man-made hydraulic systems. It is also attempted to clarify the distinction between noncohesive and cohesive sediments deposits and to describe the transition phase between them. In addition, a special attention is paid to the effect of sediment structure on the erodibility potential. This is a result of both physical (consolidation) and biological processes (stabilization and destabilization) acting on the bed. The output of the studies are relevant both to sewer systems and to open channel, including channel design and flood hazard prediction.

The publication [b1] constitutes an introduction to the research and deals with the methodological aspects of experimental work. It was an investigation on the accuracy of hydraulic parameters measurement and the determination of the shear stress acting on the rigid flume bottom and sediment surface at varied flow conditions. The testing facility was a tilting, 11 m long recirculating flume. The flume has a semi-circular cross-section with an internal diameter of 0.39 m. The novel, at that time, acoustic Doppler velocitymeter (ADV) was deployed to record turbulent characteristics of the flow. The sensor recorded three components of flow velocity with a frequency up to 25 Hz. The quality of the records was analysed including a spectral analysis of the noise biasing the actual velocities. Further, the turbulent intensities and turbulent shear stress were determined from the recorded time series and compared to theoretical ones (Nezu and Nakagawa, 1993). An important finding from this study was that the shear stress recorded directly above the noncohesive sediment at incipient of motion, i.e. the critical shear stresses, was about 20% lower than according to the traditional criterion by Shields. This effect can be attributed to the increased component of lateral stress, thus and effect of narrow channel and presence of rough walls. Another issue of this study was the verification of a side wall elimination method by Klijwegt (1992) to divide the flow field into parts related to the bottom and walls, hence to veriy the method to determine the average bed shear stress. This measurements have been used to modify some calculation assumptions for this method in this set-up.

The work [b2] examines the erosional behaviour of fine graded sediment mixtures, starting with artificial ones constituting of sand, cohesive binder – clay, and/or organic material – crushed olivestone. Artificial mixtures were previously used by other researchers, as such mixtures deliver more comprehensive and reproductive results compared to natural sediments. Natural sediments collected from a sewer system were tested as well. A specific feature of the experiment was that the sediment was incubated over a period of 1 to 13 days under oxygen reach low flow conditions, as to assess the impact of this factor on the (de)consolidation and erosion. In parallel, sediments were placed in sedimentation tubes to observe the change of the physical parameters (e.g. volumetric density, water content). The tests showed an decreased erosion resistance of the natural deposited sediments due to the biological effects, both aerobic – initially, and anaerobic in the latter phase. The observed effects were the sediment fluidisation and gaseous products secretion leading to the volumetric density decrease (increase of the sediment deposit thickness), and break-up of interparticle bonds. Further, the result of this was a decrease of critical shear stress, an intensive 'first foul' flush, i.e. high concentration of suspended matter at increased flow rate, and higher erosion/transport rates at a given flow rate or bed shear stress. The influence of sediment structure has been clearly demonstrated. The test also showed that the artificial mixtures do not mimic the natural one very well. The reason was attributed to the different type of organic matter and bacterial community. Importantly, the tests also showed a specific mode of sediment deposits reaction to flow – bed forms characteristic for partly cohesive sediments. This observation indicated the direction for the next studies, i.e. on the quantification of the mobility behavior of sediments displaying a certain degree of cohesion.

However, first, the study focusing on the influence of sediment structure on sediment erosion behavior has been extended. The related works [b3 and b4] were presented both at national and international level. The study put under investigation a natural, cohesive sediment (mud) taken from a river Scheldt. A novelty of the experimental method was the application of the ADV instrument to record the shear stress over an undisturbed sample of sediment taken in situ. For this I developed a sampling method using special boxes for sediments, to be collected and put under testing in the flume. Before and after tests boxes with the sediment were weighted to determine the eroded sediments, by that the average erosion rates over erosion time. In parallel, the samples of sediments with disturbed structure (exactly mixed and purred into the boxes) were tested, so that the effect of deposit structure (or its destruction) could be quantified. Mud was taken from two different depths of deposit located upstream of a weir: from the top – less consolidated material, and from a depth of 30-40 cm – consolidated material. The physical properties of collected sediments were respectively: weight concentration – 468 g/l and 555 g/l; organic matter content – 10.11% and 8.94%; water content – 163% and 126% and void content (gaseous capillary and bubbles) – 3.1% and 8.4%. The tests allowed to quantitatively and qualitatively characterize the erosional behavior of the mud. Remarkably, the natural structure of consolidated sediment reduces its erosion resistance (compared to the mixed one), even by an order of magnitude. An opposite effect has been observed for the 'young' sediment. The disturbance of natural arrangement of not decomposed organic elements (leafs, woods, grass) in the mud leads to an increased erodibility. This study also has a relevant aspect regarding methodology when studying this type of cohesive sediments. The destruction of natural structure may lead to wrong answers. Secondly, erosion resistance cannot directly be linked to the physical parameters such as weight concentration or rheological parameters. The obtained results on the erosion values were compared to data in literature to depict the generality of the results.

As mentioned concerning the test with natural sewer sediment, a specific behavior of the deposit under the varied flows was observed. The fines from the top layer of the bed material were washed out and carried as suspended load, the granular component formed regular, quasi 2D isolated ripples moving over the undisturbed deeper deposit. In the next works [b5, b6] I put a special focus on the response of the top layer of sediment in transition between noncohesive and cohesive to deliver a more detailed description available in literature. Previous works actually concentrated on establishing the critical shear stresses and erosion/transport rates at a given flow rate, however, there was a lack of a comprehensive study on bed forms, resistance and transport. The experimental method relied on testing in the semicircular flume the noncohesive sediment as a reference material, being a fine sand with the average grain diameter d_{50}=0.19, and further testing mixtures of sand with clay with gradually increased weight concentration, i.e. 3, 6 and 10%. Test were executed in a wide range of flow condition, so the Froude number reached a value 0.6, which allowed obtaining the bed forms range from ripples, through dunes to washed-out dunes (for sand). The mixtures started to exhibit cohesive properties for the clay content of 6 %. The addition of clay resulted in the increased critical shear stress and different sediment bed response compared to the clean sand with varied flow conditions. The bed forms development was restricted to ripples in size up to 10 times smaller compared to dunes of sand for the same water flow conditions. The disturbance depth (the mobile sediment layer) was only of a few millimeters. A conclusion from this testing was that appearance of specific bed forms is the characteristic feature of partly cohesive sediments. For cohesive sediments the granular bed forms are not observed – the eroded material is rolled, brakes down and transported in suspension. For partly cohesive sediments, still bed forms, although reduced, are observed. The study further examined the bed form sizes and roughness for noncohesive material and partly cohesive material. For sand a relationship was found: $k_s/d_{50}=e^{30H/L}$, where k_s – grain roughness, H i L – height and length of bed forms. The reduced bed form sizes for partly cohesive mixtures result in lower resistance to flow. For instance, while the Darcy-Weissbach coefficient for the sand bed was 0.042, for the mixture (6-10% clay) only 0,02. The variation of the bed roughness with flow has been clearly established. Further the bed shear stress was analyzed in terms of partitioning according to a concept of Einstein (1950). The total bed shear stress was divided into the grain shear stress and bed form related shear stress. The grain shear stress is regarded as 'effective' in terms of sediment transport. Therefore the measured bed load and suspended load was related to the grain shear stress.

The article [6] extend the above study by testing additional mixture of sand, clay and an organic matter. Many works already indicated that the bed shear stress may change a little with rising flow (what was observed in the own study). Therefore, the focus was on bed shear stress partitioning and establishing the relationship between the total bed shear stress and the grain shear stress; in other words establishing the effect of bed form development on the bed shearing. In sewer pipe hydraulics a formula by Ota & Nalluri (2003) was proposed linking the total and grain shear stress in a linear fashion. However this linear formula (performing well for low flow regime), is valid for the regime of washed out dunes – in fact such conditions take place in the sewer pipe during storm conditions. Therefore I adapted an open channel formula (Brownlie, 1983) to account for the pipe effects. The obtained relationship between the total bed shear stress and grain shear stress (with prime) is $\theta_b = 0.184 \ln \theta_b' + 0.65$ (with a correction of false print in the publication).

In addition, in [b6] a scale effect has been demonstrated (also cited) by comparing the shear stress partitioning from the present laboratory study and according to methods by van Rijn (1886) and Ramez (1996) used for river flows with larger depths. The upper flat bed regime in a small laboratory flume appears at lower relative bed shear stress than in large channels.

Next works [b7, b8] form a summary of conducted experimental research, including the collaboration with the University of Sheffield, and an attempt to provide a practical implication. In [b7] an assessment of the hydraulic performance of sewer pipe with deposited sediment is made. Typically, it was argued that sediments and related bed forms reduce the capacity of sewer pipes by flow field reduction and increased resistance to flow. This was put to a closer consideration taking into account own results both for noncohesive and cohesive sediments. The papers demonstrated the potential variation of Manning's roughness coefficient as a function of the Froude number, F . For low F-number, the Manning's n for a flat bed obtained a value 0,01, and 0,017 for flow condition with dune-formed deposit. However, for the upper regime, during storm conditions equivalent to the design level, the n-value diminishes again, approaching the value for the flat bed. Thus the potential detrimental effect of bed forms disappears at the most critical situations. The sediment bed roughness (for fine sediments) can obtain even smaller value than that for pipe walls – the cohesion contributes to this. Further, the paper includes a non-dimensional analysis of the hydraulic parameters to assess to what extend the sediment bed affects the flow in pipe. The paper provides a non-dimensional plot on the sewer pipe performance with sediment deposits of different thickness and relative roughness. A small sediment deposit has a negligible effect on conveyance. The final conclusion is that it may indeed be rational and appropriate to design sewer pipelines with an allowable deposit, as it has been proposed in recent literature under a term 'allowable deposition'.

The article [6] focusses on the concept of defining the "predictability" of sediment transport. Engineers are faced with a number of sediment transport formulas derived from different tests and described as suitable for application in sewers. Bed and suspended load formulas vary in form and performance, generally depending on the data sets that were used to calibrated them. As different sediment types have been tested no single, generally valid formula has been established so far. Formulas are distributed in the scientific literature and are often reported without the information necessary to define their range of potential applicability. Therefore, this paper along with analyzing the formulas available (Ota&Nalluri, 2003, May, 1993, Ackers, 1984, Nalluri&Alvarez, 1992, Perrusquia&Nalluri, 1995, Arthur et.

Al., 1996), also comments on their development conditions and assumptions they rely on to aid engineers in the selection of the most appropriate sediment transport formulae to correspond with the environment in which they are working.

Based on own data, the formula for noncohesive sediments transport in pipes with free surface flows, according to Ota & Naluri (2003) has been positively verified. This formula adopts the well-known form after Meyer-Peter&Mueller (1948) and reads:

$$\Phi = 16.5(\theta_b' - 0.036)^{1.67}.$$

The work also deals with the predictability of cohesive sediments. Prediction formulas are based on the critical shear stress and empirical coefficients determined in the course of experimental research. To date, there is no analytical solution in this respect because of the complexity of mobility of such sediments. Also for sediments in transition between noncohesive and cohesive there is need to develop a correct, linking modelling approach.

Currently preparation works are carried out under the lead of the University of Sheffield on a monograph 'Second edition of Solids in Sewers – IWA Scientific and Technical Report'. I transferred my own input, i.e. chapter, to this publication.

The next works included in the cycle are related to an open channel – the Odra River. The works were conducted in the Institute of Meteorology and Water Management National Research Institute (IMGW-PIB) and evolve from a context of flood flow modelling and flood hazard estimates. To do it better the knowledge of hydraulic and morphologic patterns is needed for a wide range of flow conditions. For this I initiated a research project entitled 'Alluvial processes and flow resistance during floods'. The paper [b9] presents results from a dedicated field study to determine the local and global flow and morphologic characteristics for a 4 km-long reach of the Middle Odra river (km 332, downstream of the gauging station Ścinawa) including curved and straight sections of the channel regulated by groynes. A series of bed sediment sampling (sand and gravel), measurements of flows (using ADCP), bottom tracking and water levels records have been carried out at varied discharge to deliver a comprehensive set of data for the analysis of water depth, flow velocity, discharge, and hence resistance parameters. The measurements were carried out in June 2013 during a high water event, with a peak discharge of 720 m^3/s (SSQ=180 $m^3 \cdot s^{-1}$). The in-channel water depth for the maximum discharge was up to 6 meters, while for the most extreme flood in the reach depths of ca. 8 m were recorded. This study showed that the bed forms in the main channel (thalweg) reach a maximum height of 1 m and a length of 20-25 m for high water condition. The bed forms characteristics were analyzed in terms of flow conditions. The analysis of hydraulic parameters divides river cross-section into channel zone between the groynes, zone of groynes and flood plains. So the resistance for the alluvial bed has further been determined (for the first time for this river section); the Manning's n value varied in a relatively narrow band of 0,025-0,029 for the straight section, and rises in a linear fashion from 0,026 to 0,04 on the curved section. A data set from the flood in 2010 (Q ca. 2000 m^3/s) has also been used for this estimates. Also the rating curves (*H-Q* relationship) for the bank channel and central zone have been obtained, so the flow partitioning over the whole cross-section in dependence of the discharge.

Another issue tackled in this paper was the effect of groynes on the conveyance of the main channel. The hydrodynamic modelling tool MIKE11 (DHI, 2009) was used to compute the water surface elevation at the study site. Two 1D models were constructed: one used the cross-sections of the river channel measured through the groyne crests, the other used cross-sections measured through the groyne fields. Furthermore, the roughness coefficient as determined from measurements for the central zone was applied for the whole bank channel. The result is that the first model delivers a relatively good agreement between measured and recorded water levels. The other model seriously overestimates the conveyance of the Odra river. This provides an important practical clue on how to model such a river regulated by groynes in the 1D approach, i.e. representation of the channel geometry and roughness.

Further, the paper [b10] provides an extended morphological analysis of the in-situ obtained data and a prediction to the extreme flood conditions as to evaluated the potential effect of bed form development and resistance to flow during extreme floods. The analysis uses the flow velocities (extrapolation), and Foude'a number, as well the criteria for morphological regimes according to Karim (1995) and Van den Berga & Geldera (1993) (for river flow with depths larger than 1m). From the clearly established power type relationship between the water depth and flow velocity for the channel section, the Foude number is calculated for a range of possible flow conditions. I has been found that the maximum value of Froude number for the Middle Odra river can be as high as 0.34. This is the range of dunes and washing out of dunes. However, no flat bed conditions will be reached. Therefore it is believed that no significant decrease of the resistance should take place compared to those values described above. Further, the channel bed related flow, in other words, the sediment transport affected flow, is assessed in terms of the total flow. The channel contribution to flow diminishes relatively with flow; it is100% for low flows but for the discharge, say 2000 m^3/s, the in-channel flow constitutes only about 40% of the total. Hence the conclusion is, that the sediment transport becomes less significant in the overall channel conveyance capacity. It has been indicated that the groynes and bank vegetation, and vegetation on the flood plains play a more determinant role. Understandably, the relative influence of above mentioned factors is site dependent, it depends on the river channel and floodplain geometry. However, this results put light on the flood flow conditions for the Middle Odra river and help to estimate the flood hazard and flood risk as well as its management.

As my contribution to the scientific knowledge I regard:

– finding/confirmation that the critical shear stress in circular cross-sections are about 20% lower compared to the traditional Shield's values;

– demonstration of biological processes and sediment structure influence, along with the quantitative and qualitative assessment, on the erosional behavior of sewer sediments;

– the same for river muds;

– description of transport of partly cohesive sediments including morphological patterns, resistance to flow, shear stress partitioning and sediment transport rates (suspended and bed load);

– a function linking non-dimensional bed shear stress and effective (grain) shear stress and verification of formulas (performance) for the non-cohesive sediment transport in circular pipes, with ;

– support to the rationality of the concept of the allowable deposition for sewer pipe design and maintenance;

– development of a number numerical models for studying flow conditions for different river reaches;

– evaluation of the bed morphology of the Middle Odra river channel in varied flow conditions with quantifying the effect of sediment transport on the flow resistance and discharge-level relationship, taking into account the linear and curved course of the river.

– assessment of groyne effect on the channel flood conveyance and its numerical 1D modelling;

5. Description of other scientific achievement and works for water economy

In my scientific activities one may distinguish five major fields related to the open channels and pipe hydraulics and sediment transport:

- water and sediment transport and morphological processes in open channels, along with ecological aspects;
- hydrometry (flow and sediment transport measurements in open channels and laboratory experiments, yield of hydraulic structures, acoustic methods);
- numerical flow modeling (1D and 2D), in particular of floods and flood mapping,
- numerical modeling of transients in pressurized pipes and pipe networks,
- hydrodynamics of floating bodies under wave and stream action, wave energy absorption.

My record will be presented in a chronological order. I participated to works conducted by a number of institutional and inter-institutional work groups within national and international projects. Yet, before achieving the degree of PhD, I was a researcher on the project led by prof. Włodzimierz Parzonka, devoted to a study on the sediment transport (balance) and channel dynamics of the Odra river. The project was financed by National Research Found. My contribution was related to the elaboration of research methodology, execution of field measurements, data analysis, numerical calculations of the sediment transport (both bed load and suspended load) in collaboration with prof. Marian Mokwa and prof. Wojciech Bartnik from the Agricultural University in Cracow. The focus of the study on the suspended load within the project formed the core of my PhD dissertation. In parallel, I was a participant of a bilateral scientific project on the sediment mobility between the Agricultural University of Wrocław and the Ghent University. I participated to workshops and field works organized both in Poland (on the Odra and Widawa rivers) and Belgium (the Zwalm catchment).

In 2000, after completing my PhD, I worked on a study related to the training of the Widawa river in the context of protection of the Wrocław city against flood. The study included hydraulic modelling in collaboration with prof. Laura Radczuk and dr Jan Jełowicki. Next I moved to Belgium for a three months scientific stay within the bilateral project (May-July 2000). The consequence of this stay was my engagement to the Hydraulics Laboratory of the Ghent University for next seven years. Noteworthy to say that the Laboratory was created by an eminent scientist – prof. L.J Tison in 1935. The Director was prof. Ronny Verhoeven (prof. emeritus now). The Laboratory has a wide portfolio of research activities, including vascular hydraulic studies and development of an artificial heart (in cooperation with the

Medical Faculty). It is well equipped with facilities for studies of pipe and open channel hydraulics as well as with teaching set-ups.

Initially I was involved in a feasibility study of wave energy extraction in Belgian coastal sea (financed by the Flemish Research Found – FWO) under leadership of prof. M. Vantorre. My contribution was numerical and experimental study of a point absorber in heave – both the hydrodynamic behavior under varied wave conditions and design optimization. The experimental test were executed in a wave facility (100 m long wave flume) of WL Borgerhout (Antwerp) and delivered valuable physical data and linear theory verification on floating body motion under varied (regular and irregular) wave action. The study concept and results have been published in Journal of Applied Ocean Research: *„Modelling of hydraulic performance and wave energy extraction by a point absorber in heave"*, a frequently citied publication attached to the documentation among other original scientific works of the Author.

This study and gained experience resulted in later research within an EU founded project, of which the Ghent University was the coordinator (prof. Julien De Rouck) and the international consortium was formed by research institutions and a private investor. My participation was both the preparation of the project proposal and execution of the project called SEEWEC – acronym from: Sustainable Energy Efficient Wave Energy Converter under 'Workpackage 5: Refining and verification of overall design. Review and verification of parameters to be optimised from the point of view of energy absorption: Geometry of the point absorber and the characteristics of the (re)active control algorithm. (reports confidential).

Because of my experience in 3D hydrodynamic modelling I also got an research episode on the ship modelling and designing of the hull (in 2002). Its behavior were tested both in physical and numerical tests under waves and currents in shallow waters of the Scheldt estuary and of the Black Sea, to ensure the save floating of designed ships to serve the port in Antwerp. However, I soon resigned from conducting these studies in favor of my actual scientific interests.

Even in the period of studies on wave energy, I did not stop dealing with sediments. Yet, a work presenting an analysis of data on suspended sediment transport gained during my PhD study was presented at an international conference (Banasiak et al., 2002). Further, in a collaboration with Dr Robert Kasperek from the Wrocław University of Environmental and Life Sciences (formerly Agricultural University of Wrocław), a work was published concerning the mobility of multifractional noncohesive sediments – uniform and bi-modal mixtures (Kasperek & Banasiak, 2002).

Further, next to sewer sediment transport I also participated to a research project on sediment mobility (typically in suspension) under combined action of waves and current (e.g. conditions in estuaries). I conducted experimental investigations exploiting the ADV instruments laser sensors for suspended particles detection in a wave flume in WL Bogerhout and wave basin of Danish Hydraulics Institute (DHI, Denmark) (Delgado et al., 2005). The work further included an analysis of oscillating water velocity profiles and concentration of suspended matter over the water column.

Another research project had an ecological context, dealt with the restoration of selected Flemish rivers heavily trained in the past. The study included an analysis of historical morphology patters, in particular meandering, an feasibility study on the renaturalization, a laboratory study on implementation of artificial. temporal structures (deflectors) to promote development of the natural like river course (Banasiak e al., 2004).

Simultaneously, I was in charge of conducting measurement campaigns on surface and ground water gauging in selected areas (partly depression areas), as well as monitoring of releases of storm water from sewer systems into the open watercourses (via overflow structures, where measuring instrumentation was placed). This task lasted for several years with reporting on a yearly basis to the Flemish Environmental Ministry. I used to take part in hydrometric measurements, which is my fancy job.

A valuable scientific experience I also gained within a bilateral project between Polish (SGGW Warsaw - prof. Tomasz Okruszko) and the Flemish partners (University of Antwerp - prof. Patrick Meire and Ghent University). The research, next to ecological aspects, focused on the recognition of the flow conditions and water balance in the Biebrza river and its tribudaries (Poland, National Park area) and comprised hydrometric campaigns (executed in different seasons), numerical modelling, GIS applications (Verhoeven i in., 2004, Świątek et al., 2008). A relevant issue was also the influence of plants growth on flow conditions and water level – discharge relationships (to be strongly season dependent).

A similar context had another Flemish project between the Ghent University (Hydraulics Laboratory) and the University of Antwerp. Not only the plant growth in a study river (the Aa) on the flow and nutrients assimilation was investigated, but also a study on controlled flooding on the polder to effectively intercept the loads of sediments and nutrients from the Demer river during flood events. My contribution in this respect included in situ data collection (hydrometric measurements and suspended sediment sampling) and a twodimensional (2D) modelling in DELFT3D. Unfortunately, the last task was not completed because of the earlier decision of moving back to Poland.

Next to the leading involvement in open channel flow and sediment transport, a significant part of my professional work was devoted to pipe hydraulics. In a vast majority it was related to the transients in pressurized pipes and networks for water and waste water and designing the countermeasures against the water hammer (Verhoeven & Banasiak, 2005). It was mainly a consultancy work in a cooperation with the Studiebureau VERHOEVEN c.v.b.a. I am the author or coauthor of more than 200 expertise's, including ones for the networks of Antwerp, Brussels, main pipelines of fresh water in Belgium carrying water from the south – Ardennes and France – to the North. A remarkable achievement in this area was a study of a 100 km long, branched pipeline of oil products, a study for a major player in oil industry (Banasiak & Verhoeven, 2006). This concerned the safety measures for efficient and energy effective transport of oil product using special agents – additives, called 'fluidizers', which are able drastically reduce head loss with transport velocities up to 3-4 m/s. The study took into consideration the situations of the need for emergency, rapid valve closure. As a result of extended modelling a special procedure of valve control at critical sections were proposed to avoid pressure peak and drops with associated harmful cavitation.

From the period of 2008-2010 worth to mention about my valuable – in my opinion – experience obtained regarding the consultancy work: continuation of the cooperation with the Studiebureau VERHOEVEN c.v.b.a. and work for SETEC Engineering GmbH., Austria (master plan for water supply in Iraq, the northern part), project management support (Technical University of Wrocław, collaboration with prof. Marek Kozłowski), hydrotechnical, pipe- and pump station construction at Naviga-Stal sp. z o.o. The later was a role of a project engineer for the successfully constructed and put into operation water intake located in the Nysa reservoir, for the Europe's largest bioethanol refinery in Goświnowice, Poland.

The employment since 2010 in the IMGW-PIB, in the Centre of Flood and Drought Modelling has been offered new scientific possibilities in hydrology and river hydraulics domain. I am a (senior) specialist and since 2012 the deputy of the Head of the Centre. The following basic activities are to be mentioned:

Firstly, the works on flood hazard studies and flood risk estimates using hydrodynamic modelling, in particular the development and a wider application of 2D hydrodynamic modelling (in MIKE platform). The first remarkable example is a case study of a dramatic flood in 2010 on the Nysa Łużycka river and the Witka river (tributary) causing a lot of damages, including the failure of the Niedów dam (Banasiak, 2012). A 2D model was built (for a 20 km long river reach) and thoroughly calibrated based on the data collected in the field (personal survey) and by a method of successive approximations of unknown hydrologic and hydraulic values. The final outcome of flow simulations in unsteady mode was a clear picture of the passage of the flood, both in terms of water levels and flooding areas. Importantly, it has been found and demonstrated that the damage due to the dam failure was spatially restricted, so that the city of Zgorzelec did not suffer from it significantly, as it was initially argued by the German party. The report was delivered to the Head of Water Authority (Prezes KZGW) and the results were presented at a Polish-German meeting, which helped to a closure of disputes.

With the IMGW-PIB I have been involved in 2010-2015 in three major, national wide projects, being the implementation of the EU Flood Directive in Polish water management policy: 'Preliminary Assessment of Flood Risk' (WORP), IT System of the Country's Protection against Extreme Hazards' (ISOK) and 'Flood Risk Management Plans' (PZRP).

My overall responsibility in these projects was the preparation the flood hazard maps based on numerical modelling for the following rivers: Odra (on the section from Chałupki, km 20 – Słubice, km 570), Widawa, Oława, Opawa. I also consulted methodological aspects of the project and contributed to organization of the work flow. Basically, the flood hazard maps are based on 1D (MIKE11) modelling. However, I also produced a number of 2D (MIKE21) models, such as for the cities of Wrocław, Opole, Kędzierzyn-Koźle, then completed a cascade of 2D models for the Upper Odra. The realization of the model cascade further downstream for the Middle Odra in under progress (in total 22 models). Within ISOK I also executed the modelling to determine the potential flood hazard related to the embankment failure. In PZRP 2D models have also been successfully applied to evaluate the efficiency of planned or recently executed (an update) investment projects, both of the technical (including the modernization of the Wrocław System – WWW, building of the Racibórz reservoir) and non-technical type. I also constructed 2D models for cities of Głogów, Nowa Sól and Słubice to study the flood hazard due to ice jams on the Odra river, as it is a real thread in winter and early spring. Models of my authorships were also utilized in other expertise's (see list attached).

In the context of above work, to increase the reliability of modelling results and flood hazerd estimates, I initiated a scientific project: 'Sedimentation processes during flood". Next to the results outlined in the previous section [papers b9, b10], an articles has been produced '*Flood flows in the Odra River in 2010...*' [Banasiak i Krzyżanowski, 2015]. During the 2010 flood in the Odra basin a measuring campaign was executed that produced a set of data on peak discharges. Flow measurements located near gauging stations were taken from a boat with an Acoustic Doppler Current Profiler (ADCP) equipped with a GPS. The paper presents a detailed analysis of the records, including referencing to ortophotomaps, to assess the quality of ADCP recording, local flow characteristics and finally to re-evaluate the total discharge values. Further, the flow is divided between the main channel and the floodplains, while the main channel in the case of the presence of groynes is additionally divided into a central zone be-tween the groynes and zones of groynes. Partitioning of particular zones to the total discharge is calculated along with average and maximum local flow velocities. The study delivers the data for the development of more reliable numerical modelling tools, which in turn may fulfil the measuring gaps in situ. It is shown that the modern field data acquisition, GIS post processing, and numerical modelling support each other and improve the final overall result, bringing hydrologic products to a higher stand-ard. The synergy of hydraulics and geoinformatics in hydrology is therefore highly recommendable. This study can be considered as a introduction to next scientific activities of the Author.

Further, I performed numerous presentations on flood hazard estimation and numerical modelling (eg. http://www.isok.gov.pl/dane/web_articles_files/189/06-1-r-banasiak-modele-hydrodynamiczne-i-tworzenie-map-zagrozenia-powodziowego.pdf). I have been participating to the public consultancy of the project deliveries.

In total, my scientific record comprises 58 published works, including 8 per reviewed papers in international journals, 4 articles in national journals, 37 full papers published in conference proceedings (11 before obtaining the PhD degree), 9 publications in books of abstracts. I participated to 12 scientific projects, being an executor of 8, chief executor of 3 an 1 the project leader. I am author or co-author of 9 project reports, 16 expertise's and over 200 expertises's on transients in pipes and their protection against water hammer. The language of publications was predominantly English. I took and presented works at 14 international conferences and 12 national conferences and multiple workshops. The table below gives a summary of publications in journals with impact factor.

Summary of scientific publications

Lp.	Type	Before PhD	After PhD	Sum
1.	Monographs		-	-
2.	Scientific papers: a) published in journals from Philadelfia list, JCR - autor - coauthor b) other per-review journals c) published in international and national conference proceedings d) published in international and national conference proceedings as abstracts	11 11	47 6 1 5 6 26 9	58 6 1 5 6 37 9
3.	Unpublished works (scientific and technical): including: a) realized in scientific grants b) studies c) expertise		231 8 3 220	231 8 3 220

List of publication with impact factor (IF) and points by MNiSzW, December 2014 r.

Periodic	Impact factor IF	Reference number to list A	Number of publications	Points
Applied Ocean Research	1,212	900	1	25
Water Research	5,323	10803	1	45
Water Air and Soil Pollution	1,685	10797	1	25
J. of Hydraulic Engineering	1,258	6236	1	30
Water Science and Technology	1,212	10808	2	20

The total impact factor IF of listed works is 11.9. The number of citation according to the Web of Science (without selfcitations) – 49, the Hirsch index (WoS) – 3. The total number of citations by Scholar – 185.

Since 2007 r. I have been listed in an American bibliography *Marquis' 'Who's Who in Science and Engineering'*. I reviewed two papers for J. of Hydraulic Engineering and Water Research and one paper for a conference on wave energy extraction (in the period 2007/2008).

My teaching experience goes back to the PhD studies, were I conducted exercises on the subject 'hydraulic engineering'. During my work at the Ghent University I did exercises and examination on hydraulics – laboratory experiments. This was for both regular university students and for students from a program IUPWARE ('Master of Water Resources Engineering', Leuven et al,), dedicated to the Third World and developing countries. Teaching language was Dutch and English, respectively. In addition, I speak German and Russian. I took a course 'Scientific English'.

I was the supervisor of two master thesis's and a reviewer a several others. Currently I am the supervisor of one PhD student.

Robert Banasiak