Józef Żychowski

Issues connected with scientific research

During my master's course the subject of my research was physical geography. In particular I focused on the influence of anthropogenic factor, or changes in use, on the development of young valley landforms in the Osława catchment area. Field research was an integral part of investigating the morphology of valleys in the Osława catchment area. I ascertained that forest is conducive - particularly during heavier precipitation - to deep gushes in weathered layers by periodic watercourses, with their valleys characterised by narrow beds and steep sides. After deforestation I observed rapid development of hillslope processes on the hillsides. In places, where the weathered layer is thick, care should be taken in making reforestation decisions, and even not allow it to go ahead. The additional research results on discharges were published by me at a later date.

Żychowski J. 2002. Zalesianie stoków górskich w strefach nadgranicznych przyczyną degradacji środowiska przyrodniczego w przyszłości. [Mountain hillslope reforestation in border regions as a cause of degradation of the natural environment in the future] [in:] Czynniki i bariery regionalnej współpracy transgranicznej - bilans dokonań. , ["Factors and obstacles for regional trans-border cooperation - summary of achievements."] 50th Polish Geographical Society Convention. Rzeszów University

Upon graduation I was employed by Zakład Geografii Fizycznej IG WSP where initially my interests focused on geomorphology. I was looking for quantitive methods to parameterise the environment. Together with my co-workers we suggested the surface formation indicator or landform relief index. It allows for a quantitive representation of landform relief and for a presentation of landform relief classification in an objective manner. The said research was significantly limited by measuring areas on maps. Together with G. Kawka I was granted a patent for a planimetric device for measuring irregular surfaces.

Lach J., Tabor J., Żychowski J., 1979. Der Dehnungskoeffizient fur die Oberflache als morphometrisches Mass des Reliefs. Wissenschaftliche Zeitschrift. Dresden.
Lach J., Tabor J., Żychowski J., 1980. Współczynnik rozwinięcia powierzchni jako wskaźnik syntetycznego przedstawienia rzeźby. ["Surface formation index as an indicator for synthetic relief representation."] Rocznik Naukowo-Dydaktyczny WSP in Kraków. of 71, Prace Geograficzne VIII.
Kawka G., Żychowski J., 1984. Układ pomiarowy powierzchni plam barwnych tworzących obraz, ["Surface measurement system for colour coded representation"] PPR patent specification No. 193379.

In my Ph.D. thesis I determined the influence of selected geographical environment elements - taking into account their characteristics - on discharges in 2 small catchment areas. Natural environment elements were presented quantitatively and comprehensively indicating the differences between the catchment areas. Such a holistic approach was grounded on in-house and field research as well as my own limnigraph records. I paid particular attention to the characteristics or discharge parameters: including the high frequency periods and duration of freshet waves depending on the type of precipitation and the relation between discharge volumes as recorded by individual hydrographs and atmospheric precipitation. I determined functions expressing the relationships between heavy and persistent precipitation and daily freshet waves. This research showed that apart from land use, the intensity and character of precipitation affects the transformation of precipitation into discharge. I also determined that intense heavy or storm precipitation in a given day cause relatively larger discharges in the

catchment area with a higher concentration of forests. Furthermore, I determined what precipitation intensities and which catchment area characteristics affect the way in which water levels rise in river channels following rain free periods.

Żychowski J., 1988. Wpływ wybranych elementów środowiska geograficznego na odpływy w małych zlewniach Beskidu Niskiego, ["The effects of selected geographical environment elements on discharges in small Beskid Niski catchment areas"] Streszczenia prac habilitacyjnych i doktorskich, [Ph.D. theses abstracts], 1987.
Żychowski J., 1988. Wpływ wybranych elementów środowiska geograficznego na kształtowanie wezbrań w małych zlewniach wschodniej części Beskidu Niskiego, ["The effects of selected geographical environment elements on freshnets in the eastern part of Beskid z Niski"] Sprawozdania Posiedzeń Komisji Naukowych [Scientific Committees Reports"], Volume XXX/1-2, January - December 1986
Żychowski J., 2000. Przyczyny różnej transformacji opadów w odpływy w dwóch zlewniach Beskidu Niskiego ["Reasons for different transformations of precipitation into discharges in two Beskid Niski catchment areas"]. [in:] "Działalność człowieka i jego środowisko" ["Human activity and the environment"], edit. Z. Zioło. Wyd. Nauk. AP, Kraków. P. 93 - 121.

The research which I conducted on 5 small catchment areas in Beskid Niski drew my attention the effects of anthropogenic impact on Jasiołka channel processes in Beskid Niski. I analysed the causes of river bed erosion in Karpaty and the changes to channel processes over time. I concluded that the uptake of gravels from Jasiołka river bottom, using heavy machinery, reduced the erosion base for tributaries by more than 1 m. I also determined the rate of river bed erosion for a tributary of Jasiołka. This research indicated significant erosion as well as reduction in the level of groundwater in valley sides where I observed a reduction of the erosion base.

Żychowski J., 1995. Zagrożenie dla środowiska geograficznego eksploatacją żwirów na Jasiołce, Człowiek a Środowisko ["Danger to the geographic environment posed by Jasiołka gravel dredging, Man and the Environment"] 44th Polish Geographical Society Convention, Toruń 24-27 August 1995.

In order for a quantitive assessment of the spatial distribution of geographic elements in catchment areas, such as land usage, areas of a given actual inclines, eastern rock formations etc, I constructed an appropriate measure. It allows for a comparison of indicators relating to a given element of the environment in catchment areas under assessment and the distribution of different elements in that same catchment area.

Żychowski J., 1991. Propozycja ilościowej oceny przestrzennego rozmieszczenia cech elementów środowiska geograficznego w zlewniach. ["Proposal for a quantitive assessment of geographic environment elements spatial distribution in catchment areas."] Rocznik Naukowo-Dydaktyczny WSP in Kraków. of 142, Prace Geograficzne XIII.

Based on 17 catchment areas of Beskid Niski and Pogórze I determined a relationship between the average catchment area incline calculated using simplified methods (Kajetanowicz, Strahler) and Staeinhouse (1942) exact method.

Żychowski J., 1999. Średnie nachylenie zlewni ["Average catchment area incline"], Polish Hydrological Conference Kraków - Dobrzyce, 21-23 May 1999 r., "Interdyscyplinarność w badaniach dorzecza" ["Interdisciplinary approach to water basin research"] (conference materials).p. 173-175.

Ac a comprehensive water quality measure I proposed the regional physical and chemical potable water quality measure. It allows for a comparison of the quantity of different ions (WR_z) and regional water quality (WJ) regardless of the concentrations of ions being measured. This indicator is a relative measure.

Żychowski J. 2002. Miernik regionalnej fizyczno - chemicznej jakości wody do picia. ["Measure of regional physical and chemical potable water quality"] [in:] "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], v. II. Pub. Uniwersytet Łódzki, edit. Burchard J., Łódź, p. 275- 282.

I also assessed the differences in precipitation at neighbouring precipitation stations (7 km) located in Beskid Niski. In this research I focused on: frequency of days with rain of different intensities, total number of rainy days, volume of precipitations of different intensities on a unit of area, volume of precipitations of different durations on a unit of area, frequency of precipitations of different durations as well as variations of rainfall intensity with duration of over 5 days. I concluded that the largest differences between Jaśliska and Tylawa stations pertain to those years, where average precipitation significantly exceeded historic figures. Intensive, long lasting precipitation as well as storms were the reasons for the indicated differences. During periods of non-intense rainfall, the differences between the stations are smaller.

Żychowski J., 1996. Ocena porównawcza reprezentatywności posterunków opadowych w Beskidzie Niskim. ["Comparative assessment of precipitation stations representativeness in Beskid Niski."] Rocznik Naukowo-Dydaktyczny WSP in Kraków. of 184, Prace Geograficzne XIII. P. 83-101.

I also researched the effects of a trellis drainage system on the variations to groundwater discharges in catchment areas of a similar size. To do this I used my own limnigraph records. The research encompassed: groundwater discharge characteristics, recession curves, effects of the environment on recession curves and relation between groundwater resources and environmental characteristics. I demonstrated significant differences in groundwater discharges between the catchment areas subject to research. In Maszanka catchment area - with the main subsequent valley compared to the obsequent Bełcz valley - with the dip of the strata on the opposite direction to the flow direction the groundwater discharges, catchment area retention etc. are twice as large.

Żychowski J., 1999. Zróżnicowanie odpływów gruntowych w rzeźbie rusztowej na przykładzie reprezentatywnych zlewni Beskidu Niskiego ["Variation in groundwater discharges in a trellis drainage system based on a representative example of Beskid Niski catchment area"]. Wiadomości Ziem Górskich, 33-49.

In a co-authored historical and geographic monograph of the Brzesko commune I presented the state of anthropogenic transformation of its geographical environment. The research pertained to atmospheric pollution - emissions and ambient concentration, chemical quality of surface and underground waters, bacteriological contamination of water, industrial and communal wastes, concentration of elements in the soil (own field research) and hydro management. We demonstrated time trends for fluctuation of contamination indicators in, for example, air, water, soil etc. We indicated locations and years, where the highest temporary concentrations of researched contaminants occurred. We also defined the causes for these trends.

Lach J., Żychowski J., 2006. Antropogeniczne przeobrażenia środowiska przyrodniczego ["Anthropogenic transformation of the natural environment"]. [in:] Kiryk F., Lach J., (edit.). Brzesko. Dzieje miasta i regionu ["History of the town and region"]. Urząd miejski w Brzesku ["Brzesko Town Hall"], 1037 - 1057.

In a number of articles I treated the problem of the effects of human activities and environmental characteristics on the spatial distribution of elements contained therein. I conducted these researches with the aid of a world class device (Elmer Perkins 2001, Annalyst 200). They pertained to: Zn and Cu circulation in the area of foot of Pogórze Karpackie, spatial variations in relative concentrations of Zn and Cu at selected local government units, their concentrations in selected environments, relationship between Cu and Zn concentrations with environmental characteristics and delimitation of Zn and Cu concentrations within the region of Bochnia. In my work on Zn and Cu concentrations I researched their concentrations in soil (own results), rocks and plants (own results), their wet and dry depositions and methods for removal of these elements by clover crops. I also took into account the historical crops (own calculations). I concluded that relatively large amounts of the following elements are removed from the researched environments: Zn in the Raba valley and Cu from Przegórze and Pogórze Karpackie. I determined that Zn - in the northern section (Dolina Raby) and Cu - in the southern (Przedgórze and Pogórze Karpackie) circulations are similar.

The tests also included the concentrations of many elements in characteristic environments of Brzesko commune. Due to the concentrations of characteristic elements I distinguished different types of environments: forests and open fields, between houses, by roads and in the vicinity of various human activity locations. I demonstrated significant spatial differences in the concentrations of elements within a relatively small area. Different landform reliefs also impact these variations. Elements, which are characteristic for the research conducted in Karpaty and areas forming landform basins were also identified. I paid particular attention to locations with maximum concentrations of heavy elements.

In another report I recognised spatial differences in Zn and Cu concentrations in soil in the vicinity of Bochnia. Within the scope of that work I delaminated locations with characteristic concentration. I also determined patterns in Zn and Cu concentration changes in relation to distance from roads and in relation to the environmental characteristics, such as predominant wind directions, landforms, buildings, forests etc. I demonstrated, amongst others, that the highest Zn concentrations occur in the vicinity of PKS station (national coach station), stop in city centre, upper parts of steep road inclines, road sheer slopes and in the vicinity of zinc plated road side barriers. Whereas the largest concentrations of Cu were present in the vicinity of roadways. This was particularly true for long road inclines and in the most direct vicinity of the road (up to 5 m) on the leeward side. I observed the lowest concentrations of Zn and Cu in airy areas: upper parts of hills, in the foothills, behind compact buildings etc. I determined the reasons for small Cu and Zn concentrations in estates. I also demonstrated a different trend for changes in Zn concentrations with respect to Cu in relation to the distance from the roadway. I noticed a different concentration of elements subject to research in the western part of the research area, where increased human activity is to be observed that in the eastern part - small economic units. I demonstrated various correlations between Zn and Cu depending upon the location of the research area in relation to the prevailing wind direction.

Żychowski J.,2000. Obieg cynku i miedzi w strefie progu Pogórza Karpackiego na przykładzie okolic Bochni [Zinc and copper circulation within the ears of the foothills of Pogórze Karpackie]. [in:] " Działalność człowieka i jego środowisko" [Human activity and the environment"], edit. Z. Zioło. Pub. Nauk. AP, Kraków. P.153-163.

Żychowski J., Kolber M., 2003. Zróżnicowanie składu chemicznego gleb na obszarze zurbanizowanym w strefie progowej Karpat (na przykładzie gminy Brzesko, [Differences in the soil chemical composition in the urbanised area of the foothills of Karpaty (on an example of Brezsko commune)] [in:] Dynamika zmian środowiska geograficznego pod wpływem antropopresji [Changes in the natural environment subject to anthropogenic impact] (edit. J. Lach), Narodowy Fundusz Ochrony środowiska i Gospodarki Wodnej, Akademia Pedagogiczna, Kraków, p.240 - 249).
Żychowski J. Kolber M., 2005. Zróżnicowanie zawartości cynku w glebach w strefie progowej Karpat [Differences in the soil copper content in the foothills of Karpaty] . [in:] Struktury i procesy społeczno - gospodarcze w różnych wymiarach terytorialnych. [Socio - economic processes and structures in different geographical territories.] University of Szczecin, Polish Geographical Society, Szczecin Branch, Szczecin. Oficyna IN PLUS. 54th Polish Geographical Society Convention "Geograficzne aspekty badań morza i wybrzeża". ["Geographical aspects of sea and coast research."] Szczecin - Świnoujście 9 - 11 June 05
Żychowski J. 2006. The effect of abiotic environment on Cu content in soil on the example of urbanized area. Ecological chemistry and engineering. 13. 591 - 596.
Żychowski J., 2007. Delimitation of zinc and copper concentration in Bochnia soil. Ecological chemistry and engineering. V. 14, No. 1. 91-97.

The next research issue was the impact of the geographical environment on the quality of groundwater in rural areas. I tested contamination of waters by: manganese, copper, zinc, aluminium and fluoride ions, anionic and cationic detergents with the use of a DX-120 DIONEX ionic chromatograph. In this work I demonstrated spatial differences in the groundwater chemistry dependent upon the characteristics of the environment and anthropogenic factors in Nowy Wiśnicz commune. Excession of the allowable concentration levels of detergents and manganese ions were sporadically present in the valley bed or within lower local flattenings. I detected detergents in 25 out of 95 tested wells in 8 villages. Their concentrations exceeded the limits set by concentration regulations in a few of the wells. Aluminium, zinc and copper ions were rarely present, and if so, then at low concentrations. Such cases were observed in lower parts of the hillsides. In the tested samples I demonstrated a shortfall of fluoride.

Żychowski J. 2002. Jakość wód podziemnych w gminie Nowy Wiśnicz [Quality of underground waters in the Nowy Wiśnicz commune]. [in:] Geograficzne uwarunkowania rozwoju Małopolski [Geographical preconditions for development in Małoposka]. Edited by Zb. Górki, A. Jelonka, Kraków.

A research problem which was initiated by Professor Jan Lach Ph.D, and which I was involved with since 1995, was the impact of cemeteries on the quality of underground waters. I presented the initial findings at the 1996 conference in Kraków. I presented most results on an up to date basis (since 1997) at conferences on water quality organised by the University of Łódź. I presented some of the results at some other universities and the Polish Academy of Sciences in Kraków. These works covered: concentrations of different ions, selected amino acids, organic compounds and bacteria in groundwaters under cemeteries or the surrounding areas.

The first peer-reviewed publication on this subject pertained to the evaluation of contamination of groundwaters under 77 cemeteries, located in various regions of south-east Poland. I conducted these tests together with colleagues for the following ions: NO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-}, F^-, $NH_4^+$and K^+. The largest excessions of the allowable concentrations for potable water occurred for the following ions: NO_3^-, SO_4^{2-}, NH_4^+ K^+ and to a smaller degree $PO_4^{3-}$and Cl^-.I recorded the largest excessions in valley beds located in Pogórza, Kotlina

Sandomierska, Oświęcimska and Żywiecka and to a smaller degree in Wyżyna Krakowska and Doły Jasielsko-Sanockie. Relatively lower concentrations of these ions were present in Beskidy and Wyżyna Lubelska. I recorded the lowest concentrations in Wyżyna Miechowska and Działa Proszowicke, and thus at locations with deep groundwaters. The quality of water in wells at cemeteries does not raise many objections also at upper parts of hillsides in the central foothills area. Whereas in the Karpaty foothills zone I recorded single incidents of very high concentrations of the following ions: NH_4^+, PO_4^{3-} and NO_3^-. Significantly varied results were present in limestone structures , where the groundwater level lies deep, and the inflow of contaminants is dependent upon the course of fissures. The research indicated the significance of soil, relief, weather conditions and the fluctuations in the water level in the negative impact of cemeteries on the environment.

Żychowski J., Kolber M., Górski P., 1996. Poster: Stan fizyko-chemiczny wód podziemnych w pobliżu cmentarzy [Physical and chemical state of underground waters in the vicinity of cemeteries], [in:] Ogólnopolskie Sympozjum "Dynamika zmian środowiska geograficznego pod wpływem antropopresji", ["Changes in the natural environment subject to anthropogenic impact" symposium] (conference materials), Kraków, 26-27. 09.1996. p.165–166.
Żychowski J., Lach J., Kolber M., 2000. Właściwości fizyczno–chemiczne wód podziemnych nekropolii Polski południowo-wschodniej [Physical and chemical characteristic of necropoles groundwaters in south-east Poland] , in: "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], v. I. Edit. Burchard J., pub. University of Łódź, Łódź, p. 249–261.

Sometime later, together with my co-workers I expanded these tests to include groundwater chemical composition analyses in the vicinity of necropoles in southern Poland. We paid particular attention to the role of soil conditions. The lowest groundwater contamination in the vicinity of cemeteries was observed if they are located on Holocene alluvium and in oxbow lakes filled with low porosity sediments. This is particularly clear in areas with a small incline. Whereas heavy contamination occurred when the aquifer consisted of sands and gravels, and in particular underlain by Miocene clay aquifuge such as those on the bed of Kotlina Sandomierska. We also observed significant concentrations of ions at the foothills of Wyżyna Krakowska and Karpaty. In these regions, larges inclines facilitated dispersion of the tested ions over larger distances. Ion concentrations varied over time and corresponded to precipitation. Sulphate and potassium ion excessions of double the limit and similar phosphate ion excessions were most common. However, we recorded these in the vicinity of a significantly lower number of cemeteries. Whereas ammonium ion excessions and in particular fluoride were sporadic. Large excessions of nitrate levels were also rare along the courses of rivers.

Żychowski J., Lach J., Kolber M., 2000. Przestrzenna zmienność chemizmu wód podziemnych w otoczeniu nekropolii w Polsce południowej [Spatial variations in groundwater chemical composition in the vicinity of necropoles in southern Poland]. "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], V.I. Pub. University of Łódź, Łódź, p. 261–269.

I conducted the first research on the impact of mass graves on the soil and groundwaters in Niepołomice pertaining to a WW2 grave. The upper parts of the tested cross section contained relatively high amounts of elements originating from human corpses: Na, Ca, Cl, C, N, P i S. Concentrations of these elements increased with the depth of the tested cross section. Whereas in a control location their concentrations decreased with depth. The concentrations

of tested elements were smaller by a few orders of magnitude in control locations, for example Ca – 4 times, Na, Cl – 3 times, S – 2 up to 4 times and N – 8 times. I also confirmed the presence of phosphorus in the tested sediments: Na_3P, Cu_3P_2, Ca_3P_2, PCl_3, $Ca(H_2PO_4)_2$, P_3N_5, $Al(H_2PO_4)_3$, K_3P, PBr_5 and $[PH_4]J$ as well as sulphides: Na_2S, CuS, ZnS, NiS, K_3S, PbS and MnS. Water sampled from a puddle and a ditch located below a mass grave exhibits large concentrations of many ions: nitrate, phosphate, iron, manganese, zinc and copper.

Żychowski J., 2000. Wpływ masowego grobu zlokalizowanego w utworach aluwialnych na jakość środowiska przyrodniczego [Impact of a mass grave located in alluvial formations on the quality of the natural environment]. [in:] "Środowisko przyrodnicze i gospodarka Dolnego Śląska u progu trzeciego tysiąclecia" ["Natural environment and economy of Dolny Śląsk at the brink of the third millennium"], 49th Polish Geographical Society Convention , Szklarska Poręba, 20-24 IX 2000 r., Wrocław 2000. p.161 - 167.
Żychowski J., 2000. Wpływ lokalnego, holoceńskiego czynnika na jakość utworów terasy plejstoceńskiej [Impact of local, Holocene factor on the quality of Pleistocene fluvial terrace], [in:] Transformacja dolin plejstoceńskich w holocenie [Transformation of Pleistocene valleys during Holocene]. Strefowość i piętrowość zjawiska [Phenomenon zoning and accumulation]. (13-14 April 2000 r.), the Polish Academy of Sciences symposium, Komitet Badań Czwartorzędu, Stowarzyszenie Geomorfologów Polskich, UŚ Wydział Nauk o Ziemi, p.127-130.

Testing for selected amino acids was an innovative undertaking, perhaps even on a World scale: lysene, glutamic acid, glycine and isoleucine in groundwaters at selected cemeteries in south-eastern Poland. These compounds are a product of protein decay, or putrefaction. These are both simple and more complex amino acids which similar to lysene decay as a result of decarboxylation into less complex substances such as cadaverine (toxic ptomaine). I conducted these tests together with colleagues using a HPLS chromatograph. We analysed samples from, 71 wells located at cemeteries on the following beds: sand (16), alluvial (26), loess (20) and flysh clays (9). Additionally we also collected 19 samples in order to determine hydro - amino acid background. The concentration of lysene in tested waters collected from cemeteries are double that of glutamic acid. We recorded the highest concentration of lysene in groundwaters of cemeteries located at river fluvial terraces - 2.3 mg/1. Lysene concentrations in samples collected from the aforementioned cemeteries are circa 1/3 more than the background. Only on clay soils lysene concentrations were more than that in control material. Glutamic acid occurred in most of the tested sediments at similar concentration levels, circa 1.1 mg/l - in clays 0.9 mg/l. Thus lysene proved to be a better measure for organic contamination.

Subsequent tests showed that the largest concentrations of glycine occur in waters under cemeteries located on alluvial formations and loesses. Its average concentration in these formations exceeds 10 ppm and is higher than the concentrations of other amino acids. The largest differences between the concentration of glycine in tested waters from cemeteries and their hydro - amino acid backgrounds were recorded in loess formations. These differences are also significant in alluvial formations and in sands. Whereas in clay formations, the smallest concentrations of glycine were observed. Its migration is limited by the low porosity of the soil. We determined that glycine concentrations above 12 ppm, indicate its origin in corpse decomposition. Furthermore we noticed that the location of the burial site clearly differentiates the concentration of discussed amino acids.

Żychowski J., Lach J., Kolber M.,2002. Zróżnicowanie zawartości lizyny i kwasu glutaminowego w wodach podziemnych na wybranych cmentarzach w Polsce południowo - wschodniej [Differences in the concentrations of lysene and glutamic acid at selected cemeteries in south-east Poland]. [in:]

"Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], v. II. Edit. Burchard J., pub. University of Łódź, Łódź, p. 241–251.
Żychowski J., Lach J., Kolber M., 2003. Zróżnicowanie zawartości wybranych aminokwasów w wodach podziemnych na cmentarzach w różnych podłożach" ["Differences in the concentrations of selected amino acids in groundwaters at cemeteries on different beds"].[in:] XIII Ogólnopolska Konferencja Naukowa entitled "Chemizm opadów atmosferycznych, wód powierzchniowych i podziemnych. [Chemism of atmospheric precipitation, surface waters and groundwaters.] University of Łódź, 2 - 14. 11. 2003 Łódź, Przegląd Geologiczny. 51, 11.
Żychowski J., Lach J., Kolber M., 2003. Występowanie aminokwasów: glicyny, leucyny i izoleucyny w wodach podziemnych na cmentarzach zlokalizowanych w różnych środowiskach [Occurrence of amino-acids: glycine, leucine and isoleucine in groundwaters at cemeteries located in various environments]. Przegląd Geologiczny. Vol. 51, No. 11, p. 962–963.
Żychowski J., Lach J., Kolber M., 2005. Zróżnicowanie zawartości glicyny, leucyny i izoleucyny w wodach podziemnych na cmentarzach zlokalizowanych w różnych podłożach [Differences in concentrations of: glycine, leucine and isoleucine in groundwaters at cemeteries located on various soils] [in:] "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to the quality of water in Poland."], v. III, Edit. Burchard J., pub. University of Łódź, Łódź, p. 281–290.

I broadened my interests pertaining to the concentrations of amino acids in groundwaters by tests for concentrations of other, selected organic compounds: lysene, cadaverine, bromine-dichloromethane, chlorenvinfos, etholamine, chloride, chlorocholine and phosphamidon. I collected groundwater samples from a piezometer located within the scope of a mass grave. I detected lower concentrations of lysene - 1.45 mg/l w as compared to the results obtained for cemeteries. They indicate the final stage of decomposition. Comparatively high concentration of etholamine (1.98 µg/l) in the tested groundwater indicates slow decomposition of fats in this environment. On the other hand the existence of chlorenvinfos (1.21 mg/l) excludes alkaline environment of the burial site. In the tested samples I recorded relatively high concentrations of the toxic chloride chlorocholine (2.41µg/l), which is corrosive. Furthermore I demonstrated the occurrence, I think of low concentrations, of cadaverine (0.11 mg/l) which is also harmful to health.

Żychowski J., 2007. Wpływ masowego grobu na zawartość wybranych związków organicznych w wodzie gruntowej [Impact of a mass grave on the concentrations of selected organic compounds in groundwater] [in:] "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], v. IV, Edit. Ziułkiewicz M., pub.. University of Łódź, Łódź, p. 359–366.

I also analysed, together with co-workers, the concentrations of those ions which are most frequently tested for around the world under cemeteries. We collected water samples from piezometers placed in a mass grave and it a control site. Their analysis was conducted using liquid chromatography. Furthermore, we used the ASA (Elmer Perkins 2001, Aanalyst 200) method for testing soil samples. Immediately after drilling the hole we detected in the piezometer water sample, significantly higher concentrations of phosphate ions and significantly lower concentrations of nitrate ions than at the control site. Under a mass grave, groundwater, as compared to the control sample, exhibits higher concentrations - from 2 to 5 times - of nitrate, ammonium, phosphate, chloride and sulphate ions. In samples collected at various depths under the mass grave, we also confirmed the occurrence of elements at higher concentrations, such as: F, Ni and Cl (by a few orders of magnitude), P, N, S and K (by two orders of magnitude) and slightly higher J, Mn, Cu and Zn, than at the control location.

Żychowski J., Lach J., Kolber M., 2007. Wpływ podłoża z masowym pochówkiem z II wojny światowej na skład chemiczny wód gruntowych [Impact of soil with mass burial sites from WW2 on the chemical composition of groundwaters] [in:] "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], v. IV, edit. Ziułkiewicz M., pub.. University of Łódź, Łódź, p. 349–358.

I conducted detailed tests of the phenomenon of decomposition together with my co-workers on the mass grave in Niepołomice. To this end we uncovered two cross-sections. One in the vicinity and the second above the burial site. Additionally we performed two bores, one in the mass grave and the second as control. Mineral - petrographic tests of the collected samples were performed using: polarising microscope and scanning microscope. We also tested for relative concentration of the following elements: Na, K, Mg, Ca, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Al, Si, Pb, N, P, S, F, Cl and I as well as selected chemical compounds using the ASA method. For compiling the results we used Statistica statistical software. The differences between the concentrations of elements in the tested cross-sections as well as their concentrations diminishing with depth suggest that many elements migrate from the burial site: P, Cl, F, Na, Zn, Cu, I as well as K, Ca, S and N. Whereas we did not confirm that Cd, Cr and Al and probably Pb also originated from the buried corpses. We included Fe and Mn as elements associated with the environment. Many ions, such as Ca, K, Mg, Ni and Cd migrate from the burial site together with water and precipitates in the form of various compounds in the water level fluctuation zone. On iron hydroxides we observed phosphorus compounds (effects of phosphate ions sorption). Higher concentrations of elements in the upper parts of the cross sections as well as high rH (5) indicate dominance of oxidation processes. Whereas in the lower sections of the tested cross sections, frequent upward movements of the water level leads to reduction processes. This is indicated by low rH (12). Significant microscope magnifications allowed us to notice, in the sandy sediments - collected from the immediate vicinity of the trace - secondary minerals and organic concentrations.

Żychowski J., Pawlikowski M., Lach J., 2006. Produkty dekompozycji szczątków organicznych na przykładzie masowego grobu w Niepołomicach. [Products of organic remains decomposition on the example of mass grave in Niepołomine] Uczelniane Wydawnictwo Naukowo-Dydaktyczne. AGH Quarterly. Geology 32, 2, 203 - 225.

Working with an archaeologist and a geologist I also tested the impact of a Gothic grave from the Roman period, located in Babi Dół near Gdańsk on the changes to the mineral and chemical compositions of sediments and backfill. We collected samples from a number of environments: a depth at which the burial site was located, from undisturbed areas around the grave and ouklip layers containing iron oxides and hydroxides. Observations of the morphology of iron compounds and products of corrosion of brown clips concentrations were conducted by the sue of a scanning microscope. We use a Polmi A microscope to analyse powder samples from the sediments. Whereas phosphate ions in solutions of samples from the vicinity of the burial site were treated with a Spektol spectrometer. This work indicated, amongst others, that oxides, carbonates, phosphates, chlorides and copper sulphates which occurred with the aid of the products of burial site decomposition are the products of bronze clips corrosion. The products covering the bronze clips were weakly crystalline. There were no tin compounds, which are one of the main components of bronze in the clips. The reason was mainly low temperature, which causes a physical transformation of tin. In these tests we demonstrated sorption - of phosphorus compounds extracted from the grave by iron oxides. The sediment in the vicinity of the grave as well as the sediment of the backfill contained

insignificant concentrations of phosphorus genetically associated with decomposition. PO_4^{3-} ion concentration tests indicate their migration from the nearby Radunia.

Mączyńska M., Pawlikowski M., Żychowski J., 2006. Wyniki badań mineralogicznych i chemicznych grobu 104 i jego otoczenia. Cmentarzysko kultury wielbarskiej Babi Dół-Borcz, powiat Kartuzy. [Results of mineral and chemical compositions tests of grave 104 and its vicinity. Burial site of Dól-Borocz Weilbark culture, Kartuzy poviat. Pomorania Antiqua. Archeological Museum in Gdańsk, vol. XXI. 249- 263.

I also began research on the impact of cemeteries and mass graves on the presence of bacteria in groundwaters. I tested for the presence of bacteria, which were detected in the vicinity of burials sites in Europe and Australia: *Bacillus cereus, Staphylococcus aureus, Staphylococcus sp. T., Clostridium perfringens,,* Streptococcus genus bacteria - - faecal streptococci (FS) as well as faecal bacteria similar to E. coli - thermotolerant coliforms (TTC). These bacteria occur in large quantities in human bodies and they were measured in climates similar to that of Poland. I performed these tests in the vicinity of 9 cemeteries and mass graves as well as at control sites. I observed the largest differences between the quantity of bacteria (*Staphylococcus aureus and* faecal streptococci FS) in water from wells at or below burial sites in Mikluszowice, Cerkiew and Biecz and their bacteriological backgrounds. Increased quantities of bacteria (*taphylococcus aureus* and and to a lesser degree - thermotolerant coliforms TTC) are favoured by sandy soils, shallow levels of groundwaters, young burials sites and landslide prone areas. The tests conducted during stable conditions of a moderate climate, indicate a small impact of burial sites on the number of bacteria in groundwaters and their surroundings.

Żychowski J., 2009. Wpływ wybranych cmentarzy i masowych grobów z I i II wojny światowej na obecność bakterii w wodach podziemnych [Impact of selected graves and mass burial sites from WW 1 and 2 on the presence of bacterium in groundwaters] [in:] "Stan i antropogeniczne zmiany jakości wód w Polsce" ["State and anthropogenic changes to water quality in Poland"], v. VI, edit. Ziułkiewicz M., pub.. University of Łódź, Łódź, p. 359–366.

I also tested the impact of burial sites on the environment comprehensively, taking into account biotic elements. These tests pertained to the impact of a mass grave on the composition of elements in: soil sediments, pine resin, birch touchwood, above ground moss as well as incrustation on a cut down stump of pine. I analysed the solid samples using the ASA method. Whereas I tested air samples collected above the mass grave using a gas chronomatograph. I assessed the scale if the impact based on the differences in the concentrations of elements in the grave environment and control sites. In the vicinity of the tested grave I demonstrated relatively high concentrations of elements which originate from decomposition: P, S, N, C, Cl, Na and Ca. Particularly characteristic was the high concentration of P in the soil and air. In the air above the mass grave I also detected many chemical compounds in a gaseous form: H_2, HBr, HJ, SO_2, CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_2H_2, PH_4, H_2S. A qualitative analysis of gasses, after eliminating the background, demonstrated the existence of phosphane family gasses. Whereas I did not prove the presence of N and P in resin. This is probably associated with the fact, that pine has a taproot, which penetrates to greater depths of the soil.

Żychowski J., 2009. Zawartości pierwiastków w wybranych elementach środowiska przyrodniczego otoczenia masowego grobu położonego w Puszczy Niepołomickiej [Concentrations of elements in selected sections of the natural environment in the vicinity of a

mass grave located in Puszcza Niepołomicka]. Acta Scientiarum Polonorum Formatio Circumiectus 8 (3-4), p. 41-54.

In order to determine the impact of selected Kraków cemeteries on a number of components of the natural environment, I tested the concentrations of elements in the soil above the burial sites, clovers, mushrooms and the concentrations of ions in groundwaters. I compared the obtained results with the geo-chemical background and with results of tests performed at other cemeteries in south-east Poland. I also paid attention to the geological products of decomposition. I detected low concentrations of elements above burial sites. High concentrations of iron ions in groundwaters indicate their advantageous presence if sediments for sorption of decomposition products. Relatively low concentrations of contaminants are associated with the correct location of the cemeteries, other words, with deep groundwaters, presence of sorbents in sediments, surfaces of cemeteries are non-permeable and drainage systems are clear.

Żychowski J., 2010. Wpływ krakowskich cmentarzy na środowisko przyrodnicze [Impact of Kraków cemeteries on the natural environment]. Przegląd Geograficzny, 82, 3, p. 409-433.

In this work I presented results of tests conducted across the world on the impact of cemeteries on the quality of groundwaters. In Europe such tests were initiated by van Haaren in 1951. They were sporadically continued in the 70s and 80s of the last century in Germany (Schraps 1972), Great Britain (Gray et al. 1974), Canada (Levine et al. 1984) , and RSA (Alfodi, Croukamp 1988). Whereas regular tests were initiated only towards the end of the 80s and primarily in the 90s, in: **Brazil** (Pacheco 1986, Mendes et al. 1989), **RSA** (Fisher, Croukamp 1993, Engelbrecht 1993), **Australia** (Knight, Dent 1995) and **Poland** (Żychowski et al.. 1996). Research of this type, but at a smaller scale was also carried out in other countries, such as the USA, Great Britain, Portugal and France. Furthermore, a number of reports were published on this subject (Ucisik, Rushbrook 1998, Creely 2004, Morgan 2004). I pay particular attention to environmental conditions which, according to researchers, have a significant impact on the chemical contamination of water. The highest levels of contaminants occur at cemeteries located in warm and humid climates, such as RSA and Brazil. Most researchers are of the opinion, that the biggest danger from cemeteries are ions containing phosphorus as well as bacteria and viruses.

Żychowski J., 2010. Przegląd wyników badań prowadzonych na świecie nad wpływem cmentarzy na chemizm wód podziemnych [Review of research conducted across the worlds on the impact of groundwaters], [in:] Antropogeniczna transformacja środowiska przyrodniczego [Anthropogenic transformation of the natural environment]. Księga Jubileuszowa dedicated to Prof. Jan Lach, edit. Wilczyńska-Michalik W., Wydawnictwo Attyka, Kraków, 2010, p. 67-90.

Other research took into account the significance of iron compounds and clay minerals in the process of corpse decomposition. Particular attention was paid to the co-presence of phosphorus compounds in differentiated soils of 9 selected mass graves from WW 1 and 2. These tests were conducted with the use of scanning and polarising microscopes. The samples were collected at different depths from ditches and bore holes on or in the vicinity of the grave. It was observed that phosphorus in siltstone formations of small water relation fluctuations was present in weakly crystalline form.

Whereas in psammitic-siltstone materials with large humidity fluctuations in amorphous compounds. More permanent aggregate concentrations of decomposition products were observed in quartz grains with clay-iron areola. Fragments of soft tissues were only detected in WW2 graves. It was also shown that the soil quality composition does not differ between WW 1 and 2 graves. The occurrence and presence of products of decomposition in the soil is mostly dependent on the formation of sediments, within which the burial sites are located. Of significant importance are also water relations.

Żychowski J., 2011. Geological aspects of decomposition of corpses in mass graves from WW1 and 2, located in SE Poland, Environmental Geology. DOI 10.1007/s12665-010-0867-x, Springer, First online, ss. 20. Environmental Earth Sciences, 64, (2), 437-448.

In order to demonstrate the impact of selected cemeteries in Kraków on the components of the environment, I also tested the concentrations of elements in soils above the burial sites, in clovers and mushrooms as well as concentrations of ions in groundwaters. I compared these results
with the geo-chemical background and with results from other cemeteries in south-east Poland. I also took into account geological products of decomposition. I detected low concentrations of elements originating from decomposition above burial sites. High concentrations of iron ions in groundwater indicate their presence in the soil and the role they play in the sorption of products of decomposition. relatively low concentrations of tested elements and ions are associated with appropriate locations of cemeteries: deep groundwater levels, presence of sorbents slowing down the migration of testes products, non-porosity of the cemetery surface and favourable drainage systems.

Żychowski J., 2011. The *impact of cemeteries in Kraków on the natural environment – selected aspects.* Geographia Polonica, 84, 1, 13-32.

Cemeteries have a negative impact on the quality of groundwater. The highest levels of contaminants were detected at cemeteries located in warm and humid climates, such as RSA and Brazil. Ammonium is considered to be the primary product of decomposition. The majority of researchers also concur to increased levels of nitrogen and phosphorus as well as bacteria and viruses. Tests evaluating other contaminants are also expected, such as amino acid, organic compound, formaldehyde and arsenic concentrations. The problem of a negative impact of cemeteries on the environment must, in the first place, be solved in large cities, where cemeteries are huge and there is a shortage of burial sites. Furthermore, there are problems associated location and high real property prices. Partial limitation of the negative impact on the environment may be achieved by convincing people to a more humanitarian form of a burial, such as cremation, which may be considered as a lesser evil. In future the impact of cemeteries on the environment should be monitored. There exists a requirement for international cooperation, which will take into account the current state of research and environmental working conditions and will allow for a certain standardisation of methods.

Żychowski J., 2012. *Impact of cemeteries on groundwater chemistry: A review.* Catena, 93, pp. 29-37. http://dx.doi.org/10.1016/j.catena.2012.01.009

I analysed the problem of the impact of mass burial sites on the natural environment in my habilitation thesis „Impact of WW 1 and 2 mass graves on the natural environment". Pub. AP Kraków 2008, 1 – 305. The work presents the evaluation of the impact of mass graves on the chemical characteristics of soils and groundwater depending on the characteristics of their natural environments. This problem was notices recently in connection with the large number of deceased in natural disasters and as a result of research conducted on the impact of cemeteries on the quality of groundwaters in a number of countries around the world (Ucisk, Rushbrook 1998; Tricket al. 2001; Matos 2001; Creely 2004; Morgan 2004; Dent 2004). These tests also pertained to the migration processes of decomposition products relative to the tested environments and determined the correct characteristics for graves and their environments for the most favourable location of cemeteries.

I consider the biggest achievements of my habilitation theses to be:

For the tests I used some of the most state of the art testing methods. I performed environmental tests on the concentration of elements and selected chemical compounds in the soil using atomic absorption spectroscopy method (Perkin Elmer 2001, Aanalyst 50/300). I measured ion concentrations using a HPLC chromatograph. Mineral - petrographic tests were performed using a polarising microscope and a scanning microscope connected with semiquantitative chemical analyses etc. These tests are characterised by a high degree of precision and may be considered to be objective, and in connection with the fact that they were conducted in Poland for the first time, will constitute a point of reference for further development of tests of this type.

In the thesis, I presented an unknown, in Poland and dispersed around the world scientific accomplishments on the current state of research on the impact of cemeteries on the environment. I collected and ordered the factors which are conducive and those which limit the migration of contaminants in the vicinity of the burial site. Mainly cemetery directors expressed interest in these results.

The numerous conclusions which I summarised at the end of the thesis are, in my opinion, of a pragmatic dimension. As they will allow for correct location, expansion and usage of cemeteries according to their local conditions and facilities.

I considered each of the researched problems using separate and varied testing methodology, such as: element and chemical compound concentrations in the soil, assessment of the natural environment, water pollution, mineral-petrographic products of decomposition, etc.

I assessed the concentrations of various elements using a relative scale of my own device. I also grouped the elements contained in each of the 245 tested graves into sensible sets and determined their rankings for each of them. These results allowed for a determination of the method in which characteristics of the environment and graves impact the concentrations of elements.

I conducted an evaluation of the environment for tested sites, significant for a comparison of future test results based on objective statistical method, using quantitative, relative assessment for the environmental characteristics, which were mentioned in the world test results. I assessed each of the 26 characteristics using a 5 point scale, taking into account their qualitative volatility.

The chapter on the pollution of groundwaters was preceded by an assessment of climate and weather conditions. This will allow for a comparison of obtained results with tests conducted in the future. I also demonstrated the scope of pollution of the tested water, comparing ion concentrations in water from the tested graves with: hydro-geological

background, limits as set by the ministerial resolution and by testing the volatility in time of the test results concerning the same location.

I carried out an **assessment of the impact of mass graves** on the environment on the basis of

Determination, of whether a relationship exists between the selected environmental conditions of the tested graves and the concentrations of characteristic elements in the soil. I tested this relation using a chi-squared independence test. The exclusion of such independence allowed me to prove a stochastic dependence between the variables. I performed this test for two groupings, within which the 240 graves were put into 9 groups. In one case I grouped the graves in relation to the characteristic properties of the environment and the graves. Another grouping pertained to selected elements typical for the soil of mass graves. An identical number of grave groups in both groupings was ensured by a non-hierarchical method of k-averages. However, this method required the knowledge of the parameters of 9 graves, around which I concentrated the groupings. I determined the number of groups and grave parameters, both for the environmental conditions and concentrations of elements using the Ward method in the Statistica software. In the groupings I did not take into account all of the grave parameters - 26 tested qualitative variables (characteristics of the environment and graves) and 20 quantitative variables (relative element values). Assuredly some of the variables were mutually correlated and thus I made a selection. To this end I performed two groupings of graves in accordance to the variables by the Ward method and various measures of distance depending on the variables (qualitative and quantitative). In each of the two groupings I selected, with the aid of a variability indicator, the characteristic properties of the environment and graves as well as elements.

Based on this, I ascertained a stochastic relationship with a probability of 79 % between the grave surface, the incline of ground lying above, soil formations, humidity of the sample collection location and the usage of land surrounding the grave and the following elements: Cr, Cu, Zn, P and S contained in the soil of the mass graves.

I considered the **impact of mass graves** on the environment taking into consideration only 86 tested burial sites, for which concentrations of elements were also measured in control locations.

In the thesis I also presented the never before analysed problem on the concentrations of chemical compounds on the backfill above the burial site: Cu_3P_2, K_3P, Na_3P, Ca_3P_2, PH_4J, $Ca(H_2PO_4)_2$, Na_2S, CuS, PbS. I carried out the tests for 21 graves. The results allowed for a grouping of these graves. I demonstrated that the following induce the grouping: the time of their establishment, relative locations and to a lesser degree the grave drainage method. Large WW2 graves contain little sulfides with a large presence of phosphorus and $Ca(H_2PO_4)_2$. In other WW2 graves I detected a significant share of $Ca(H_2PO_4)_2$ and a relatively large proportion of sulfides. The biggest differences here were observed in WW1 graves, In graves from that period there are relatively few $Ca(H_2PO_4)_2$ and sulfides.

In my thesis I also developed mineral-petrographic **research started previously.** I paid particular attention to the presence of organic matter, phosphorus compounds and the co-existence of iron compounds and clay minerals. I performed the analyses in the vicinity of the 9 selected mass graves with varies soils. I collected the samples from ditches in the vicinity of graves and bore holes on mass graves. The obtained results indicated a number of patterns. I determined relations between the formation of sediments, fluctuations of groundwater levels and hillside incline where the burial sites are located and the rate of decomposition and migrations of its products. I noticed, that a larger proportion of clay minerals in sediments, increases the presence of secondary Fe oxides and hydroxides. Sediments enriched in such manner also absorb anthropogenic P to a larger extent. Such favourable soil conditions were

most frequently observed on local flattenings and slopes of a slight incline. The decay products are mostly absorbed my clay minerals and Fe compounds which are conducive to P sorption and limit the discharge of decomposition products away from the burial site. In homogenous units, such as sands, decomposition products silt-up only on the surfaces of a few grains, which are also enriched by amorphous phosphorus compounds. The migration of decomposition products is also limited by the presence of homogenous clays with no fissures and a developed system of rotting roots. Longer stagnation of groundwaters levels leads to a good structural ordering of compounds which are products of decomposition, and consequently to their slow crystallisation above the surface of the groundwater. In WW2 grave sediments tests I did not confirm secondary minerals in the form of crystals. I also ascertained that the development of decomposition processes and migration of its products is facilitated by a mixed and soft grave backfill. These places are prone to periodic saturation by atmospheric water.

In the habilitation thesis I also performed an assessment of groundwater quality and to a smell extent, also surface water in the vicinity of the burial sites. I carried out these tests for 11 ions within and in the vicinity of 26 WW 1 and 2 mass graves and comparatively for cemeteries. They included a chemical assessment of groundwater quality within the scope of graves or in their vicinity, and a comparison with the chemical background. I also tested time volatility of the chemical composition of groundwater. I also set the obtained results against the allowable limits for tested ions in potable water. The highest excessions of the allowable concentrations and significant differences between the quality of groundwater under graves and control sites pertain to phosphate, iron, manganese ions and to a lesser extent copper, tin and aluminium ions. The largest concentrations of ions are present within the vicinity of the largest WW2 mass graves and in the vicinity of those which are located along the routes of rivers Wisła, Dunajec and Raba. In these location the level of groundwater is either shallow or rises periodically. Whereas in deep groundwater deposits I did not detect high concentrations of these ions. Phosphate ions indicated the largest volatility throughout the year at cemeteries located along the routes of rivers and hillsides in Karpaty. Large spatial variations in the concentrations of ions in groundwater in the vicinity of cemeteries is a result of: different permeability of the soil, different levels of precipitation, periodic fluctuations of air temperature around zero and spatial differentiation of clay minerals and iron compounds concentrations.

The largest differences between the tested ions in groundwater surrounding graves and control sites occur within the area of sandy soils located on Miocene clays. Groundwater - particularly during significant periods of water level fluctuations - is a medium for decomposition products. In the vicinity of cemeteries located in the upper sections of hills, with deep groundwater is flysh clay formations, the quality of the water is unsatisfactory only due to the concentrations of iron and manganese ions.