http://dx.doi.org/10.15576/GLL/2013.1.107

GLL

Geomatics, Landmanagement and Landscape No. 1 • 2013, 107–115

ASSESSMENT OF WATER INFLOWING, STORED AND FLOWING AWAY FROM MŚCIWOJÓW RESERVOIR

Agnieszka Policht-Latawiec

Summary

The hydrochemical analyses of water inflowing, stored and flowing away from Mściwojów water reservoir were conducted from April to November 2012. Measured were 27 physico-chemical indices of surface water sampled at 8 dates from four measurement-control points. Analysis of results revealed that water inflowing into Kałużnik river was the best quality – corresponded to class III, but only due to nitrate nitrogen. In the water Wierzbiak from the river, only two from among 16 indices exceeded class II (nitrate nitrogen and phosphates). Water in the reservoir was classified to quality class III because of the temperature and $BOD_{5,}$ similar as water flowing away from the reservoir. Moreover, the paper assessed usable values of inflowing water, stored in the reservoir and flowing away from it. On the basis of the analysis, it was stated that water cannot be supplied to people since it does not meet the requirements stated in the Minister's regulations concerning the conditions of the natural habitat of cyprinids and salmonids.

Keywords

water quality • Wierzbiak river • Kałużnik river • usable values

Introduction

In view of the subject of on paper presented, it is necessary to state and assess changes of quality (features) of water flowing in the main watercourse but also water from the tributaries immediately feeding the reservoir. Generally, the current quality status of surface waters in Poland, particularly rivers is considered as poor. It is usually, the outcome of unbalanced water resources management, particularly the supply untreated or insufficiently treated sewage into rivers [Szczykutowicz et al. 2003, Krzanowski et al. 2005].

Water degradation is apparent as unfavourable changes of their physicochemical and biological features, both owing to introduction of excessive amounts of organic and inorganic substances and heated water discharge, or radioactive substances [Dobrzańska et al. 1997]. In result, the balance between pollutant concentrations caused by human activity and potential of self-purification of water environment become disturbed. This was the cause of destruction and annihilation of numerous aquatic biocenoses, excessive increase in productivity and eutrophication of waters [Pawełek 2002].

Surface and underground waters are also polluted with other substances coming from various sources. These are both natural sources, such as: geological substratum, vegetation or atmosphere [Rajda et al. 2002] and anthropogenic. This would be connected with life and economic activities of humans [Rajda and Kanownik 2005]. Natural sources of pollution are less dangerous for water purity than anthropogenic ones. In villages, and farms the most dangerous are household wastewater and animal excrements (manure, slurry or liquid manure) but also landfill sites. Agricultural lands are perceived as one of the basic sources of area pollution [Taylor 1988, Ilnicki et al. 2002, Rajda and Kanownik 2007]. In these areas surface waters are polluted mainly due to the application of excessive doses of nitrogen and phosphorus fertilizers [Pawlik-Dobrowolski 1983, Grunert et al. 2004].

At the initial stage of operation, Dam reservoirs accumulate chemical substances inflowing from the catchment, including biogens. These may also function as a kind of treatment plants, biologically favourably changing physical features and chemical composition of waters below the reservoir. The result, water flowing away is generally more deficient in biogens but richer in organic matter. However, with time, the result of chemical elements release from bottom sediments, water reservoirs may become a hazard to the natural environment [Kostecki 1992].

Research on the chemistry and degree of pollution of Mściwój reservoir water is quite extensive [Czamara and Wiatkowski 2002, 2004, Czamara and Grześków 2008, Szafrański and Stefanek 2008, Czamara et al. 2008, Dąbrowska 2008, 2010].

Concentrations of chemical elements and basic physical properties of water sampled from watercourses and the reservoir are assessed in the paper. On the basis of the data, on water quality indices, an attempt was made to assess the quality of water inflowing, stored and flowing away from Mściwój reservoir.

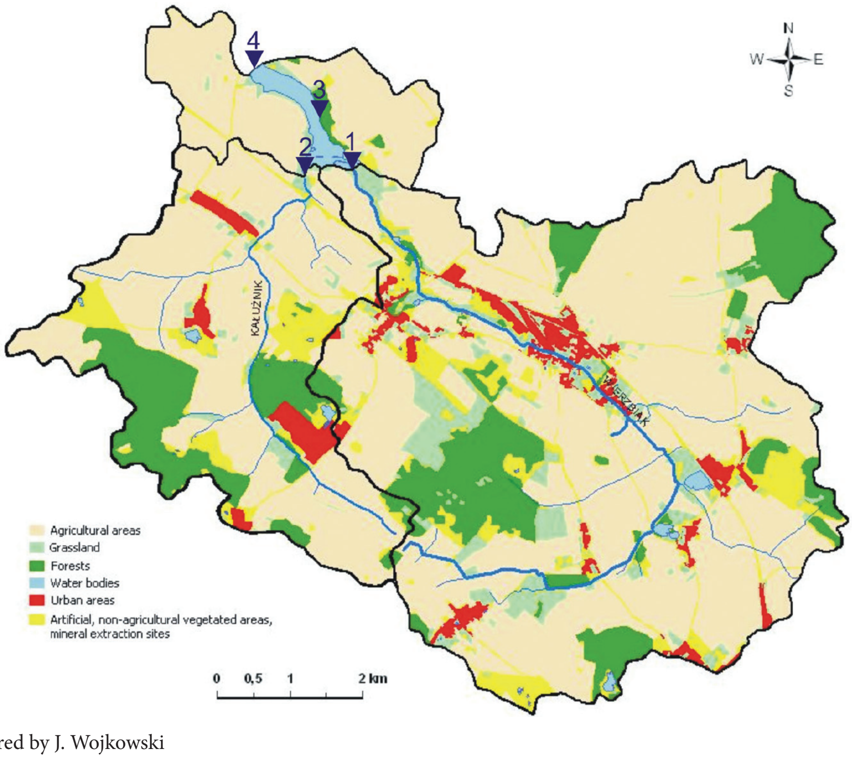
2. Material and methods

Quality of water in the Wierzbiak and Kałużnik rivers and in Mściwój reservoir were assessed on the basis of the Author's own physiochemical analyses. These were conducted during the period from April to November 2012. Water for analyses was sampled at one month intervals, on randomly chosen days, in measurement-control points situated in the following cross sections (Figure 1):

- inflow to the reservoir: the Wierzbiak river – point No. 1, the Kałużnik river – No. 2,
- outflow from the reservoir – point No. 3,
- outflow from the reservoir below the dam – point No. 4.

Assessed were 27 physicochemical indices. The temperature and oxygen saturation were measured on site by means of CO–411 oxygen meter, water reaction by means of CP–104 pehameter and electrolytic conductivity (EC) by CC–102 conductometer. In the laboratory, total suspended solids (TS) were determined using. The gravimetric method, total dissolved solids (TDS) by evaporation, concentrations of Ca^{2+}, Na^{+}, K^{+}, Mg^{2+}, Mn^{2+} ions and content of Cr, Zn, Cd, Cu, Ni, Pb and Fe_{org} were assessed by means of atomic absorption spectrometry on UNICAM SOLAR 969 spectrometer. Concentration of ammonium nitrogen ($N\text{-}NH_4^{+}$), nitrite ($N\text{-}NO_2^{-}$), nitrate nitrogen ($N\text{-}NO_3^{-}$), PO_4^{3+} and Cl^{-} were determined by means of flow colorimetric analysis on FIAstar 5000 apparatus. Concentration of SO_4^{2-} was assessed using precipitation method, BOD_5 by Winkler's method while COD_{Mn} (oxidability) was determined by means of permanganate method [Hermanowicz 1999]. Also chlorophyll "a" was determined in water.

Minimum and maximum values were established for all indices and then arithmetic means were calculated. Water quality was assessed on the basis of the previous Regulations of the Minister the Environment, dated 20 August 2008. On the method of classification of the status of surface water bodies (Dz. U. Nr 162, poz.1008) because the new Regulation of the Minister of the Environment, dated 9 November 2011, is less exacting than the one mentioned above. Water usable values were estimated from the perspective of potable water supply [Rozporządzenie... 2002] and as fish habitat under natural conditions [Rozporządzenie... 2002].



Prepared by J. Wojkowski

Fig. 1. Localization of measurement-control points

Table. Range and mean values of physicochemical features of inflowing waters (1 – Wierzbiak river, 2 – Kałużnik river), stored (3 – main reservoir) and flowing away (4 – Wierzbiak river) and assessment of its usable values

Index		Maximum–Minimum / Average				Water quality class [8]				Usefulness of surface water											
										Drinking water [9]				As a natural environment for fish [10]							
														salmonids				cyprinids			
		Measurement-control points																			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Temperature [°C]		2,9–21,2 / 12,1	3,0–19,0 / 11	2,6–27,5 / 15,1	3,1–25,1 / 14,1	I	I	III	III	A1	A1	no	no	yes	yes	no	no	yes	yes	yes	yes
pH		7,00–7,98 / 7,49	7,04–8,01 / 7,52	7,20–8,72 / 7,96	7,19–9,09 / 8,14	I	I	II	III	A1	A1	A2	no	yes	yes	yes	no	yes	yes	yes	no
EC	$\mu S \cdot cm^{-1}$	296–578 / 437	360–490 / 425	288–560 / 424	462–545 / 504	I	I	I	I	A1	A1	A1	A1	–	–	–	–	–	–	–	–
BZT_5	$[mg\ O_2 \cdot dm^{-3}]$	2,9–4,0 / 3,5	3,0–4,6 / 3,8	2,6–6,8 / 4,7	3,1–10,1 / 6,6	II	II	III	III	A2	A2	A3	no	no	no	no	no	yes	yes	no	no
$ChZT_{Mn}$	$[mg\ O_2 \cdot dm^{-3}]$	3,1–9,0 / 6,1	3,0–6,0 / 4,5	2,9–11,0 / 7,0	3,4–8,8 / 6,1	II	I	II	II	A1	A1	A1	A1	–	–	–	–	–	–	–	–
O_2	%	55–75 / 65	53–64 / 59	47–80 / 64	64–67 / 66	I	I	I	I	A1	A2	A1	A2	–	–	–	–	–	–	–	–

Dissolved solids	$mg \cdot dm^{-3}$	76–458 / 267	85–428 / 257	135–442 / 577	188–408 / 298	I	I	I	I	–	–	–	–	–	–	–	–	–	–	–	–
Total suspended solids		1–2 / 1,5	3–5 / 4	0–0,6 / 0,3	2–3 / 2,5	I	I	I	I	A1	A1	A1	A1	yes	yes	yes	yes	yes	yes	yes	yes
$N\text{–}NH_4^+$		0,03–0,05 / 0,04	0,08–0,453 / 0,27	0,08– 0,10 / 0,09	0–0,09 / 0,05	I	I	I	I	–	–	–	–	yes	yes	yes	yes	yes	yes	yes	yes
$N\text{-}NO_3^-$		0,28–5,26 / 2,77	0,34–14,78 / 7,56	0,0–0,10 / 0,05	0,03–0,07 / 0,05	III	III	I	I	–	–	–	–	–	–	–	–	–	–	–	–
NO_2^-		0,04–0,19 / 0,62	0,03–1,87 / 0,95	0,00–0,03 / 0,01	0,00–0,04 / 0,02	–	–	–	–	–	–	–	–	no	no	no	no	no	no	yes	no
PO_4^{3-}		0–0,42 / 0,21	0,11–0,27 / 0,19	0,05–0,26 / 0,16	0,04–0,27 / 0,16	III	II	II	II	A2	A1	A1	A1	–	–	–	–	–	–	–	–
P_{total}		0–0,24 / 0,12	0,04–0,09 / 0,07	0,02–0,08 / 0,05	0,01–0,09 / 0,05	II	I	I	I	–	–	–	–	no	yes	yes	yes	yes	yes	yes	yes
SO_4^{2-}		31–109 / 70	43–111 / 77	27–110 / 69	32–105 / 69	I	I	I	I	A1	A1	A1	A1	–	–	–	–	–	–	–	–
$Fe^{2+/3+}$		0,11–0,21 / 0,16	0,09–0,15 / 0,12	0,05–0,08 / 0,07	0,03–0,05 / 0,04	–	–	–	–	A1	A1	A1	A1	–	–	–	–	–	–	–	–
Mn^{2+}		0,03–0,06 / 0,05	0,02–0,03 / 0,03	0,04–0,05 / 0,05	0,0–0,02 / 0,01	–	–	–	–	A2	A1	A1	A1	–	–	–	–	–	–	–	–
Ca^{2+}		16–62 / 39	15–60 / 38	20–57 / 39	30–56 / 43	I	I	I	1	–	–	–	–	–	–	–	–	–	–	–	–
Mg^{2+}		2–16 / 9	3–12 / 8	4–5 / 5	5–17 / 11	I	I	I	I	–	–	–	–	–	–	–	–	–	–	–	–
Cl^-		14–54 / 34	5–38 / 22	10–62 / 36	11–61 / 36	I	I	I	I	A1	A1	A1	A1	–	–	–	–	–	–	–	–

EC – Electrolytic conductivity, A1– water requiring simple physical treatment, A2 – water requiring typical physical and cheimical treatment, A3 – water requiring high-perfomance physical and chemial treatment

3. Results

Considering their thermal characteristics, the analized water samples were classified to quality class III (points 3 and 4), except points 1 and 2, where water was in class I (see Table).

Values of the natural river water reaction, oscillate around neutral. It is connected with calcium concentrations in water, which are small at high but big at low $CaCO_3$ content [Chełmicki 2002]. In the Wierzbiak and Kałużnik rivers (direct tributaries to Mściwój reservoir), water pH ranged from 7 to 8.01, i.e. in class I. Water in the reservoir revealed the reaction similar to alkaline (8.72) but already on the outflow from the reservoir the reaction was alkaline (9.09). Therefore, this classifies the water to class III according to the regulation of 2008 [Rozporządzenie... 2008]. In neither of the investigated points, electrolytic conductivity exceeded 1000 $\mu S \cdot cm^{-1}$ – i.e. the value permissible for I class quality. BOD_5 concentrations in the Wierzbiak and Kałużnik river waters were similar and placed them in II quality class, whereas water stored and flowing away from the reservoir to class III. The degree of oxygen saturation, dissolved solid concentration, total suspended solids and ammonium nitrogen corresponded to water quality class I in all studied points. Regulations of 2008, which takes into consideration nitrate nitrogen, classifies waters of the Wierzbiak and Kałużnik rivers as quality class III. Phosphate concentrations placed water at all points to class II, except point 1, where the concentration exceeded values permissible for class III. The total phosphorus concentration slightly exceeded the limit for class I only in point 1, whereas in the other points in remained on the level of class I. Water assessment in the analized points, conducted on the basis of minerals values (sulphates, chlorides, magnesium and calcium) revealed that they did not exceed permissible values for water quality for class I on any date of measurement (see Table).

According to the regulations in force, on water usability for potable water supply, three out of 12 analysed indices (temperature – point 1,2, water pH and BOD_5 – point 4) do not meet the requirements stated for these categories in the regulations of 2002 [Rozporządzenie... 2001] (see Table). Water in measurement-control point 3 was classified to A3 category because of BOD_5 concentrations, whereas to A2 category due to concentrations of manganese and phosphates in point 1, degree of oxygen saturation (in points 2 and 4) and water pH only in point 3. Values of the other indices were in the A1 category. Summing up: when analized water was to be used for water supply, it should be taken only from points 1 and 2 and only used after typical physical and chemical treatment appropriate for A2 category.

Water analized in measurement-control points, does not meet the requirements for salmonid or cyprinid fish habitat. According to the regulations of 2002 in-force [Rozporządzenie... 2002], BOD_5 and nitrite concentrations exceeded values permissible for both fish species in almost all analysed points, except points 1 and 2 for the oxygen index and point 3 for nitrites (see Table). Considering living conditions for salmonids, in points 1 and 3, only four among 7 analysed indices meet the standards, five indices in point 2 and three indices in point 4. On the other hand, considering cyprinids, water of the studied river section in points 1,2 and 3 might provide a viable habitat for them due to six indicators and in point 4 – due to four indicators.

Average content of chlorophyll “a” in the Wierzbiak river water (point 1) was 2.4 $\mu g \cdot dm^{-3}$, 0.2 $\mu g \cdot dm^{-3}$ in the Kałużnik (point 2), 73.4 $\mu g \cdot dm^{-3}$ in the reservoir (point 3) and 35.52 $\mu g \cdot dm^{-3}$ on the outflow from the reservoir (point 4).

4. Conclusion

Water quality and the resulting usable values change with the changing anthropogenic pressure in the catchment area [Rajda and Kanownik 2007, Ilnicki et al. 2002]. Pollution may be counteracted through sanitation of settlement areas. This would require construction of sewerage system and efficient sewage treatment plants [Ostrowski et al. 2005]. Quality of water in Mściwój reservoir was affected mainly by surface runoffs from the nearest reservoir catchment which comprise forests, arable fields, meadows and pastures and also by precipitation.

Analysis of the research results, revealed that water flowing with the Kałużnik river was of the best quality – categorised to class III but only due to nitrate nitrogen. In the water of the Wierzbiak river, only two (nitrate nitrogen and phosphates) among 16 indices exceeded values for class II. Similarly in the reservoir, where the temperature and BOD_5 water was classified to quality class III. On the outflow from the reservoir, the water was revealed the worst quality because of its temperature, pH and BOD_5 – class III. All inflowing water should be monitored because it feeds the Mściwojów water reservoir. The which fulfils numerous functions, including a recreational one. Moreover, it also provides a refuge for avifauna [http://lto.most.org.pl] and habitats of rare wetland and aquatic plants. The waters flowing away from the reservoir should also be monitoring. They affect the quality of the Wierzbiak river water below the reservoir.

Studies on usable values of water inflowing, stored and flowing away from the reservoir demonstrated that they cannot be used for water supply because of high temperature and water pH and BOD_5 concentration. Moreover, on the inflow to the reservoir, the Wierzbiak river does not meet the requirements for natural salmonid habitat because of BOD_5, nitrites and total phosphorus. The Kałużnik river only exceeded concentrations of nitrites and total phosphorus. Waters of the Wierzbiak and Kałużnik rivers may provide natural habitat conditions for cyprinids due to six indices: the temperature, BOD_5, total suspended solids, ammonium, nitrate nitrogen and total phosphorus. One of the analized indices, did not meet the requirements posed in the regulations in force of 2002 [Rozporządzenie... 2002]. Conclusion, each analysed point values permissible for fish habitats as stated in the regulation in force, were exceeded.

References

Chełmicki W. 2002. Woda. Zasoby, degradacja, ochrona. Warszawa. Wydawnictwo Naukowe PWN, 306.

Czamara A., Grześków L. 2008. Ocena skuteczności działania zbiornika wstępnego w Mściwojowie. Zesz. Probl. Postęp. Nauk Rolnicz. Melioracje wodne w inżynierii kształtowania środowiska.

Czamara W., Czamara A., Wiatkowski M. 2008. The Use of Pre-dams with Plant Filters to Improve Water Quality in Storage Reservoirs. Archiv. Environ. Protect., 34, 79–89.

Czamara W., Wiatkowski M. 2002. Zastosowanie zbiornika wstępnego w Mściwojowie do ochrony retencjonowanej wody. Konferencja Naukowa pt. „Ochrona i Kształtowanie Środowiska". Roczniki Akademii Rolniczej w Poznaniu Nr CCCXLII, Melioracje i Inżynieria Środowiska 23, 43–52.

Czamara W., Wiatkowski M. 2004. Dopływ głównych substancji biogennych do zbiornika wodnego w Mściwojowie. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu. Inżynieria Środowiska XIII, 502, 43–50.

Dąbrowska J. 2008. Czynniki kształtujące jakość wód powierzchniowych w zlewni zbiornika Mściwojów. XX Jubileuszowa Krajowa Konferencja, VIII Międzynarodowa Konferencja „Zaopatrzenie w wodę, jakość i ochrona wód", PZITS, Poznań – Gniezno.

Dąbrowska J. 2010. Wpływ osadnika wstępnego z filtrem biologicznym na zmiany wartości wybranych parametrów fizykochemicznych wody. Infrastr. Ekol. Teren. Roln., 8, 5–13.

Dobrzańska B., Dobrzański G., Kiełczewski D. 1997. Ocena środowiska przyrodniczego. Wyd. Ekonomia i Środowisko, Białystok.

Grunert R., Okruszko T., Giełczewski M. 2004. Rola zanieczyszczeń obszarowych w kształtowaniu jakości wód powierzchniowych Górnej Narwi. Roczniki AR w Poznaniu CCCLVII, 111–118.

Hermanowicz W., Dojlido J., Dożańska W., Koziorowski B., Zerbe J. 1999. Fizyczno-chemiczne badanie wody i ścieków. Wyd. Arkady. Warszawa.

Ilnicki P., Karwacka K., Poniedziałek B. 2002. Zanieczyszczenia powierzchniowe i punktowe w zlewni rzeki Prosny w latach 1993–1998. Rocz. AR w Poznaniu, CCCXLII, 113–121.

Kostecki M. 1992. Badania limnologiczne zbiornika zaporowego Tresna. Część IV. Dynamika przemian oraz bilans podstawowych form azotu w wodzie zbiornika. Archiw. Ochr. Środow., 3–4, 71–89.

Krzanowski S., Wałęga A., Cupak A. 2005. Wpływ sposobu zagospodarowania zlewni na jakość wody rzeki Raby i jej wybranych dopływów (Bysinki i Krzyworzeki). Zesz. Nauk. AR w Krakowie, 420, ser. Inżynieria Środowiska 26, 31–46.

Ostrowski K., Bogdał A., Rajda W., Policht A. 2005. Wpływ zabudowy miejskiej na jakość wody w potoku podgórskim. Zesz. Nauk. AR w Krakowie nr 420, ser. Inżynieria Środowiska, 26, 21–29.

Pawełek J. 2002. Eutrophication In the Podkamycze reservoirs securing water intake for Cracow from the Rudawa river. Zesz. Nauk. AR w Krakowie nr 393, ser. Inżynieria Środowiska, 32, 97–107.

Pawlik-Dobrowolski J. 1983. Zmiany składu chemicznego wód powierzchniowych pod wpływem zanieczyszczeń obszarowych (w Karpatach Zachodnich). Rozprawa habilitacyjna, IMUZ Falenty.

Rajda W., Kanownik W. 2005. Wpływ czynników antropogenicznych na jakość wody potoku na terenie podmiejskim i zurbanizowanym. Wiad. Mel. Łąk., 176–179.

Rajda W., Natkaniec J., Bogdał A. 2002. Jakość wody opadowej i odpływającej ze zurbanizowanej mikrozlewni podmiejskiej o zróżnicowanym użytkowaniu. Acta Scientar. Polonor., ser. Formatio Circumiectus, 1–2 (1–2), 49–60.

Rajda W., Kanownik W. 2007. Some Water Quality Indices in Small Watercourses in Urbanized Areas. Archiv. Environ. Protect., 33 (4), 31–38.

Szafrański Cz., Stefanek P. 2008. Wstępna ocena wpływu zbiornika Mściwojów na przepływy w rzece Wierzbiak i głębokości zwierciadła wody gruntowej w terenach przyległych. Środkowo-Pomorskie Towarzystwo Naukowe Ochrony Środowiska. Rocz. Ochr. Środow., 10, 491–502.

Szczykutowicz A., Koc G., Radzka E. 2003. Zanieczyszczenie wody rzeki Liwiec związkami fosforu i azotu w latach 1992–2000. Wiad. Mel. i Łąk., 22–23.

Taylor R. 1988. Biogenne zanieczyszczenia obszarowe wód powierzchniowych. Gosp. Wodna, 8, 175–176.

Rozporządzenie Ministra Środowiska z dnia 9 listopada 2011 r. w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych (Dz. U. Nr 257, poz. 1545).

Rozporządzenie Ministra Środowiska z dnia 27 listopada 2002 r. w sprawie wymagań, jakim powinny odpowiadać wody powierzchniowe wykorzystywane do zaopatrzenia ludności w wodę przeznaczoną do spożycia (Dz. U. 2002 Nr 204, poz. 1728).

Rozporządzenie ministra środowiska z dnia 4 października 2002 r. w sprawie wymagań, jakim powinny odpowiadać wody śródlądowe będące środowiskiem życia ryb w warunkach naturalnych (Dz. U. 2002 Nr 176, poz. 1455).

Dr inż. Agnieszka Policht-Latawiec
Uniwersytet Rolniczy w Krakowie
Katedra Melioracji i Kształtowania Środowiska
31–059 Kraków, al. Mickiewicza 24–28,
e-mail: a.policht@ur.krakow.pl
http://lto.most.org.pl