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measurements applying Hellmann's pluviometer, weekly groundwater levels measurements and periodic determination of water storage. Samples of underflow water were also taken (once a week) from the wells (seasonally four times a year) and from pluviometers (after a heavier precipitation). Physico-chemical analyses comprised determination of twenty indices and components characterizing physical properties, oxygen conditions, nutrients concentration, biogenes presence (nitrogen and phosphorus compounds), as well as mineral composition (content of Ca, Mg, Na, K, Fe, Cl and SO_4). Water analyses were carried out in agreement with The system of norms concerning water and sewage analytics (Wykaz, norm 1993).

Results and discussion

The Hutka water course microcatchment up to the Huta Pusta section covering the area of 52 ha is afforested in 89%. The remaining 11% of the area consists mainly of wetlands and wastelands. The Hutka catchment is of a typical forest character and presents high retentional capabilities. The visual sign of the retention is the outflow reduced by 35% in comparison with similar agriculturally utilized catchments, as well as evaporation which is 25% higher. It is proved by balanced runs of monthly water courses in the flow and relatively slight monthly changes of retention (Miler et al.,1999).

In the period of the analysed investigations, i.e. in the hydrological years 1997/98, 1998/99 and 1999/2000, the course of meteorological conditions can be described as close to the average. The annual sums of precipitation were similar to many - year - mean and equalled respectively 597 and 512 mm in the first two years. The third year faced precipitation reaching 624 mm and was slightly higher (87 mm) than the many - year - mean when simultaneously a compensating higher annual air temperature mean occurred, implying a higher evapotranspiration. Slight surpluses of atmospheric precipitation are usually used by intensified evapotranspiration which regulates the process of surface runoff to a meaningful degree. An even distribution of a single runoff in the period of the research was observed. In the analysed period single runoffs changed within the range 0.29 - 2.92 L/s.km^2 (Fig. 1).

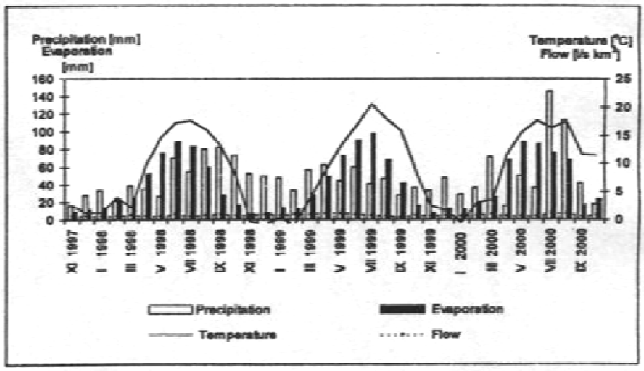
The natural water circulation cycle of the Hutka catchment similarly to the other catchments in the region, is disturbed by anthropogenic factors, and especially dust fall and other harmful chemical compounds such as NO_x , PO_4 and others. The factors influence the elements of the balance of successive stages of energy and matter circulation and may cause permanent changes in their character. They bring about climatic changes both qualitative and quantitative which are reflected in the catchment water circulation disturbances.

The concentrations of sulfates (SO_4), iron (Fe), nitrogen compounds (nitrate N-NO_3, ammonium N-NH_4), reaction (pH), calcium (Ca), chlorides (Cl), sodium (Na) and potassium (K) qualify the Hutka catchment water to fall into purity class one (Rozporządzenie MOŚZN, 1991) (Tab. 1).

Mean phosphates and nitrate nitrogen concentrations decrease the quality class of the water down to purity class two. The increase of the phosphates, with a simultaneous decrease in the dissolved oxygen content is observable in summer and autumn months and may result from both releasing soluable phosphorus compounds from bottom sediments in anaerobic conditions, as well as from precipitation. A meaningfully lower

Figure 1 Monthly evaporation means (mm), as well as single outflow means (L/s.km^2) against the background of monthly atmospheric precipitation sums and air temperature means (°C) in 1997/ /98–1999/ 2000 hydrological years

Obrázok 1 Priemerné mesačné hodnoty vyparovania (mm) a špecifického odvádzania (l/s-km^2) v pomere k súhrnu mesačných zrážok (mm) a priemerných teplôt vzduchu (°C) v hydrologických rokoch 1997/98–1999/2000



quality is observed in groundwater as compared to surface water. Relatively light soils occurring in the majority of the habitats (where wells were introduced) may be the result of a quick washing away of nutrients from surface layers and their penetration and concentration in groundwater (Ryszkowski et al., 1996). Dominant pollutants in the water are biogenes (nitrogen compounds N-NO_3, N-NO_2, N-NH_4 and phosphorus - PO_4).

In the selected habitats of fresh coniferous forest, fresh mixed coniferous forest and alder carr forest no clear dominance of any of the analysed biogenic pollutants was found (N-NO_3, N-NH_4, PO_4 and K). On the basis of mean indices values of water quality (Wskazówki,1995) it can be generally stated that groundwaters of the catchment occur in purity class II and III.

Conclusions

1. The Hutka river catchment afforested in 89% presents high retentional capabilities. The meaningfully reduced single outflow and increased evapotranspiration are the proof of the potentialities. The size of the outflow was basically dependent upon meteorological conditions. Mean single outflow reached 0.86 L/s.km^2
2. The quality of the water in the underflow in the hydrological years in focus, i.e. 1997/ 98, 1998/99 and 1999/2000 can be described as good. However, summer and spring months showed low contents of dissolved oxygen and very high quantities of phosphates. It periodically influenced the worsening of the quality of the Hutka water. The observed increase of the phosphate concentration accompanied by decrease of the quality of the oxygen dissolved in water may result from the release of soluble phosphorus compounds in anaerobic conditions.
3. Groundwaters of the afforested Hutka catchment correspond to purity classes II and III. The dominant pollutants are biogenic compounds (N, P), as well as potassium (K). On the basis of the carried out research it is difficult to point univocally to the forest habitats particularly contaminated with pollutants concentrations.

Table 1 Indices of water quality in the underflow, ground and precipitation waters in the Hutka catchment

Parameters / Indexes: mean min max	Types of water				
	Water of the Hutka river	Groundwater on afforested areas			Precipitation
		Fresh mixed coniferous forest	Fresh coniferous forest	Alder swamp forest	
Sulphates (mg SO_4/dm^3)	60.4 44.8 139.9	46.2 36.8 62.7	49.5 17.7 119.7	143.2* 14.8 437.0	18.0 2.5 33.4
Iron (mg Fe/dm^3)	0.35 0.13 0.82	1.47** 0.23 3.10	1.29** 0.24 3.88	3.15*** 0.24 20.50	0.15 0.11 0.18
Nitrate nitrogen (mg N-NO_3/dm^3)	0.45 0.10 0.80	1.20* 0.20 1.30	0.50 0.20 1.10	0.80 0.10 1.60	0.74 0.45 1.03
Nitrite nitrogen (mg N-NO_2/dm^3)	0.03** 0.00 0.08	0.05*** 0.02 0.09	0.05*** 0.01 0.12	0.06*** 0.01 0.16	0.035*** 0.027 0.43
Ammonia nitrogen (mg N-NH_4/dm^3)	0.28 0.02 0.46	1.87^{NN} 0.16 4.48	0.57** 0.04 1.42	1.93^{NN} 0.06 6.50	0.99 0.35 1.62
Phosphates (mg PO_4/dm^3)	0.48** 0.15 1.90	0.40** 0.20 0.90	0.50** 0.30 0.70	0.90** 0.20 5.20	1.62^{NN} 0.46 2.77
Reaction pH (-)	7.6 7.1 8.1	6.9 6.2 7.7	6.9 6.4 7.3	6.8 6.2 8.0	6.8 6.6 7.0
Hardness (mval/dm^3)	4.8 4.4 5.2	3.3 1.8 4.6	2.9 2.2 3.8	7.5 2.0 16.4	1.13 0.58 1.68
Calcium (mg Ca/dm^3)	82.0 72.0 88.0	60.0 26.0 80.0	47.0 34.0 60.0	132.0* 24.0 308.0	8.9 6.1 11.6
Magnesium (mg Mg/dm^3)	8.7 4.9 14.6	6.9 4.8 9.7	7.1 4.9 9.7	11.9 2.4 38.9	7.5 2.3 12.7
Chlorides (mg Cl/dm^3)	17.0 14.0 22.0	20.0 14.0 25.0	19.0 15.0 25.0	34.5 15.0 70.0	12.3 4.7 19.9
Sodium (mg Na/dm^3)	8.2 3.8 16.6	11.6 7.3 28.8	7.8 5.2 18.3	15.3 5.3 36.3	4.84 2.78 6.91
Potassium (mg K/dm^3)	1.4 1.1 1.8	4.2 0.6 18.0	2.0 0.7 4.5	3.0 1.2 9.3	7.57 1.80 13.3

Tabuľka 1 Ukazovatele kvality vôd v potoku, podpovrchových a zrážkových vôd v povodí Hutky
Marking: X: arithmetic mean; min, max: minimum, maximum value
Water purity classes: class I, class Ia , class Ib*, class II**, class III***, ^{NN}NON

Súhrn

V príspevku sú výsledky hydrometeorologických a chemických meraní v hydrologických rokoch 1997/98, 1998/99 a 1999/2000 v povodí (sútoku) potoka Hutka (0,52 km^2). Toto povodie sa nachádza pri Poznani, v južnej časti Veľkopoľských jazier (Pojerzezie Wielkopolskie). Výskum poukázal na to, že na 89% zalesnené povodie sa vyznačuje vysokými retenčnými schopnosťami. Prejavuje sa to značne zníženým odlyvom a vyššou evapotranspiráciou. V rokoch realizácie meraní bola dobrá kvalita vôd v skúmanom potoku. Avšak v lete a na jeseň sa v týchto vodách zistil veľmi malý obsah rozpusteného kyslíka a veľmi vysoké množstvo fosforečnanov. To spôsobilo zníženie kvality vody v potoku Hutka. Podzemné vody zalesneného povodia (sútoku) Hutky sa nachádzajú v II. a III. triede čistoty vôd. V týchto vodách prevládajú biogénne znečistenia (N, P, K).

Kľúčové slová: kvalita vody, obeh vody, lesné povodie (sútok)

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