The Effect Evaluation of Selected Land Use Category on the Change of Water Quality

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Abstract: Thanks to a current human effect on the landscape, the surface water quality depends on the methods of landscape management. The purity and quality of surface water results in both the characteristics of the water itself and the surrounding environment and also the biotic and abiotic conditions that this environment creates. The investigation was under way from March until November 2014 and it took place on chosen river flows on the border profiles between the individual land use categories. Small river flows with the watershed size to 10 km^2 were chosen in order to investigate how the water quality parameters (pH value, temperature, COD, conductivity, O_2, NO_3^- N, PO_4^{-3} and P_{total}) change when measured in selected sampling sites .The analysis of water quality indicators was realized in the laboratory of Mendel University. According to the comparison to each other the effect of land use categories on the water quality will be evaluated. Following land use categiroes were assessed: Forests, Permanent Grassland, Arable land, Scattered greenery, Built-up area, surface Water, Gardens, Roads and Orchards. Only four of six listed water quality parametres (pH value, temperature, NO_3^- N and PO_4^{-3}) are assessed in this paper. The analysis resulted in the deterioration of pH value, temperature and PO_4^{-3} in the third sampling profile – Built – up area. The highest nitrate nitrogen concentration was determined at the first sampling profile that is the source of the stream.

Key-Words: land use, self – purification, water quality, waste water, pollutants enrichment

Introduction

The Czech Republic is located in the territory of free main European watersheds. And thus the purity and quality of surface waters, which origin and flow through Czech and Moravian territory, is strictly controlled, because such flows represent the a life-giving source of water both in the Czech Republic and certain ecosystems bound directly or indirectly on water with specific supply to water quality. The land use belongs to the factors affecting the quality of surface water. These are the following categories: Forests, Permanent Grassland, Arable land, Scattered greenery, Built-up area, surface Water, Gardens, Roads and Orchards [2]. The land Use represents one of many factors, which can affect the surface water quality in the abroad, where the rivers subsequently flow. An increasing human effect on the natural resources may gradually lead to their depreciation, which can result in changes of their biological, physical or chemical characteristics. Such changes may result in damage or the disappearance of certain ecosystems which are directly or indirectly linked to the water resource. Partial results of an effect of concrete land use categories on the water quality change which were measured in six months (April – September), are summarized in this paper.

Material and Methods

The rivers stream Pernička was selected in order to evaluate the impact of individual land use categories on the water quality change. The Pernička origins above the Počítky village which is situated in the southern part of National Reserve Žďárské vrchy, which belongs to both the protected area and protected area of natural water accumulation called Žďárské vrchy. The exact location of Počítky village and the Pernička stream is shown in the Fig. 5. The selected catchment area ranged from 5 – 11 km^2 .The origin and whole upper part of Pernička stream is situated in the area with livestock breeding and pasture. The village Pernička is not equipped by the waste water treatment plant. Five sampling sites were selected on the river flow resulting in 3 220 m length, just on the borderline of individual land use categories. The order of land use categories which Pernička stream flows through is following: Permanent grassland – Built – up area – Arable land

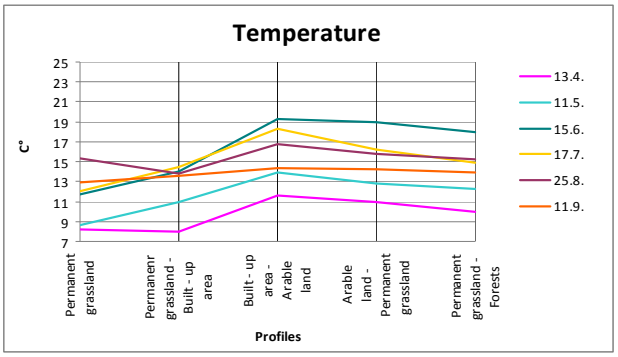
– Permanent grassland – Forests. Measurement and sampling are realized once a month from March 2014 to November 2014. The characteristics of water quality were analysed directly in situ using portable multimeter HQ30d by Hach-Lange in order to measure pH value, water conductivity, oxygen content and temperature. From the point of water quality change view the significant characteristics ($P_{total.}$, PO_4, COD, NO_3^- N, etc.) were determined in laboratory. Hubačíková (2014) deals with the similar theme [1]. According to measured values the impact of individual land use and the change of water quality were assessed on individual sites of observed stream. For now it is not possible to evaluate the impact of individual land use categories. This paper is focused only on the evaluation of certain indicators of water quality for the chosen stream – pH, temperature and NO_3^- N, PO_4^{3-}.

Results

- Temperature - t

The development of the temperature value is equal for all six measurements. During the flow through Permanent grassland the temperature was being reduced. Afterwards during the flow through Built – up area the temperature increased and then in decreased when flowing through Arable land and Permanent grassland. There is a small water pond above the third sampling site. Water accumulated in that pond is being warmed up. And thus the Built – up area significantly affects the water stream temperature.

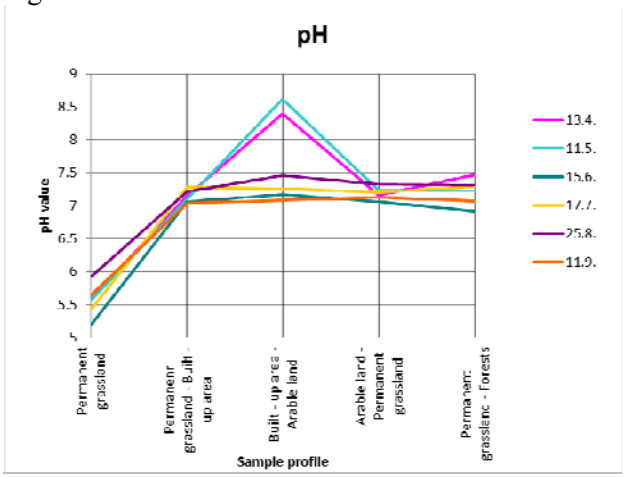
Fig. 1 Temperature value



- pH value

First sampling site (the flow origin with the livestock pasture) resulted in similar value for all the measurements resulting pH value under 6.0 concretely between 5.2 – 5.93. According the pH scale it corresponds to moderate acid to neutral pH value. In the second sampling site (Permanent grassland – Built – up area) the pH value increased to neutral value ranging from 7.04 – 7.22. According to the measurement in April and May the value increased again up to the value approximately 8.5 (8.4 – 8.62) in the third sampling site (Built – up area – Arable land). From July to September the value did not significantly changed in the third sampling site. It ranged between 7.0 – 7.5 corresponding to neutral pH value. The same results were observed for the fourth and the fifth sampling sites. No significant deflection from neutral pH value was measured during whole sampling period. According to Meybeck nad Helmer (1992) in the global scale acidification is considered to cause occasional or regional deteritoration of water quality [7].

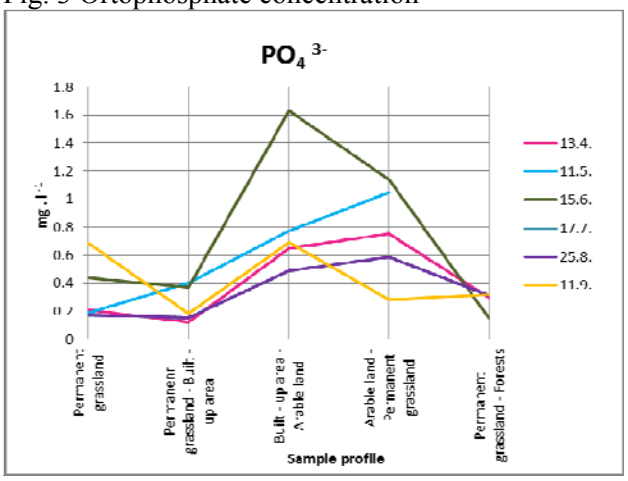
Fig. 2 Ph value



- Orthophosphates - PO_4^{-3}

The presence and concentration of orthophosphate were determined in the laboratory within 24 hours after sampling. In the second sampling site (Permanent grassland –Built – up area), where the livestock is grazed, five measurements resulted in decrease of orthophosphate concentration according to the values measured in the origin site. The increase of orthophosphate concentration was observed in the third sampling site for all samples. In the third site the highest value was measured in the middle of June, when the orthophosphate concentration reached 1.6 mg * l^{-1} which is equal to a double concentration value of other five measurements. In the fourth sampling site, the concentration slightly increased in three cases and it decreased in two cases. In the fourth sampling site (Arable land – Permanent grassland), the concentration slightly decreased again in all samples. There are no results for orthophosphate concentration for fifth sampling site in May due to the extensive growth of plants in the riverbed.

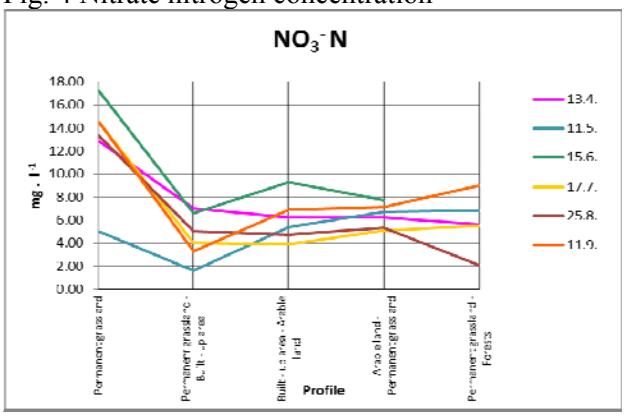
Fig. 3 Ortophosphate concentration



- Nitrate nitrogen - NO_3^-N

The presence and concentration of nitrate nitrogen were determined in the laboratory within 24 hours after sampling. The highest values (12.9 – 17.3 mg $*l^{-1}$) were measured in five samples in first sampling site. The analysis proved obvious decrease of NO_3^-N concentration in all samples collected in the second sampling site (Permanent grassland – Built – up area). Three samples resulted in decrease and three samples resulted in increase of nitrate nitrogen concentration in the third sampling site. There are no results for nitrate nitrogen concentration for fifth sampling site in May due to the extensive growth of plants in the riverbed. According to Meybeck nad Helmer (1992) in the global scale Nitrate as a pollutant is considered to cause occasional or regional deteritoration of water quality [7].

Fig. 4 Nitrate nitrogen concentration



Discussion

The measured values obtained during a six months measurement at five sampling profiles were averaged and these values were compared with values given in Regulation No. 61/2003 Coll., Government Regulation on indicators and values of acceptable pollution of surface water and wastewaters, details of the permit to discharge wastewater into surface water and sewerage systems and sensitive areas, Annex. 3 - Indicators expressing the status of water in the watercourse, environmental quality standards and requirements for water use. (Tab.1).[5] Nitrate nitrogen value exceeded the prescribed value in all five sampling profiles. The pH value exceeded the prescribed value only in the third sampling profile. The PO_4^{3-} value and temperature did not exceeded prescribed value during whole sampling period.

The measured values were then compared with Czech national standard No. 75 7221 Water Quality - Classification of surface water quality [4]. According to this standard the results obtained during at least one year can be evaluated. Additionally, only the samples with following analyzed parametres: saprobic index of macroinvertebrates, biochemical oxygen demand, chemical oxygen demand by dichromate, nitrate nitrogen, ammonia nitrogen and total phosphorus, can be classified. The values presented in this paper were obtained during a period of six months. Only 3 parameters of the mandatory parameters needed for the classification of the surface water quality were analyzed (nitrate nitrogen, total phosphorus and chemical oxygen demand). Therefore, the following comparison is only approximate. Preliminary results showed that a significant impact of different land use on water quality changes have Built up area and Permanent grassland, with cattle grazing. The classification of surface water quality is according to the Czech National Standard No. 75 7221[4] is given in Tab. 2. According to Stoate and Boatman et al. (2001) the greatest impact of the water quality is associated with simplified, high input arable systems where the nitrates and some other pesticides entre groundwater follofing leaching from arable land [6].

Conclusion

The results presented in this paper are only a partial output of the presented project dealing with the categorization of stream sections according to the land use. The previously measured results show that municipalities have significantly greater negative impact on the water quality than agriculturally cultivated land. The Pernička village households are not equipped by the waste water treatment plant and thus all the waste water pollution is treated in individual septic tanks. There is a probability of leach of such waste water into the Pernička stream. The measured data confirmed the assumption that Built – up area and Permanent grassland with

livestock grazing have got an significant effect on the water quality change.

Acknowledgement
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Fig. 5 The Pernička stream flowing through Počítky village (geoportal.gov.cz)

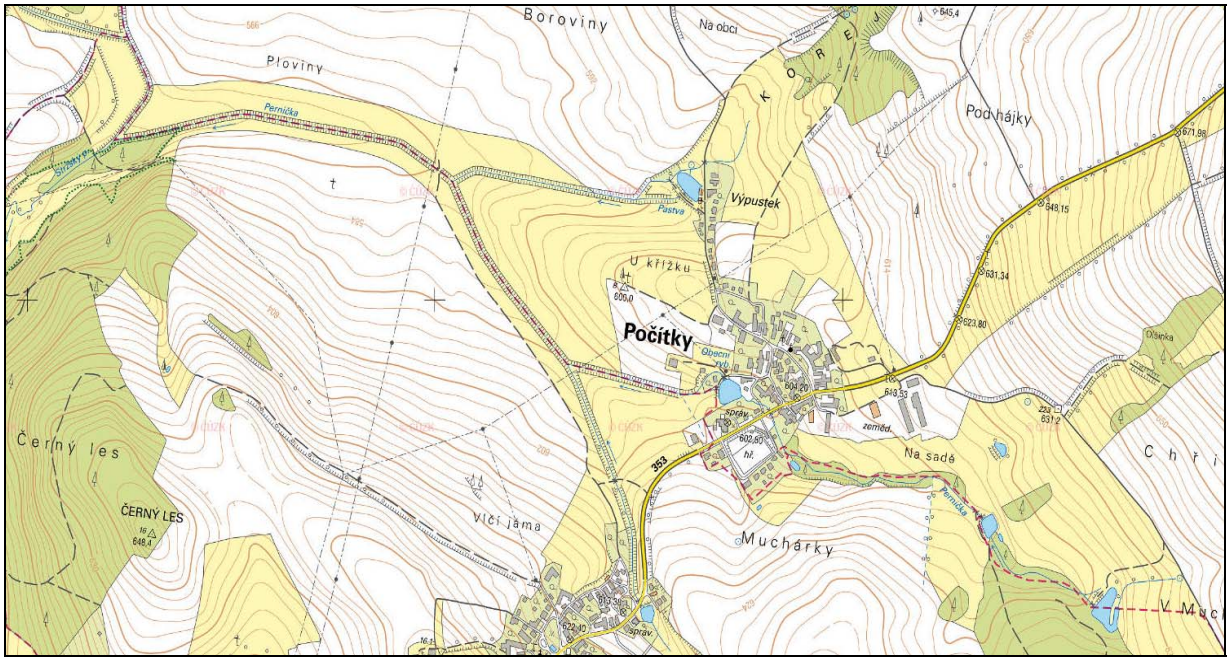

Table 1 Comparison of standardized values (Government regulation No. 61/2003) and averaged measured values

	Standartized value	Permanent grassland	Permanent grassland - Built - up area	Built - up area - Arable land	Arable land - Permanent grassland	Permanent grassland - Forests
NO^{3-} N	5.4	15.56	5.5	7.28	7.62	5.8
PO_4^{3-}		0.3756	0.277	0.9442	0.881	0.2794
pH	6.0 – 9.0	6.672	8.572	9.198	8.624	8.66
t	29	13.76	14.96	18.86	17.8	16.86

Table 2 Comparison of averaged analyzed characteristics with Czech national standard value (ČSN 75 7221)

	Permanent grassland		Permanent grassland - Built - up area		Built - up area - Arable land		Arable land - Permanent grassland		Permanent grassland - Forests	
	sample	Czech national standard	sample	Czech national standard	sample	Czech national standard	sample	Czech national standard	sample	Czech national standard
NO^{3-} N	1.56	5	5.5	2	7.28	3	7.62	3	5.8	2
P_{total}	7.07	5	11.78	5	7.05	5	6.79	5	6.14	5
COD	6.06	1	41.01	3	6.05	1	5.82	1	5.27	1

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[4] Czech Technical standard No. 75 7221 Water Quality - Classification of surface water quality

[5] Regulation No. 61/2003 Coll., Government Regulation on indicators and values of acceptable pollution of surface water and wastewaters, details of the permit to discharge wastewater into surface water and sewerage systems and sensitive areas, Annex. 3 Indicators expressing the status of water in the watercourse, environmental quality standards and requirements for water use

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