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Mirosław SKORBILOWICZ[1]

CHANGES IN WATER QUALITY OF MELIORATION SYSTEMS IN UPPER NAREW RIVER CATCHMENT

ZMIANY JAKOŚCI WÓD SYSTEMÓW MELIORACYJNYCH W ZLEWNI GÓRNEJ NARWI

Abstract: The study aimed at determining the quality of surface waters from open melioration ditches in upper Narew River catchment depending on their spatial localization. Following melioration objects were selected to study (open ditches): Orlanka, Suprasl-Grodek-Lachy, Trzcianne-Neresl, Suprasl-Fasty, Choroszcz-Konowaly, Zubowo-Ploski, Zabludow-Rudnia. The objects were meliorated in 1976–1985 in a form of open ditches network and complementary drainage. Melioration of green lands consists of the outflow ditches built to drain larger meadow complexes and accelerate the water outflow from the catchment. Most of melioration ditches are localized around agricultural lands (meadows and pastures), then on arable lands and not agriculturally performed areas (peat-bogs). Green lands are situated on peat-muck soils and occupy about 85 % of area. In total, 21 measurement points were set. Analyses were made since January 2005 till December 2007 once a month. Following items were determined in collected samples: $N\text{-}NH_4^+$, $N\text{-}NO_2^-$, $N\text{-}NO_3^-$, $P\text{-}PO_4^{3-}$, $S\text{-}SO_4^{2-}$, Cl^-, specific conductivity, acidity (pH), Ca^{2+}, Mg^{2+}, Na^+, K^+, $Fe^{2+/3+}$ and Zn^{2+} by means of colorimetric, potentiometric, as well as AAS and EAS techniques.

Water quality in melioration ditches appeared to be dependent on the character of irrigated area. Water from melioration ditches in upper Narew River catchment is characterized by I and II, and sometimes III quality class for surface water. A considerable part of organic soils in upper Narew River valley affect the chemical composition of waters from open melioration ditches.

Keywords: melioration systems, water quality, nitrates, mineral components

A tremendous amount of research has been conducted to evaluate the influence of agricultural management on nutrient transport [1–3].

The main goal of melioration consists in technical and agrotechnical operations that improve the soil productivity. It leads to a proper water balance in agricultural, forest, or aquatic ecosystems, which enhances their productivity and provides with economic efficiency of management [4].

[1] Department of Technology in Engineering and Environmental Protection, Bialystok University of Technology, ul. Wiejska 45a, 15–351 Białystok, Poland, phone: + 48 85 746 95 56, email: m.skorbilowicz@pb.edu.pl

The drainage water – understood as water from drainage and melioration ditches – is at the start of the minerals migration path within a catchment. Such water is supplied mainly by atmospheric precipitations and transports minerals mainly to surface waters, but also to deep and even to deepest waters [5].

The chemical composition of drainage water may vary, because it can be exposed to direct influences of atmospheric and anthropogenic factors that are associated with application of mineral, organic and natural fertilizers in agriculture [5, 6].

The study was aimed at evaluating the quality of surface waters from open melioration ditches in upper Narew River catchment depending on their spatial localization.

Material and methods

Studies upon the surface water quality in open melioration ditches supplying Narew River and its tributaries were carried out in 2005–2007. The following melioration ditches were selected to studies: Orlanka, Suprasl-Grodek-Lachy, Trzcianne-Neresl, Suprasl-Fasty, Choroszcz-Konowaly, Zubowo-Ploski, and Zabludow-Rudnia (Fig. 1).

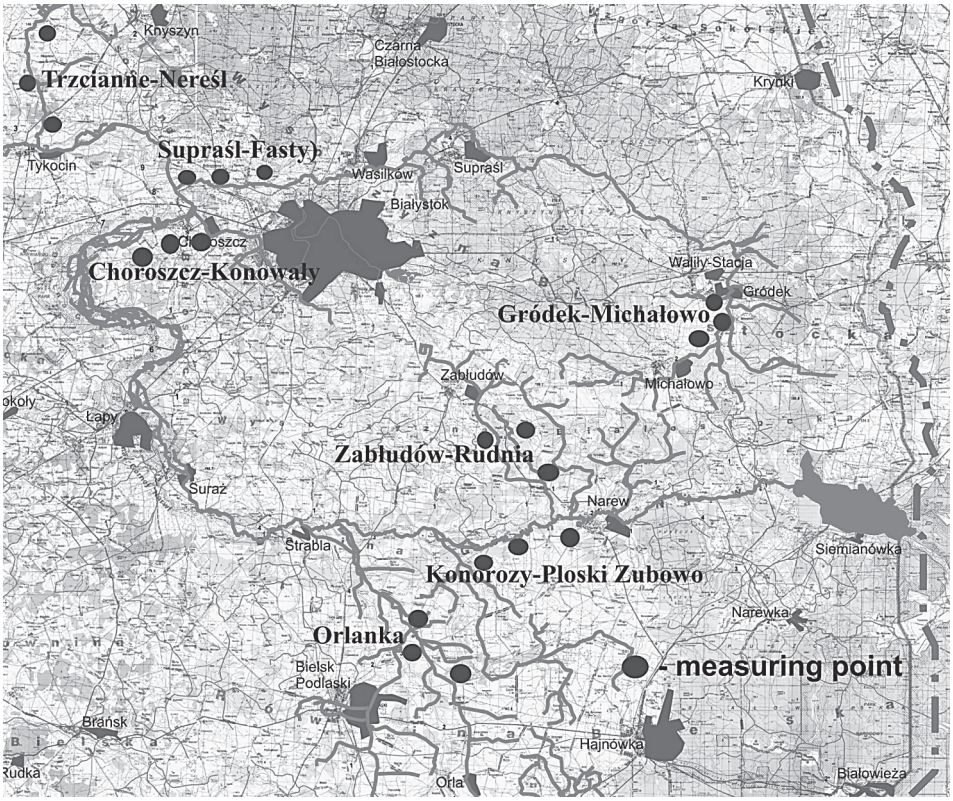

Fig. 1. Localization of sampling points for waters from meliorated areas – upper Narew River

The objects were meliorated in 1976–1985 with a network of open ditches and complementary drainage. Melioration of green lands consists of outflow ditches built to drain larger meadow complexes and accelerate the water outflow from the catchment. Most of melioration ditches are localized around agricultural lands (meadows and pastures), then on arable lands and not agriculturally performed areas (peat-bogs). Green lands are situated on peat-muck soils and occupy about 85 % of area. The thickness of peats was from 0.53 to 2.35 m. Water samples were collected at 3 points from outflow melioration ditches and intensively performed green lands. In total, 21 control points were selected. Analyses were made since January 2005 till December 2007 once a month. Following items were determined in collected samples: $N\text{-}NH_4^+$, $N\text{-}NO_2^-$, $N\text{-}NO_3^-$, $P\text{-}PO_4^{3-}$, $S\text{-}SO_4^{2-}$, Cl^-, specific conductivity, acidity (pH), Ca^{2+}, Mg^{2+}, Na^+, K^+, $Fe^{2+/3+}$ and Zn^{2+} by means of colorimetric, potentiometric, as well as AAS and EAS techniques. The results from determination of the water in studied melioration objects were subject to *Ward Cluster Analysis* (CA).

Results and discussion

The highest mean $N\text{-}NH_4^+$ concentration was found in water of melioration object Suprasl-Grodek-Lachy (2.30 mg · dm^{-3}) (Table 1), which makes it can be classified according to Directive of Minister of Environment (2004) to III quality class of surface waters. The object is localized in majority on areas covered with organic soils with the surplus of peat-muck soils. There are many meadows utilized as pastures, that seem to be the only source of increasing $N\text{-}NH_4^+$ concentration in waters of that object. The melioration works performed in Suprasl River valley made the boggy meadows were transformed into post-bog ones. It seems that elevated $N\text{-}NH_4^+$ concentration may result from the influence of post-bog soils that occur mainly around Suprasl Gorna [7]. The cited study confirm the observations made by Gotkiewicz and Gotkiewicz [8], who reported that meliorated post-bog soils, due to physical and chemical processes, may release considerable amounts of biogenic compounds. Similar $N\text{-}NH_4^+$ concentration in water of meliorated object Suprasl Gorna was recorded by Kiryluk and Wiater [9]. The lowest $N\text{-}NH_4^+$ concentration was reported in water of objects Choroszcz-Konowaly and Orlanka (0.17 and 0.10 mg · dm^{-3}, I quality class for surface water) localized on light soils developed from loamy sands and brown eluted ones. Extreme high concentrations of $N\text{-}NO_2^-$ (0.047 · dm^{-3}) and $N\text{-}NO_3^-$ (3.8 · dm^{-3}) – III quality class, were recorded in waters of object Choroszcz-Konowaly. Nitrogen compounds release processes from part of organic post-bog soils as well as high level of fertilization applied in those areas, were the probable reasons for that anomaly. The lowest $N\text{-}NO_3^-$ concentration (0.6 · dm^{-3}) was determined in object Neresl-Trzcianne localized on sandy soils covered with green lands, which seems to be a natural consequence of such system with sandy soils. Also high level of $N\text{-}NO_3^-$ (2.9 · dm^{-3}) was determined in water of melioration object Zabludow. The green lands dominate in these areas and in 85 % they are situated on peat-bog soils. No intensive meadow-pasture management is performed there. Studies conducted by Kiryluk and Skorbilowicz [10] confirm these

Table 1

Physicochemical composition of surface water from open melioration ditches in upper Narew River catchment (mean values for 2005–2007)

Melioration object, soil/indicator, unit	$N\text{-}NH_4^+$	$N\text{-}NO_2^-$	$N\text{-}NO_3^-$	$P\text{-}PO_4^{3-}$	$S\text{-}SO_4^{2-}$	Cl^-	EC*	pH	Ca^{2+}	Mg^{2+}	Na^+	K^+	$Fe^{2+/3+}$	Zn^{2+}
	[mg · dm^{-3}]						[μS · cm^{-1}]		[mg · dm^{-3}]					
Orlanka *Light loamy sand, meadows and arable lands*	0.10	0.013	1.2	0.27	14	28	540	7.6	120	15	13	7	0.347	0.042
Suprasl Grodek Lachy *Peat-muck, meadows, arable lands, wastelands*	2.30	0.014	1.6	0.14	20	37	573	7.3	91	14	9	5	0.911	0.026
Trzcianne Neresl *Green lands, sandy soils*	0.46	0.011	0.6	0.13	16	20	552	7.8	119	21	17	9	0.810	0.065
Suprasl Fasty *Loose muck and light loamy sands, peats, meadows*	0.50	0.008	1.4	0.07	17	29	571	7.3	121	19	48	28	9.433	1.678
Choroszcz Konowaly *Muck brown eluted soil, grasses*	0.17	0.047	3.8	0.06	30	35	798	7.5	205	25	21	12	0.451	0.074
Zubowo Ploski *Peat-bog, mineral-podzolic, meadows*	0.29	0.010	1.2	0.18	25	26	602	7.4	110	17	16	7	0.421	0.021
Zabludow Rudnia *Mineral podzolic, meadows*	0.38	0.018	2.9	0.22	37	49	663	7.1	131	16	21	13	0.826	0.073

* Electrical conductivity.

results, but they found that nitrate form was characterized by the highest seasonal variability.

The highest calcium concentration was found in water of Choroszcz-Konowaly object (205 · dm^{-3}), which ranks it as III quality of surface waters. At the same time, the highest concentration of magnesium ions (25 mg · dm^{-3}) and the highest value of specific conductivity (798 μS · cm^{-1}) was recorded in that object (II quality class). The soils are intensively fertilized within that area, including liming of strongly acidified ones and it may the main reason for the high levels of macronutrients in waters that flow out of the melioration ditches. Studies performed by Terelak et al [11], Koc et al [12], and Sapek [13] also indicate that. In turn, the lowest levels of macronutrients as well as specific conductivity were recorded in waters flowing out of Suprasl Gorna area (object Suprasl-Grodek-Lachy). As it is known, post-bog and peat areas with meadows and pastures dominate there. The post-bog soils usually contain small amounts of macronutrients, which probably limits their concentrations in waters flowing out of melioration ditches. Studies by Gotkiewicz and Gotkiewicz [8] confirm such observations. These authors also claim that low levels of macronutrients in waters from melioration ditches may be associated with their low concentrations in peat-muck soils.

The pH of the analyzed waters unlikely has no affect on concentration of $S\text{-}SO_4^{2-}$. This follows from the results of studies included in the Table 1. Probably the concentration of $S\text{-}SO_4^{2-}$ in water from drainage ditches is periodically dependent primarily on their water level. Low water levels cause high concentrations of $S\text{-}SO_4^{2-}$ and high water levels – low concentration of $S\text{-}SO_4^{2-}$.

Analysis of results related to water quality in studied melioration objects was made on a base of classification method – Ward Cluster Analysis (CA). Dendrogram (Fig. 2)

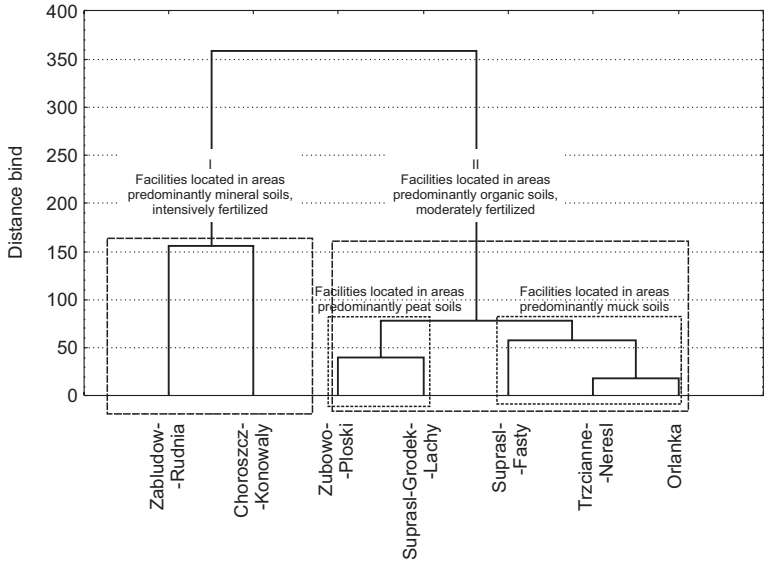

Fig. 2. Ward cluster analysis – waters from melioration systems

presents 2 groups of melioration objects that were arranged due to analysis of generated clusters. One group consists of objects localized on mainly mineral soils that are intensively fertilized and de-acidified, while the other group is composed of objects localized on organic (post-bog and peaty) as well as organic-mineral soils that are less intensively fertilized.

Conclusions

1. The dependence of quality of water in melioration ditches on soil type and land use of drained area was found.

2. Waters from melioration ditches in upper Narew River catchment are characterized by I and II, and sometimes III quality class for surface waters.

3. Majority of organic soils within upper Narew River catchment affect the chemical composition of waters in open melioration ditches.

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ZMIANY JAKOŚCI WÓD SYSTEMÓW MELIORACYJNYCH W ZLEWNI GÓRNEJ NARWI

Katedra Technologii w Inżynierii i Ochronie Środowiska
Politechnika Białostocka

Abstrakt: Celem pracy było określenie jakości wód powierzchniowych z otwartych rowów melioracyjnych w zlewni górnej Narwi w zależności od ich lokalizacji przestrzennej. Do badań wybrano następujące obiekty melioracyjne (rowy otwarte): Orlanka, Supraśl-Gródek-Lachy, Trzcianne-Nereśl, Supraśl-Fasty, Choroszcz-

-Konowały, Zubowo-Ploski oraz Zabłudów-Rudnia. Obiekty zostały zmeliorowane w latach 1976–1985 siecią rowów otwartych i drenowaniem uzupełniającym. Melioracje użytków zielonych stanowią rowy odpływowe wykonane w celu odwodnienia większych kompleksów łąk i przyśpieszenia spływu wód ze zlewni. Większość rowów melioracyjnych jest położona w obrębie użytków rolnych (łąk i pastwisk), w mniejszym stopniu na polach ornych oraz terenach nieużytkowanych rolniczo (torfowo-bagiennych). Użytki zielone są położone na glebach torfowo-murszowych stanowiące około 85 % powierzchni. Ogółem wybrano 21 punktów badawczych. Analizy wykonywano w okresie od stycznia 2005 do grudnia 2007 raz w miesiącu. W próbkach oznaczano stężenie $N\text{-}NH_4^+$, $N\text{-}NO_2^-$, $N\text{-}NO_3^-$, $P\text{-}PO_4^{3-}$, $S\text{-}SO_4^{2-}$, Cl^-, przewodność właściwą, odczyn (pH), Ca^{2+}, Mg^{2+}, Na^+, K^+, $Fe^{2+/3+}$ i Zn^{2+} metodami kolorymetrycznymi, potencjometrycznymi oraz ASA i ESA.

Na podstawie wyników badań stwierdzono, że jakość wód w rowach melioracyjnych jest uzależniona od charakteru odwadnianego obszaru. Wody z rowów melioracyjnych zlewni górnej Narwi zaliczono do I i II, a czasami III klasy jakości wód powierzchniowych. Znaczny udział gleb organicznych w dolinie górnej Narwi wywiera wpływ na skład chemiczny wód z otwartych rowów melioracyjnych.

Słowa kluczowe: systemy melioracyjne, jakość wód, azotany, składniki mineralne