THE CONTAMINATION OF SURFACE WATER AND SOIL IN BIOSPHERE RESERVE POĽANA

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Abstract

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The goal of this report is to assess the surface waters and soil contamination with oil substances in Biosphere Reserve Poľana. The contamination of water and soil occurred because of calamity wood exploitation in term of 1996–1998. We monitored some flows chosen according to intensive exploitation localities from 1996 till 2000. To complete surface waters monitoring, we analysed also soil and sediment samples in some localities in Kamenistá valley. Oil substances were determined by spectrophotometric method in infra-red extent in wave number from 3150 cm^{-1} till 2750 cm^{-1}. The most significant oil substances load was stated in locality of stream Kamenistý. Total in 1996 78 % of samples was above the limit 0.1 $mg.l^{-1}$, in 1997 it was 58 % of samples and in 1998 37 % of samples. The situation was markedly stabilized only in 2000. Also the soil near wood storages was contaminated, the most high concentration was detected in locality of stream Kamenistý again. The presence of oil substances was demonstrated also in sediments of water reservoir Hrončok.

Key words: surface water contamination, soil contamination, petroleum

Introduction

In 1996 the part of Biosphere Reserve (BR) Poľana was hit by destructive storm which involved 100-year calamity. Disposal of the calamity consequences brought the next unacceptable element – oil substances contamination of the environment that was in connection with machine works used.

The goal of the paper is an assessment a negative influence of oil substances in BR Poľana and a loading condition of surface water and soil

Oil substances load of environment was monitored within scientific-technical project "Rational Coverage and Exploitation of the Area of BR Poľana from Landscape-ecological and Forest-ecological Aspects" (VTP BE - II, 3902).

According to Slovak Technical Norm (STN) 83 09 15 as oil substances we understand hydrocarbons and their mixtures which are at the temperature 40 °C still liquid. To the oil substances belong mainly petrol, benzene and its derivates, mineral oil, petroleum, jet petroleum, light and heavy oils, black oil, oil and substances with similar properties. According to Direction of Slovak Government No. 242/1993 Coll., Appendix No. 3, the content of oil substances in water supply flows must not cross the limit 0.01 $mg.l^{-1}$, in other surface water flows the limit is stated as 0.1$mg.l^{-1}$. Negative impact of increase oil substances content in surface waters is showed as (Bienik, 1994):

- the change of organoleptic properties of water (odour, taste, color)
- the change of chemical composition of water (as a result of emulsification, change of reaeration)
- the change of biological activation of water (toxic effect at organisms, change of bacteriological flora)
- the change of physical properties of water (surface tension, oil films).

Because of low dissolubility of the most of oil substances, in the water the emulsified and clear oil substances are dominated. Generally, the more oil substances are emulsified in the water, all the more higher toxicity is showed and differences in toxicity of emulsified and non-emulsified oil substances are multiple. Toxicity for water organisms is in the rate of order units $mg.l^{-1}$ (Martoň et al., 1991).

The free oil substances from the oil film at surface which is inhibits the oxygen movement into the water, photosynthesis process is fluctuating what is unfavourable for water organisms live, Algae could be strong influenced and also other plankton (e.g. 1 liter of mineral oil covers with its film about 0.5 hectare of water surface).The surface of minor organisms shape is protected with membrane which is abhorrent the water, membrane consists of lipids mainly. Hydrophobic components of oil substances are easy retained on the membrane forming oil films and hereby infiltrating organisms bodies where they prohibits oxygen reception. Thereafter it causes perishment of minor organisms with oil substances contact. Toxicity for fish is for various oil distillation fractions (Table 1).

The sunlight has an effect for increasing toxicity because of naphtenic acids formation which work as a nerve poison in concentrations higher than 1.5 $mg.l^{-1}$ (Malinský et al., 1990).

Together with the infiltration of oil substances into the water some processes are going to be in progress which intensity depends on type of oil substances, medium character, temperature, rapidity of streaming and live activity. The part of oil substances can adsorb on undissolved matter. In suitable conditions the biological decomposition is going to pass off which is accelerated by photooxidation (Hyánek, 1991).

Biochemical decomposition of oil substances is passed off mainly in upper layers of surface waters in the presence of nutritive and oxygen and in appropriate temperature on the bottom of the fluvial flow this process is 10 times slower than on the top because the chemical oxydation through solar radiation is processing. The activity of microorganisms decrease with the loss of temperature (Tajč, 1990).

Table 1. Oil substances influence at water microorganisms

Substance	Biological objects	Impact	Concentration [mg.l^{-1}]
Petroleum	generally Salmon Trouts	mortally mortally in 1 hour mortally in 5–25 minutes	80–250 50–70 1000
Mineral crude oil	Salmon Trouts	toxic in 5–10 days	40–500
Motor oils	generally *Tubifex*	toxic limit of obnoxiousness	0.5–10 1–8
Naphtenic acids	Crawfish fish	toxic in 18 hours toxic after 60 hours mortally limit of toxicity 5–70 days	10 5 1–3
Petrol	generally water organisms	toxic after 30 minutes mortally after 30 minutes	10 25–30

The influence of oil substances into the soil depends on their volume, terrain permeability and retentive ability of the ground. Oil substances affect the most of plants species as total herbicide (Srnský, 1992). In fields target only petroleophobic plants survive (they are low sensitive for oil substances), for example Stinking Nettle and European Elder. The most of plants and wood species (Mosses, Lichens, Grass, Birch, Lombardy Poplar) are high sensitive, they are petroleophilic. After attack of oil substances plants die away or respond with delayed growth. One of the reasons of plant necrosis is that because of progressive soil infiltration. Oil substances envelop the vegetation rootles and inhibit absorption of moisture, then the plant begins to dry. When the escape of oil substances is impulsive and low amount, the oil substances are absorbed at particles surface in ground medium,

Table 2. Duration of soil recovery contaminated by oil substances (Šedivý,1992)

Soil pollution by oil substances		Duration of contaminated soil recovery	Volume of soil recovered [%]
Oil substance type	oil substances volume escaped [l.m^{-2}]		
Petroleum	9	till 1 year	100
Petrol	1 3–9	till 1 year till 2–3 years	100 100
Mineral crude oil	1 3 9	after 3 years after 3 years after 3 years	100 74 57
Motor oil	1 3 9	after3 years after 3 years after 3 years	100 59 26

eventually they rate by capillary powers in the ground. The ground is able to receive precise quantity of oil substances which can be with access of air decomposed by biological processes in the soil such that they do not pollute groundwaters. The soil recovery period is various, examples of periods of natural decomposition of oil substances are shown in Table 2.

When the impulsive leakage is in high amount, the sorbtive ability of ground is stopped and because of gravity vertical movement of oil substances is occurred and the oil substances body is formed which is drifted on the level of surface of groundwater. Devaluation of drinking water resources is shown at the concentration 0.01 mg.l^{-1} as the change of sensoric properties.

Material and methods

Surface waters samples withdrawal and sampling

Contamination of surface waters in Biosphere Reserve Poľana was watched during the years 1997–2000. Locality selection where the sampling was done was oriented in total monitoring of conditions. Following surface flows were monitored:

- stream Kamenistý
- stream Slatinský
- stream Čierny
- brook Trkotský
- Hradná
- stream Detviansky
- Hutná
- Osrblianka
- Hučava

Flows mentioned above were monitored in profiles chosen according the places of intensive exploitation. Water samples were took in as a dot samples into fairly flushed glass bottles and processed next day.

The first intake was carried out on 13th December 1996 that means it was in time of intensive wood conveytion. Next intakes were done in monthly periods – the last total intake was carried out on the 3rd November 1998. During the years 1999 and 2000 the samples were took in the most loaded locality only:

- under Sihla
- below Sihla
- stream Slatinský
- Klimentka (storage of wood conveyed)
- stream Čierny (before the confluence with stream Kamenistý)
- water reservoir Hronček

Meanwhile the last intake of samples was done on 4th October 2000.

Soil sample intake

To complete water monitoring, soil and shore sediment samples of Kamenistá valley localities were took in the term of 1997 till 1999:

- Klimentka – wood storage (under stream Kamenistý)
- Klimentka – shore sediment under stream Kamenistý
- shore sediment at the surface level of water reservoir Hronček
- shore sediment 50 cm under the head of stream Kamenistý into the water reservoir Hronček

- shore sediment 100 cm under the head of stream Kamenistý into water reservoir Hrončck
- Osrblianka – wood storage
- Osrblianka – under the stream.

The samples were took from the depth of 20 cm. The average sample was done always from 3 withdrawal dots of sample site and was treated according to the direction of methodology instructions for sampling and analysis of groundwater and soil polluted by oil and chlorinated hydrocarbons (The methodical instructions, 1995).

The shore sediment of water reservoir Hrončck was sampled in 1999, also in the depth profile of 50–100 cm because reservoir was partially discharged. Samples taken we analyzed in two ways:

a) direct extraction with trifluorotrichloromethane (Martin et al., 1991)
b) in aqueous liquor (predried samples at laboratory temperature were mixed with distilled water in ratio 1:10 and homogenized in shaking machine).

Determination of oil substances

Oil substances were determined by spectrometric method in infra-red extent as nonpolar exctratible substances. The method is based on the extraction of oil substances from acidified water sample with trifluorotrichloromethane, then the residual of polar substances is removed as adsorption at silica gel, the spectrum record in wave number from 3150 cm^{-1} till 2750 cm^{-1} is done and valence vibrancies typical for CH groups are evaluated by the assistance of empiric calculation (Horáková et al., 1988). The determination in infra-red extent is unspecied method, which estimates the unpolar substances come from a mineral oil and a little amount of the native ones from soil or vegetation. On the other hand petroleum includes some quantity of the polar substances.

Results

Surface waters

The view of oil substances load in particular withdrawal profiles during 1996–2000 is shown in Table 3. From the time process of oil substances concentration within period monitored appears that all oil substances values which are under the limit 0.1 $mg.l^{-1}$ can be assumed as impulsive extreme values coherent with exploitation of calamity wood. On the base of spectrographical records and the shape of spectral lines measured we assume that the main part of oil substances belongs to motor crude oil and engine oil, strip at wave number 3055 cm^{-1} typical for aromatic hydrocarbons is not significant.

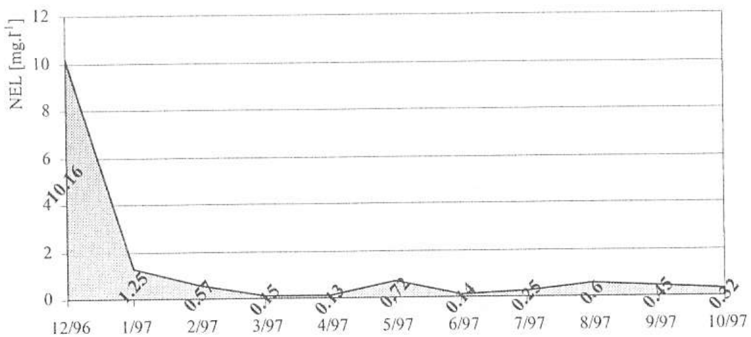

Fig. 1. Oil substances concentration in Klimentka profile.

Table 3. The concentration of non-polar extractible substances in water flows profiles monitored

The name of the flow	Specification of withdrawal sample site	The average value of non-polar extractible substance [$mg.l^{-1}$]				
		year				
		1996	1997	1998	1999	2000
Stream Kamenistý	under Sihla	0.0	0.0	0.0	0.0	0.0
	below Sihla	0.62	0.44	0.41	0.31	0.1
Stream Slatinský	Kamenistá valley	*	0.13	0.1	0.1	0.0
Stream Kamenistý	Klimentka	10.16	0.44	0.58	0.19	0.1
Stream Čierny	confluence with stream Kamenistý	1.8	0.53	0.24	0.15	0.0
Stream Kamenistý	inflow of water reservoir Hrončck	2.5	0.30	0.48	0.20	0.16
Brook Trkotský		0.23	0.06	0.1	-	-
Hradná	Suchohradná	*	0.11	0.0	-	-
Hradná	below Iviny		0.35	0.1	-	-
Hradná	Mačinová	*	0.0	0.0	-	-
Stream Detviansky	Kostolná	*	0.1	0.1	-	-
Hutná	Genzlová	*	0.81	0.1	-	-
Osrblianka	Tri vody	*	0.36	0.51	0.34	0.0
Osrblianka	Hrašková valley	*	0.4	0.21	0.0	-
Osrblianka	Veľká Prostredná	*	2.4	0.17	0.0	-
Hučava	Jasenová	0.1	0.05	0.0	-	-
Hučava	Veľká voda	2.09	0.1	0.15	-	-
Hučava	Bobrovo	1.05	0.13	0.1	-	-
Hučava	Bátovský Rock	0.19	0.04	0.0	-	-
Hučava	Šafranička	0.25	0.11	0.12	-	-

*unmeasured in 1996

Table 4. Percentage expression of overrun the limit value 0.1 $mg.l^{-1}$ in profiles chosen in 1997

The name of the flow	Specification	% of samples overrun the limit value 0.1 $mg.l^{-1}$
Stream Kamenistý	under Sihla	0
Stream Kamenistý	below Sihla	88
Stream Slatinský	Kamenistá valley	62
Stream Kamenistý	Klimentka	100
Stream Čierny	confluence with stream Kamenistý	100
Stream Kamenistý	inflow into water reservoir Hrončck	83

While in 1996 78 % of samples were overpassed the limit, in 1997 58 % of samples were overspassed and in 1998 it was only 37 %. In 1999 the number of profiles monitored was significantly reduced, the contamination under the admissible margin survived only in the locality of stream Kamenistý and Osrblianka. The situation was strongly stabilised in 2000 only, when the increased vawere appeared in Water Reservoir Hrončck only (Fig. 2).

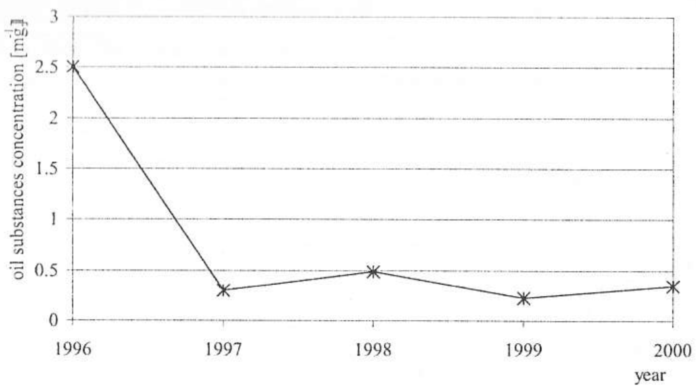

Fig. 2. Average year concentration of oil substances in reservoir Hrönček.

The assumption is that if repeated significant pollution does not happen, the planned withdrawal of samples will be "clean" in 2001.

Finally, from our observations appeared that the contamination of oil substances because of exploitation and conveytion of calamity wood has the biggest load in Kamenistá valley, where we measured values in 1996 10.6 mg.l^{-1}, what is value in the margin of toxicity for fish (Martoň et al., 1991). In 1997 we recorded in profiles of Klimentka (Fig. 1) and confluence with stream Čierny the overrun of limit value in all samples analyzed (100 %), in Hrönček profile the overrun was only in 83% samples, stream Slatinský 62 % and profile under Sihla 82 % (Table 4). We assume that the presence of higher content of oil substances under village Sihla is not connected just with calamity, but with missing sewage water plant and supply. The direct connection with calamity wood exploitation was shown in 1997, when the high concentration 10.16 mg.l^{-1} measured in December 1996 (Klimentka profile) was decomposed to the value 0.57 mg.l^{-1} in February 1997 and in May 1997 the value reached the level 0,13 mg.l^{-1}. According the literature (Alloway, Ayres, 1997), the biochemic oxydation of hydrocarbons is more difficult in winter season, because the temperature higher than 0°C is required. There is some assumption, that in the season with more appropriate temperature level, the total decomposition will happen earlier. In June the intensive exploitation had started again and oil substances concentration value was increased in 0.72 mg.l^{-1}, what it had not be so alarmed as in 1996. Next time process was the reflection of decrement or activity increasing repeated in the area. Concentrations increased had been surviving in 1998 till 1999, when it had not come to the total decomposition or in the time of exploitation decrement, as it had been come in 1997. Since the concentration increased had been survived almost 3.5 years, there is some assumption that this status was showed as the change of the stream activity.

In case of the 6th profile of stream Kamenistý – Hrönček, located in marginal part of Biosphere Reserve Poľana we state that the highest level of oil substances concentration was reached in the end of the year 1996 and the value was 2.5 mg.l^{-1}. Next year in February

the value decreased about 94.2 % to the rate 0.145 mg.l^{-1}. The increase was recorded by us again in the beginning of the summer in 1997, 1998, 1999. By this time last intake on 10th of April, 2000, mildly over limit 0.16 mg.l^{-1} of oil substances concentration was surviving. We assume that outlasting mildly increased values in water reservoir Hrönček are connected with successive antiflooding of oil substances closed in sediments. Except of status in 2000, when besides of Hrönček, increased values of oil substances in stream Kamenistý locality were not occurred, the correlation between other localities and Hrönček profile was unambiguously demonstrated – the correlation coefficient was in interval 97– 99 %.

Soil and sediments

The results of measuring oil substances concentration in the liquor of soil took in 1997 incidentally are introduced in Table 5. The most contaminated soil was the soil in brook

T a b l e 5. Oil substances concentration in the water liquor of soil (intake in 1997, depth 20 cm) converted to dry sample of soil

Intake locality	Locality specification	Water leachate for 24 hours	Water leachate for 72 hours	Water leachate for month
		oil substances concentration [mg.kg^{-1}]		
Stream Kamenistý	Klimentka under the stream	0	2.9	3.2
Stream Kamenistý	Klimentka - storage	6.1	4.8	5.2
Čierny stream	storage	1.9	5.3	5.1
Osrblianka	little landfill	10.0	8.6	5.9
Predný brook - Osrblianka	under the stream	7.3	5.5	6.7

Predný – Osrblianka locality where after 24 hours 10 mg of oil substances per 1 kg of dry soil sample was leached. Around the 30 m from this place very close to the stream the value of oil substances concentration was 7.3 mg.kg^{-1}. Those values are relatively low, in natural conditions they decompose by oxydation and microorganisms activity, as long as oil substances are not closes in the soil complex and have tendency getting into the waters during the long period with successive leaching. Our observations showed (Table 5) that increasing of oil substances concentration after 72 hours come about in the storage of stream Čierny locality approximately three times and one month later around 2.5 times. At other localities the concentration was soft decreased or remained at the same origin value. That means that it is impossible to confirm the successive leaching of oil substances except stream Čierny locality.

The second soil sample intake was done after one year, in 1998, at 3 profiles of locality stream Kamenistý – Klimentka, also direct measure of oil substances concentration was executed. In this case following some authors (Poór, 1997), some complications are to be stated in analyze process if organic fraction of soil gets in sample material. Thereafter detection of such material using interfering agent evokes some problems with interpretation of results of oil substances analyze. The results of the second intake are shown in Table 6.

T a b l e 6. Oil substances concentration in the water leachate of soil (intake in 1998, depth profile 20–60 cm) converted to dry sample of soil and in direct analyze

Intake locality	Locality specification	Depth [cm]	Direct analyze	Water leachate for 24 hours	Water leachate for month
			oil substances concentration [mg.kg^{-1}]		
Stream Kamenistý	Klimentka – storage	20	62.71	4.3	4.76
Stream Kamenistý	Klimentka – storage	40	19.43	2.76	3.51
Stream Kamenistý	Klimentka – storage	60	0.5	0.0	0.0

From Table 6 results that the highest load of oil substances is in depth 20 cm, in depth 60 cm no pollution was detected yet.

In 1999 the last sample intake from the storage in Klimentka locality was done in depth 20 cm. The water leachate for 24 hours was in concentration 2.66 mg.kg^{-1} of oil substances, for one month the oil substances in liquor was 3.53 mg.kg^{-1}.

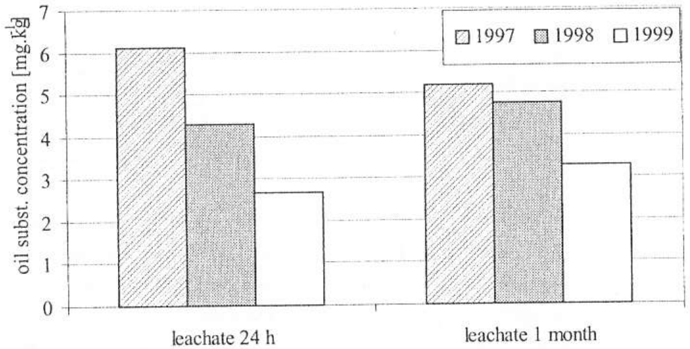

Fig. 3. Extractibility of soil substances in profile Klimentka – the storage (1997–1999).

In Fig. 3 there is the scheme of the movement of oil substances concentration leached from soil in profile Klimentka – the storage in term of three years. In the liquor for 24 hours the concentration in the year 1998 decreased about 30 % in comparison with the year 1997, in 1999 it decreased opposite 1998 about 40 %. We assume that when the contamination will be stopped, in 2001 no pollution will be detected in liquor for 24 hours. Oil substances detection in liquor for month indicates the progressive leaching of oil substances closed in the soil complex and if the same trend is followed, zero values are to be detected in 2003.

T a b l e 7. Oil substances concentration in sediments in direct analyze – stream Kamenistý (year 1998)

Locality intake	Locality specification	Oil substances concentration [mg.kg^{-1}]
Stream Kamenistý	Klimentka – the shore	17.1
Water reservoir Hrončok	sediment at the level of the surface water level	10.2
Water reservoir Hrončok	sediment 50 cm below the surface water level	16.3
Water reservoir Hrončok	sediment 1 meter below the surface water level	23.8

From table 7 results that the highest load in sediments from water reservoir Hrončok is in the sediment 1 m under the water level where oil substances concentration in two times higher then in the sediment at the water level. This fact is determined in more intensive microorganism's activity at the water level because of higher oxygen content.

Conclusion

From the results of analytical testing expressly follows that in time of intensive exploitation of calamity wood the contamination occurred in Biosphere Reserve Poľana with oil substances. The strongest oil substances load of surface waters was indicated in locality stream Kamenistý – Klimentka (year 1996, 10.16 mg.l^{-1}). Value measured is very close to the value significantly toxic for fish.

Totally in 1996 above the limit 0.1 mg.l^{-1} was 78 % of samples, in 1997 above the limit was 58 % and in 1998 it was 37 %. The situation was strongly stabilized only in 2000 when values increased were stated only in water reservoir Hrončok.

Variable content of oil substances in the top part of stream Kamenistý (from about 0.1 till 1.4 mg.l^{-1}) is because of missing sewage and waste water treatment in Sihla. Considering the "environmental clean area" there is an assumption that without the significant contribution of wood exploitation in bottom of stream Kamenistý the pollution from Sihla in normal conditions could be naturally decomposed before the enter into water reservoir Hrončok.

With oil substances also the soil near wood storage was contaminated, the highest concentration was detected in locality stream Kamenistý – Klimentka storage (62.71 mg.kg^{-1}). Percentage of leachable oil non-polar extrapolating substances (converted to dry sample in order does not cross 0.001 %. Those values are relatively low, in natural conditions are decomposed by oxydation and microorganisms activity, if oil substances are not closed in the soil complex and are leaching into the waters through the progressive leaching.

The presence of oil substances was demonstrated in sediments of reservoir Hrončok. The highest oil substances load was analyzed in the sediment which was 1 m under the water level [23.8 mg.kg^{-1}]. Here there is the assumption that in this case oil substances were closed in the soil complex, and progressive leaching and decomposing are to be followed long time.

In conclusion it is possible to state that the approach to the wood exploitation and work management is necessary to change, because there is a danger of multiplying the damages in environment. We suppose, that the risk of contamination of the forest environment in relation with the expected utilization of wood for the energetic needs can increase in certain regions (Viglasky, 1998a,b).

Using of naturally degrading oils, good technical condition of vehicles and technology discipline has to be secured with high priority in such rare and valuable localities as Biosphere Reserve Poľana is. The reparation of the statement when the contamination is the fact is because of large area of wood exploitation too serious behalf of finance, and of course, the result is not definite.

Translated by B. Kapustová

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Samešová D., Ladomerský J.: **Kontaminácia povrchovej vody a pôdy v Biosférickej rezervácii Poľana.**

Cieľom príspevku je posúdenie kontaminácie povrchovej vody a pôdy ropnými látkami v BR Poľana. Ku kontaminácii vody a pôdy došlo v súvislosti s ťažbou kalamitného dreva v r.1996-1998. Monitorovali sme vybraté toky podľa miest intenzívnej ťažby v priebehu rokov 1996-2000. Pre doplnenie monitoringu povrchovej vody sme analyzovali aj vzorky pôdy a brehových nánosov vybratých lokalít Kamenistej doliny. Ropné látky sme stanovovali ako nepolárne extrahovateľné látky spektrometrickou metódou v infračervenej oblasti pri vlnočte od 3150 cm^{-1} do 2750 cm^{-1}. Najvýraznejšie zaťaženie ropnými látkami bolo preukázané v lokalite Kamenistý potok. Celkove v roku 1996 bolo nad hranicou 0.1 $mg.l^{-1}$ 78 % vzoriek, v r.1997 to bolo 58 % a v r.1998 37 %. Výrazne sa situácia stabilizovala až v roku 2000. Ropnými látkami bola kontaminovaná aj pôda v oblasti skladov dreva, najvyššiu koncentráciu sme detekovali opäť v lokalite Kamenistého potoka. Prítomnosť ropných látok bola dokázaná tiež v brehových nánosoch vodnej nádrže Hronček.

ENVIRONMENTAL SIGNIFICANCE OF MICROORGANISMS IN THE SURFACE WATER

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Abstract

Javoreková S., Vjatráková J., Tančinová D.: Environmental significance of microorganisms in the surface water. Ekológia (Bratislava), Vol.22, No. 2, 201–210, 2003.

Among ecologically threatened areas in Slovakia are surface waters flowing through localities without sewerage but with intensive agricultural activities. In such an area there was also the Cabaj stream, the microbiological quality of which was monitored in a period covering March 1999–February 2001. Occurrence of the monitored physiological groups of microorganisms (coliform bacteria, actinomycetes, microscopic fungi, myxobacteria, lipolytic bacteria, and amylolytic bacteria) indicated that in the experimental years, the stream was polluted by post-consumer waste, vegetable waste, as well as soil. From March 1999 till February 2000, an increased supply of particularly easy degradable organic matters from faeces was observed in the Cabaj stream, and in a period of March 2000–February 2001, there were difficult degradable organic substances in the lower part of the stream. Also, the presence of typical representatives of soil microscopic fungi confirmed the stream pollution by different soil particles.

Key words: surface water, coliform bacteria, actinomycetes, amylolytic bacteria, lipolytic bacteria, myxobacteria, micromycetes

Introduction

From the environmental point of view, the current microbiological indicators monitored according to STN 75 7221 are not appropriate for evaluating changes and quality of surface waters. Therefore, it is necessary to introduce new indicators ensuring better monitoring the water quality, which is also in conformity with the European Union´s requirements. Among suitable indicators are microorganisms or their associations that record mainly changes in carbon circulation. In order to identify increased concentrations of organic substances as well as those difficult to degrade, it is good to monitor the occurrence of actinomycetes (Niemi et al., 1982), myxobacteria (Pištěková, 1989; Miklošovičová, Tržilová, 1991), microscopic fungi (Franková et al., 1998), lipolytic bacteria (Kopřivík, 1981), amy-