

ECOLOGICAL ASPECTS OF DRAINAGE CANAL SEDIMENTS - CASE STUDY -

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ABSTRACT

Sediment deposition in canals network is caused by natural and anthropogenic conditions, respectively by canal environment in Vojvodina. Also, different type of point and non-point pollutants, transport characteristic of streams, and others typical canal particularity influence sediment deposition. The primary point of canals functionality and efficiency is their permanent maintain by sediment dredging. Taking one drainage canal as the example, essential chemical properties of the sediment and hazardous and toxic substances contents (heavy metals, PCBs and PAHs) are being analysed and presented in the paper. Importance of sediments quality problems addressing to land reclamation canal network in Vojvodina are pointed out in this paper. Necessity for sediments monitoring and criteria definition for environmental discharge are drawn. Special attention is paid to agricultural land as recipient of these sediments.

KEY WORDS:

drainage canals, sediments, heavy metals, PCBs, PAHs

1. INTRODUCTION

Ever since the very first canal reclamation works when a man started combating effects of excess water by drainage methods, or supplying dryland with water by means of irrigation structures, the silt accumulation or sediment deposition issues became an unavoidable occurrence. At the early stage, the sediments-related issues were due to inadequate dredging methods or techniques, but they were successfully overcome by means of modern dredging equipment. Nowadays, however, the primary focus is aimed on the sediment quality, deposition and storage of dredged sediment for the purpose of protecting environment from unfavourable and negative impacts. As the result of wide-spread use of chemical agents in agriculture (fertilizers, pesticides, etc.), industrial developments concentrated on the locations adjacent to waterstreams and the use of streams as the recipients of inadequately treated waste water, sediments are frequently polluted with harmful, toxic and dangerous substances. Sediments polluted in such a way may be subjected to undesirable processes with unfavourable effects (accumulation,

concentration, synergic actions, etc.) thus additionally deteriorating quality of water and sediment in watercourses.

There is a relatively dense reclamation canal network - detailed canal network (DCN) in the territory of Voyvodina, reaching total length of approximately 20.000 km, with canals directly relying on agricultural arable land. These canals are of a rather small grade gradient and streamflow velocities and sediment transport regime in them greatly contribute to deposition of fine, suspended particles and silt generation at some specific sites along the canal network. If it is added to the top of that, that agriculture, in general, and in this specific area, in particular, is one of the largest "non-point source" polluter of surface waters as well as that untreated or partially treated industrial and domestic wastewaters are being directly discharged into these canals by about 300 recorded polluters, it is quite obvious that the quantity and the quality of sediments in some canal sections give cause for a serious concern (Savic et al., 2002; 2003; Pantelic et al., 2002; 2005)

2. MATERIAL AND METHODS

Apart from the fact that almost no field investigation works and studies in regard to sediment suspended in irrigation/drainage canals in Voyvodina have been carried out, there are still no generally accepted criteria related to sludge and sediment quality evaluation and clearly defined conditions for the disposal and storage of dredged sediment in most of the European countries. For the purpose of pollution prevention and control and environmental protection, stringent legislation in the form of standards, criteria, norms, etc. may (and must) be introduced, calling for the classification of sludge and sediment as per the content of hazardous substances. Given the content of hazardous and toxic substances is below established limit values, such sludge and sediment could be stored and used (deposited and spread on the land) without any limitation. If, on the contrary, sediment concentrations exceed threshold limits, they are to be classified as hazardous waste requiring specific rehabilitation procedure involving disposal of the dredged material in special containers with previous treatment, if applicable.

The paper deals with the sediment deposited in the reclamation canal "Kindja" (by the town of Kikinda in Voyvodina) belonging to the drainage system under the same name for removing excess water from 1079 hectares of land. The canal itself is 3689 m long, with the designed dimensions as follows: bottom width of 2m, slopes 1:1.5, depth of water 1m, and water discharge of 1.736 m³/s. The canal collects excess water from the adjacent arable land, in one part, and then flows through urban area and receives wastewaters discharged by two large polluters: foundry plant (outlet in the canal at km 1+200) and domestic waste waters of the town of Kikinda (outlet at km 0+700). Sediment samples were taken from the canal bottom in November 2003 using appropriate sampling equipment, from two locations: 1) before discharge of waste water and sludge - upstream from the above mentioned point source of pollution at

km 1+300; and 2) downstream from the polluters at km 0+650. Sediment analyses were conducted in the laboratory of the Research Institute of Field and Vegetable Crops in Novi Sad. The samples were analysed for mechanical composition and chemical properties, and the obtained results indicate the presence of dangerous and harmful substances (heavy metals and microelements, Polychlorinated Biphenyls - PCBs and Polycyclic Aromatic Hydrocarbons - PAHs). Standardised, state of the art and recognised analysing methods were applied.

3. RESULTS AND DISCUSSION

Suspended sediment in water bodies may contain, for the most part, necessary macro and micro nutrients, humus organic compounds and other ingredients improving properties of the soil onto which dredged sediment is to be deposited and spread. This referees particularly to the arable land, its texture and fertility, and consequently, to the yield and quality of the crops. Thus, reasons for the use of sediment on the land for agricultural purposes are more than obvious. It is clear that non-contaminated sediment may have positive impact on the land, and one of the basic principles calls for the incorporation of sediment in the land whenever possible. On the other hand, however, sediment may contain heavy loads of nutrients and other unwanted substances with harmful affects on the land, crops and public health. Great care and caution is, therefore, needed in handling and depositing sediment in the environment, as well as the introduction of restrictive measures in its application in agricultural sector, that is, in its spreading or injecting on the farmland. Mechanical characteristics and basic chemical features of the sediment from the Kindja canal are shown in Figures 1 and 2.

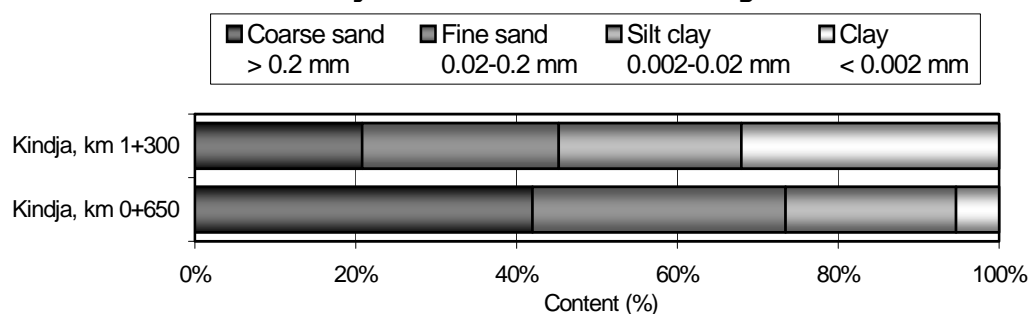


FIG. 1. MECHANICAL CHARACTERISTICS OF THE SEDIMENT FROM THE KINDJA CANAL

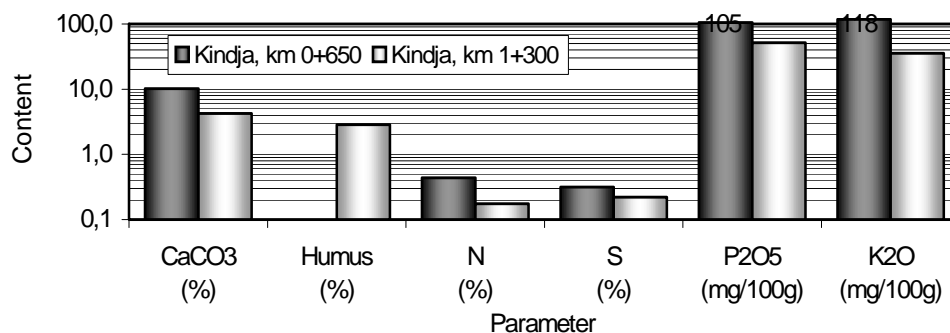


FIG. 2. BASIC CHEMICAL FEATURES OF THE SEDIMENT FROM THE KINDJA CANAL

As shown in Figure 3. considerably higher content of heavy metals and microelements is detected in the samples of sediment collected upstream from the wastewater and effluents discharge point. It can be concluded, therefore, that concentrations of lead, cadmium, copper and zinc in this sediment sample (km 0+650) are above maximum permissible levels (MPL) (MPL - Official Gazette R.S., no. 23, 1994) for while nickel concentrations are within limit values.

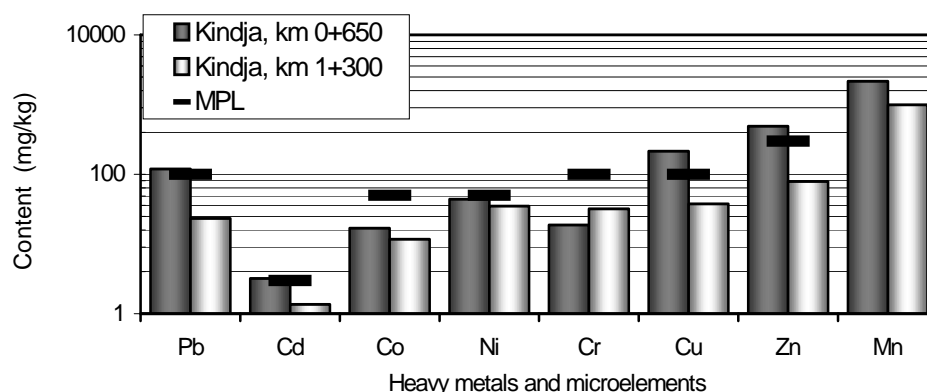


FIG. 3. HEAVY METALS AND MICROELEMENTS CONTENT IN SEDIMENT SAMPLES TAKEN FROM THE KINDJA CANAL BOTTOM DOWNSTREAM (km 0+650) AND UPSTREAM (km 1+300) FROM CONTAMINANTS COMPARED TO MPL FROM REGULATION ON PERMISSIBLE QUANTITY OF TOXIC AND HAZARDOUS SUBSTANCES IN THE SOIL. OFFICIAL GAZETTE R.S., no. 23, 1994.

Due to the extensive range of their beneficial properties, PCBs are widely used in the production of insulation material, plastics, dyes, polishes, lubricants, etc. On the other hand, however, PCBs are known for their highly toxic and carcinogenic effects and are ranked in the group of very dangerous and harmful substances. Apart from heavy metal content, the presence of highly reactive organic compounds Polychlorinated Biphenyls - PCBs: Bal 28, Bal 52, Bal 101, Bal 138, Bal 153 and Bal 180 has been detected in the taken samples, too, in the concentration of 0.0032 mg/kg at km 1+300 and in almost thirty times higher amounts at km 0+650, \square PCBs= 0.0874 mg/kg (Table 1.). Found values are still below maximum permissible concentrations (\square PCBs<0.2 mg/kg) according to the Dutch criteria for sediment classification (there are no related regulations governing this area in our country), (Savic et al., 2002).

TABLE 1. POLYCHLORINATED BIPHENYLS PCBs CONTENT IN SEDIMENT SAMPLES FROM THE KINDJA CANAL (mg/kg content in absolutely dry soil)

Kindja canal et km	Polychlorinated Biphenyls - PCBs content (mg/kg)						
	Bal 28	Bal 52	Bal 101	Bal 138	Bal 153	Bal 180	\square PCBs
0+650	0.0000	0.0619	0.0057	0.0083	0.0044	0.0070	0.0874
1+300	0.0000	0.0000	0.0011	0.0011	0.0010	0.0000	0.0032

Polycyclic Aromatic Hydrocarbons (PAHs) are organic compounds found in the nature. They are not essential compounds, i.e. not necessary for the growth and development of plants, animals and human beings. PAHs are typically produced during incomplete combustion of organic

substances at higher temperatures. When present in excessive amounts in nature, some PAHs may have toxic and carcinogenic effects on the living world, with negative impacts on the environment, and watercourses, in particular. PAH compounds are not easily dissolved in water, they attach to solid particles, particularly those of organic origin, and tend to accumulate in sediments at the bottom of waterstreams.

TABLE 2. POLYCYCLIC AROMATIC HYDROCARBONS PAH CONTENT IN SEDIMENT SAMPLES FROM THE KINDJA CANAL (mg/kg content in absolutely dry soil)

PAHs	Carcinogenic *)	PAHs content (mg/kg) and (%)			
		Kindja, km 0+650		Kindja, km 1+300	
Naphthalene	NC	/	0.0%	0.38	1.2%
Acenaphthen	NC	/	0.0%	/	0.0%
Acenaphthylen	NC	3.55	7.6%	0.85	2.6%
Fluoren	NC	/	0.0%	0.27	0.8%
Phenanthren	NC	4.87	10.5%	3.27	10.0%
Antracenen	NC	1.1	2.4%	6.15	18.9%
Fluoranthen	NC	7.08	15.2%	3.56	10.9%
Pyren	NC	4.94	10.6%	2.48	7.6%
Benzo(a)antracenen	C	5.13	11.0%	2.18	6.7%
Chrysen	WC	2.43	5.2%	1.18	3.6%
Benzo(b)fluoranten	C	4.51	9.7%	2.54	7.8%
Benzo(k)fluoranten	C	1.91	4.1%	1.05	3.2%
Benzo(a)pyren	SC	3.14	6.7%	1.67	5.1%
Dibenzo(a,h)antracenen	C	1.65	3.5%	2.61	8.0%
Benzo(g,h,i)perilen	NC	2.86	6.1%	2.48	7.6%
Indeno(1,2,3-cd)pyren	C	3.37	7.2%	1.91	5.9%
Total PAH (□ PAH)		46.52	100.0%	32.59	100.0%
The Netherlands sediments classif. MPL (□ PAH)		10.00	--	10.00	--

*) NC= non-carcinogenic; WC=weakly carcinogenic;
C=carcinogenic; SC=strongly carcinogenic

PAH contents found in the analyzed samples are given in the Table 2. Based on the Dutch criteria, it can be concluded that the concentrations of PAH compounds found in the sediment at the bottom of Kindja canal are exceeding limit values (□PAHs < 10 mg/kg), and that the removal and deposition of polluted sediment at dedicated depots may have adverse effect on the environment. This is particularly true for PAH components with potential carcinogenic effects, found in significant quantities in the analysed samples of sediment, namely, 22.14 mg/kg at km 0+650 and 13.14 mg/kg at km 1+300.

4. CONCLUSIONS

Issues related to the sediment quality assessment, conditions under which suspended sediment may be dredged and stored or spread in the environment (particularly on the cropland) are to be treated and addressed as issues of immediate concern in our country, too (due both to the volume and the properties of sediments), with the trend of getting more prevailing in the coming period.

Excessive content of some heavy metals in the sediment from the reclamation canal of Kindja, presence of PCBs, and particularly, amounts of PAH compounds exceeding limit values, are a clear indication of potential harmful effects that dredging and spreading of the polluted sediment may have on the environment. To the top of this, negative impact of untreated waste waters and effluents directly discharged into the streams is significant.

Yet another cause for concern is the lack of research data related to the sediment quality in the reclamation canals. During the canal maintenance works and dredging operations, dredged sediment is usually spread on the adjacent cropland without taking into consideration potential environmental hazards and implications and risks for human and animal health. Moreover, sediments of inadequate quality may have considerable affect on the characteristics and use of water from the streams in which they are formed and deposited. For these reasons, it is of utmost importance to set and conduct continuous monitoring of the sediment in the watercourses, and to assess and analyse larger number of polluted sediment samples from contaminated canal sections.

To this end, provisions and criteria under which sediment may be dredged and stored or used in agriculture are to be clearly defined and conformed. Special attention is to be devoted to the environmental, surface and ground waters protection, and before all, to the cropland, foodstuffs and food production protection. Plans and expectations in regard to sale and promotion of agricultural products from Vojvodina at the European marketplace could be implemented only if appropriate legislation governing this area is duly taken into account, such as EU Directive on the use of sludge in agriculture or the most recent document on sludge the implementation of which is to be expected soon.

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