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## Purification of waters and elimination of organochloric insecticides by means of active coal

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**Abstract:** Pollution of water and the determination of the degree of its pollution with numerous physical, chemical and biological pollutants have become general, ever increasing social and health related problems. Within this study, the concentrations of some most frequently used organochloric insecticides (OCI):  $\alpha$ -hexachlorocyclohexane ( $\alpha$ -HCH),  $\gamma$ -hexachlorocyclohexane (lindane), heptachlor, aldrin, dieldrin, endrin, dichlorodiphenyl trichloroethane (DDT) were investigated. OCI are highly toxic substances for the human population and their effective elimination from the environment is of paramount interest. To determine the OCI concentration in water samples, the EPA–608 method and the liquid–liquid extraction principle were applied. A procedure for OCI elimination was realized by passing the water over four columns filled with various active coals: KRF, K-81/B, NORIT ROW-0.8 and AQUA SORB CS. These active coals are carbonized coconut shells activated by different procedures. The obtained results indicated that best purification of potable and waste water achieved using a column with Norit Row-0.8 filling. Research proved that small quantities of OCI can also be effectively removed using a Norit Row-0.8 active coal filled column, without altering the organoleptic properties of the water, which meets the requirements of water purification processes.

**Keywords:** potable (drinking) water; waste water; organochloric insecticides; waters purification; active coal; gas chromatography.

### INTRODUCTION

The process of environment pollution was particularly initiated with the modern development of agriculture, cattle breeding and industry. The consequences thereof have become increasingly visible in the biosphere, the thin shell around the earth, where 90 % of the entire life persists between 3000 m above sea level to 90 m under the sea surface.

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As the population of the earth increases, the problems of water quantity and quality are encountered and the problem of how to provide a sufficient quantity of good quality water for food production and the needs of the population must be addressed. The solutions seem to be the more efficient use of the water resources and the prevention of their pollution.<sup>1</sup>

Pollution of potable, surface and wastewaters has increased. Waters have become more and more polluted with both organic and inorganic matters. The most frequent polluters of organic origin are oil derivatives, organochloric insecticides (OCI), polychlorinated biphenyls and others. Jovan Čičević with collaborators has contributed substantially to the management of the issue of environmental pollution, primarily of waters and sediments.<sup>2-4</sup> They made quite a big contribution in the isolation, evidencing and determination of oil derivatives in various samples.

One of the major factors of water pollution is the application of synthetic toxic OCI in agriculture. Separate attention has been paid to their production and efficient application. Their degradation products have, however, been neglected, although they can produce detrimental effects for months and years after application of the insecticides.

The ever increasing application of organochloric insecticides and their stability in nature demand the need for the isolation, evidencing and determination of these active materials in various types of samples.

Due to their many-year production and wide and uncontrolled application, residues of organochloric insecticides can be found in samples from the ecosystem. Residues of these toxicants have been detected in different parts of the biosphere, confirming their presence and cycling in the environment.<sup>5</sup>

The degree of waters pollution is particularly high. In Serbia, according to regulations and by-laws, the maximal allowed concentration of total pesticides in drinking water is 0.5 µg/l.<sup>6-10</sup>

Some of most frequently used OCIs in agricultural production were tested in this study.  $\alpha$ -HCH is an organochloric insecticide used for the protection of forests. Lindane is a wide spectrum insecticide used for agricultural and non-agricultural purposes, including the treatment of seeds and soils, trees, trunks and stocked materials, animals against ectoparasites and in the area of medical protection. Heptachlorine has been used for over 30 years as a stomach and contact insecticide, mainly for the control of termites and earth insects. Aldrin is an organochloric insecticide previously used for termination of insects, e.g., termites and hoppers, for the protection of crops such as potatoes and corn. This chemical is laboratory made and cannot be found in nature. Dieldrin is an organochloric insecticide used against termites, textile and agricultural pests and insects-spread diseases. It was mainly used for the protection of corn, cotton and potatoes. Endrin is an organochloric insecticide that has been used since used 1950 against a

large number of agricultural pests, primarily for the protection of cotton, rice, sugar cane, corn and other crops. DDT is the first chlorated insecticide used in agriculture, forestry and medical protection.<sup>11,12</sup>

The physicochemical properties of the analyzed OCIs are given in Table I.<sup>11,12</sup>

TABLE I. Physicochemical characteristics of the analyzed organochloric insecticides

Insecticide Formula	Density ( $t / ^\circ\text{C}$ ), $\text{g}/\text{cm}^3$	Melting point, $^\circ\text{C}$	Solubility in water ( $t / ^\circ\text{C}$ ) mg/l
$\alpha$ -HCH C $_6\text{H}_6\text{Cl}_6$	1.87 (20)	158	2 (28)
Lindane C $_6\text{H}_6\text{Cl}_6$	1.85 (40)	112.8	10 (20)
Heptachlor C $_{10}\text{H}_5\text{Cl}_7$	1.65–1.67 (25)	135–145	0.056 (20)
Aldrin C $_{12}\text{H}_8\text{Cl}_6$	1.54 (20)	104–104.5	0.027 (25)
Dieldrin C $_{12}\text{H}_8\text{Cl}_6\text{O}$	1.62 (20)	175–176	0.186 (20)
Endrin C $_{12}\text{H}_8\text{Cl}_6\text{O}$	1.64 (20)	226–230	0.230 (25)
4,4-DDT C $_{14}\text{H}_9\text{Cl}_5$ –		108.5–109.0	0.003 (20)

Pesticides, such as organochloric insecticides, are frequently removed from water by adsorption on active coal. The adsorption mechanism is of a physical nature (van der Waals attraction forces). The degree of adsorption is dependent on the structure and shape of the adsorbate molecules, the structure and size of the active coal pores, the adsorbate polarity, dissociation, temperature and pH value.

A number of papers<sup>13–15</sup> analyze the adsorption of certain kinds of pesticides onto commercially available active coals and onto carbon fibers. Gerard and collaborators<sup>13</sup> studied the adsorption of diuron, MCPA, atrazine and chloridazole onto Chemviron's F 400 coal and came to the conclusion that highest adsorption was that of diuron and lowest of MCPA. Martin-Gullon<sup>14</sup> compared the adsorption of atrazine on commercial Norit GAC 1240 and on Donacarbon carbon fiber and found that the adsorption efficiency was several times higher onto the carbon fibers. Schreiber and collaborators<sup>15</sup> studied the influence of temperature and molecule size on adsorption onto F 300 active coal and came to the conclusion that adsorption at elevated temperatures was better and that the adsorption of smaller molecules was favored.

Most studies were aimed at investigating the adsorption of individual pesticides from the derivatives groups comprising urea, pyridazinone, phenoxy acetic acid and triazine, with a much smaller number considering members of the group of chlorinated pesticides. Various types of pesticides are, however, simultaneously present in waters.

It is therefore of both theoretical and practical significance to investigate the adsorption capabilities of commercially available active coals for the simultaneous elimination of various types of pesticides, especially of OCI.

The present research was aimed at developing satisfactory procedures for the purification of waters contaminated with OCI, without changing the organoleptic properties of the waters. For this purpose, samples of both potable and waste water were used.

## EXPERIMENTAL

*Materials and analytical methods*

In this work, potable and waste waters sampled at the following locations were investigated:

1. Potable water from the tap at the Public Health Institute in Kraljevo and non-chlorinated water from the Konarevo pumping station, from where the City of Kraljevo is supplied with potable water.

2. Wastewaters from the Agricultural–Industrial Plant (PIK) Takovo and the Agricultural Cooperative (ZZ) Lunovo Selo.

PIK Takovo and ZZ Lunovo Selo both produce alcoholic and non-alcoholic products; hence, their waste waters are similar. Waste waters from PIK Takovo are discharged into the town collector from where they are led to the purification plant, purified and finally discharged into the Despotovica River.

Wastewaters from the Agricultural Cooperative Lunovo Selo are discharged into the Lužnica River (which is not categorized) that flows into the Skrapež River and later into the Zapadna Morava River.

The water samples were prepared according to the literature<sup>16</sup> or by means of modified standard methods.

Physicochemical analyses of the water samples were realized by volumetric methods (consumption of  $\text{KMnO}_4$ , content of Ca and Mg), electrochemical methods (pH value) and spectrophotometric methods (contents of nitrate, ammonium, Fe, chemical demand in oxygen (COD), biological demand in oxygen ( $\text{BOD}_5$ ), suspended matter, total organic carbon (TOC) and surface agents (detergents, DBS).

The instruments employed were a pH-meter (Hanna), a spectrophotometer (Lambda 2, Perkin Elmer) and a pastel UV (Secoman Analyzer).

The determinations of the organochloric insecticides, *i.e.*,  $\alpha$ -HCH, lindane, heptachlor, aldrin, dieldrin, endrin and DDT, were realized according to the Rule Book on the Hygienic Acceptability of Potable Water, FRY (Official Gazette No. 42/98 and 44/99).

The standards organochloric insecticides investigated in this work,  $\alpha$ -HCH, lindane, heptachlor, aldrin, dieldrin, endrin and DDT, were obtained from Dr. Ehrensorfer GmbH (Augsburg, Germany).

The organochloric insecticides present were prepared according to the appropriate EPA-608 method, by liquid–liquid extraction. The method is equally applicable for the determination of organochloric insecticides in both potable and waste waters. The water sample was extracted with dichloromethane and the obtained extract was dried and concentrated to 1  $\text{cm}^3$ . The extract is evaporated in nitrogen flow and than 1  $\text{cm}^3$  of *n*-hexane is added. The tested organochloric insecticides were detected by gas chromatography using a Perkin Elmer 8500 instrument with an electron capture detector (ECD) and either a glass 1.5% OV-17+1.95% OV-210 or a capillary SPB-5 (30 m length) column. The oven temperature was maintained isothermally at 230 °C for the glass column or 250 °C for the capillary column.

Samples of potable and wastewaters were spiked with a standard mixture of organochloric insecticides and passed through the columns. The standard mixture consisted of  $\alpha$ -HCH, lindane, heptachlor, aldrin, dieldrin, endrin and DDT, which was diluted to a concentration that could be detected by the ECD.

Four columns, 60 cm high and 12 cm in diameter, containing different active coals were used for the elimination of OCI from the water samples. The columns were filled with active coal up to two thirds: Column 1 (K1) – active coal KRF, Column 2 (K2) – active coal K-81/B, Column 3 (K3) – active coal NORIT ROW-0.8 and Column 4 (K4) – active coal Aqua Sorb

CS. The active coals KRF and K-81/B are domestic productions (Miloje Zakić, Kruševac), while Norit Row-0.8 is a Dutch production, and Aqua Sorb CS is Swedish. The specifications of the adsorbing characteristics of these coals are presented in Table II.

TABLE II. Characteristics of the investigated active coals

Coal property	Active coal			
	KRF	K-81/B	Norit Row-0.8	Aqua Sorb CS
Total pores volume, cm <sup>3</sup> /g	0.8–1.0	0.8–1.0	–	0.62
Specific surface (BET), m <sup>2</sup> /g	1200	1200	1150	1100
Micro pores volume, cm <sup>3</sup> /g	0.45–0.5	0.45–0.50	–	–
Iodine number, mg/g	1150–1250	1150–1250	1050	1050
Methylene Blue index, cm <sup>3</sup>	16–18	16–18	22	–
Filling mass, kg/ m <sup>3</sup>	420–470	420–460	–	–

After filtering through qualitative filter paper REF 235 produced by Albert to remove the coarser impurities, the water samples were passed through all four columns, at a flow rate of 10 cm<sup>3</sup>/min. They were previously filtered.

#### RESULTS AND DISCUSSION

Based on the set investigation goal, results were obtained by testing the samples of potable water (tap water at the Public Health Institute in Kraljevo and from the Konarevo pumping station) and waste water (PIK Takovo and ZZ Lunovo Selo).

##### *Physicochemical analyses of the waters*

The physicochemical parameters of the waters were analyzed prior to and after passage through the columns.

Physicochemical characteristics of the water samples before passage through the columns are presented in Table III.

Physicochemical analyses of the potable water samples taken from the Public Health Institute and from the Konarevo pumping station show that these waters meet the standards set in the Rule Book FRY<sup>6</sup> on the hygienic acceptability of potable water (Table III).

The quality of the waste water from PIK Takovo is standardized by the Rule Book on prescribed values of dangerous and toxic matters discharged in the Municipality of Gornji Milanovac.<sup>17</sup> The standards of the Gornji Milanovac Municipality are extremely high in relation to the European ones and have to be harmonized accordingly.

In ZZ Lunovo Selo, they do not have any standards for their wastewater discharge into the non-categorized Lužnica River that flows into the Skrapež River and later into the Zapadna Morava River. The only quality-related criterion is that wastewaters must not alter the quality of the recipient into which they are discharged.

TABLE III. Physicochemical characteristics of the examined water samples

Parameter	Tap water <sup>a</sup>	Pumping station <sup>b</sup>	MAC <sup>1c</sup>	w.w. Takovo <sup>d</sup>	MAC <sup>2e</sup>	w.w. Lunovo S. <sup>f</sup>
pH value	7.8	8.0	6.8–8.5	4.9	6.5–9.0	5.0
Nitrates conc., mg/l	13.4	12.9	50.0	–	50.0	–
NH <sub>3</sub> conc., mg/l	0.038	0.050	0.100	1.70	50.0	6.892
Consumption of KMnO <sub>4</sub> , mg/l	5.4 6.0		8.0	183	–	118
COD, mg/l	–	–	–	305	460	146
BOD <sub>5</sub> , mg/l	–	–	–	74	300	69
Suspended matters, mg/l	–	–	–	246	500	180
Calcium conc., mg/l	40.1	44.1	200	50.0	–	76.2
Magnesium conc., mg/l	0.60	0.60	50	3.0	–	1.8
Iron conc., mg/l	0.061	0.052	0.30	–	–	–
TOC, mg/l	–	–	–	55	20	49
DBS, mg/l	–	–	–	3.6	–	9.0

<sup>a</sup>Potable water tap at the Public Health Institute in Kraljevo; <sup>b</sup>water taken at the Konarevo pumping station; <sup>c</sup>according to Book of Rules on hygienic adequacy of potable water FRY (Official Gazette no. 42/98 and 44/99); <sup>d</sup>waste waters taken at the Agricultural Industrial Plant Takovo; <sup>e</sup>according to the Gornji Milanovac Rule Book on prescribed values of dangerous and toxic matters discharged; <sup>f</sup>waste waters taken at the Agricultural Cooperative Lunovo Selo

The physico-chemical analyses revealed reduced pH values and increased concentrations of total organic carbon (Table III).

After passage through the columns, the water samples were subjected to physicochemical analyses. The results obtained with potable waters are presented in Table IV and with waste waters in Table V.

TABLE IV. Results of the physicochemical analyses of potable water, sampled at the Public Health Institute and at the Konarevo pumping station prior to and after passage through the active coal-containing columns

Parameter	Tap water					Pumping station					MAC
	Sample	Column				Sample	Column				
		K1	K2	K3	K4		K1	K2	K3	K4	
pH value	7.8	9.73	9.74	6.85	8.99	8.05	9.52	9.62	6.90	9.19	6.8–8.5
Nitrates conc., mg/l	13	1.6	2.3	<1.0	4.6	13	1.6	1.3	<1.0	3.7	50
NH <sub>3</sub> conc., µg/l	58	20	25	17	42	50	27	33	18	17	100
Consumption of KMnO <sub>4</sub> , mg/l	5.37	5.16	4.32	3.05	3.79	6.00	5.68	5.43	2.37	4.10	8.00
Calcium, mg/l	40.1	28.0	32.1	20.0	22.0	44.1	24.1	28.0	22.1	20.0	200
Magnesium, mg/l	0.60	0.21	0.60	0.21	0.41	0.60	0.25	0.41	0.28	0.30	50
Iron, µg/l	61	44	40	32	61	52	38	29	20	44	300

After passage of the water samples through the columns K1, K2 and K4, pH values measured were higher than allowed by the a.m. Rule Book. The ranges of the other tested physical and chemical parameters were within the limits pre-

scribed by the Rule Book. On passing the samples through K3 column filled with Norit Row-0.8 active coal, no change in the pH value was observed that exceeded the range set in the Rule Book (Table IV).

Passage of the waste waters of PIK Takovo and ZZ Lunovo Selo through the K1, K2, K3 and K4 columns, resulted in a high degree of purification in all cases. However, only the purified waste water from the K3 column had a pH value that was not above the maximum allowed value (Table V).

TABLE V. Results of the physicochemical analyses of the waste waters from PIK Takovo and Lunovo Selo, prior to and after passage through the active coal-containing columns

Parameter	w.w. Takovo						w.w. Lunovo S.				
	Sample	Column				MAC	Sample	Column			
		K1	K2	K3	K4			K1	K2	K3	K4
pH value	4.9	9.6	9.8	7.6	9.0	6.5–9.0	5.0	9.3	9.6	6.9	9.1
NH <sub>3</sub> conc., mg/l	1.7	0.083	0.050	0.020	0.22	50	6.9	0.34	0.13	0.12	0.64
Consumption of KMnO <sub>4</sub> , mg/l	183	36.3	39.5	23.4	25.8	–	118	19.8	41.4	18.4	25.8
COD, mg/l	305	3.6	6.4	2.2	3.5	460	146	7.9	25	5.6	8.3
BOD <sub>5</sub> , mg/l	74	1.3	2.6	0.9	1.5	300	69	3.3	12	2.5	3.7
Suspended solids, mg/l	246	29	38	8	12	500	180	44	62	11	15
Ca, mg/l	50	40	28	12	8.0	–	76	28	32	20	30
Mg, mg/l	3.0	1.8	1.8	1.6	1.8	–	1.8	1.8	1.4	0.60	0.60
TOC, mg/l	55	<1.0	1.9	1.0	1.0	20	49	2.7	8.1	2.4	2.5
DBS, mg/l	3.6	<1.0	<1.0	<1.0	<1.0	–	9.0	<1.0	1.1	<1.0	<1.0

#### OCI analysis of the waters

In the investigated waters, as well as in the spiked potable and waste waters, the contents of organochloric insecticides were determined prior to and after their passage through the active coal-containing columns.

The investigated organochloric insecticides were detected by means of gas chromatography, with the following detection limits:  $\alpha$ -HCH (0.0012  $\mu$ g/l), lindane (0.0015  $\mu$ g/l), heptachlor (0.0012  $\mu$ g/l), aldrin (0.0024  $\mu$ g/l), dieldrin (0.0014  $\mu$ g/l), endrin (0.0012  $\mu$ g/l) and DDT (0.0054  $\mu$ g/l).

The results obtained for the potable waters are presented in Tables VI and VII for the tap and pumping station water, respectively.

The total concentrations of OCI in the tap water (0.257  $\mu$ g/l) (Table VI) and in the pumping station water (0.294  $\mu$ g/l) (Table VII) meet the norm of the Rule Book on the hygienic acceptability of potable water that allows a maximum total content of pesticides of 0.5  $\mu$ g/l.

TABLE VI. The results of gas chromatographic analysis of OCl in potable and spiked potable water sampled from the tap at the Public Health Institute in Kraljevo, prior to and after having it passed through active coal containing columns

OCl, $\mu\text{g l}^{-1}$	Sample	Columns				Standard	Sample + standard	Columns				MAC <sup>a</sup>	
		K1	K2	K3	K4			K1	K2	K3	K4		
$\alpha$ -HCH	0.0	0.0	0.0	0.0	0.0	0.10	0.10	0.0	0.0	0.0	0.0	0.0	/
Lindane	0.043	0.038	0.039	0.023	0.035	0.10	0.12	0.058	0.067	0.050	0.054	0.054	0.20
Heptachlor	0.093	0.081	0.020	0.0	0.0	0.10	0.167	0.12	0.096	0.026	0.10	0.10	0.03
Aldrin	0.053	0.034	0.032	0.016	0.025	0.10	0.16	0.030	0.021	0.012	0.022	0.022	0.03
Dieldrin	0.028	0.004	0.017	0.000	0.025	0.10	0.18	0.0	0.045	0.0	0.0	0.0	0.03
Endrin	0.040	0.010	0.039	0.0	0.0	0.20	0.20	0.0	0.055	0.0	0.0	0.0	—
DDT	0.0	0.0	0.0	0.0	0.0	0.50	0.50	0.0	0.011	0.0	0.026	0.026	0.10
$\Sigma$	0.26	0.17	0.15	0.039	0.085	1.20	1.35	0.21	0.30	0.088	0.20	0.20	—
Adsorption, %	—	35.0	42.8	84.8	66.9	—	—	84.3	78.2	93.5	85.1	85.1	—

<sup>a</sup>According to Book of Rules on hygienic adequacy of potable water SRY (Official Gazette no. 42/98 and 44/99)

TABLE VII. The results of gas chromatographic analysis of OCl in potable and spiked potable water sampled from Konarevo pumping station, prior to and after having it passed through active coals containing columns

OCl, $\mu\text{g l}^{-1}$	Sample	Columns				Standard	Sample + standard	Columns				MAC <sup>a</sup>	
		K1	K2	K3	K4			K1	K2	K3	K4		
$\alpha$ -HCH	0.0	0.0	0.0	0.0	0.0	0.10	0.11	0.0	0.0	0.0	0.0	0.0	—
Lindane	0.057	0.0	0.050	0.0	0.0	0.10	0.15	0.10	0.095	0.070	0.095	0.095	0.20
Heptachlor	0.11	0.10	0.055	0.0	0.067	0.10	0.19	0.14	0.091	0.025	0.11	0.11	0.03
Aldrin	0.060	0.055	0.053	0.035	0.066	0.10	0.14	0.076	0.030	0.028	0.063	0.063	0.03
Dieldrin	0.0	0.0	0.0	0.0	0.0	0.10	0.089	0.0	0.0	0.0	0.0	0.0	0.03
Endrin	0.064	0.035	0.054	0.025	0.052	0.20	0.23	0.082	0.13	0.025	0.11	0.11	/
DDT	0.0	0.0	0.0	0.0	0.0	0.50	0.49	0.0	0.070	0.0	0.030	0.030	0.10
$\Sigma$	0.29	0.19	0.21	0.060	0.18	1.2	1.4	0.40	0.42	0.15	0.41	0.41	—
Adsorption, %	—	35.4	27.9	79.6	37.1	—	—	71.4	70.3	89.4	70.8	70.8	—

<sup>a</sup>According to Book of Rules on hygienic adequacy of potable water SRY (Official Gazette no. 42/98 and 44/99)



The analyses results obtained for the total and individual OCI in the water sampled at the Public Health Institute in Kraljevo after passage through the columns showed that best purification results were achieved with the K3 column (84.8 % removed).

Confirmation of purification efficiency was achieved by adding known concentrations of the corresponding OCI standards. The overall purification effect was even better, ranging from 78 to 93 %. The best purification efficiency (93.50 %) was exhibited with the K3 column (Table VI).

The obtained results of the total and individual OCI analyses in the water sampled at the Konarevo pumping station after its passage through the columns showed that the best purification results were obtained with the K3 column (79.60 %).

Confirmation of the purification efficiency was achieved by adding known concentrations of the corresponding OCI standards. The overall purification efficiency was even better and ranged from 70 to 89 %. The best purification effect (89.43 %) was achieved with the K3 column (Table VII).

The obtained analyses results for the examined waste waters are presented in Tables VIII and IX.

Determination of the elimination of the total and individual OCI from the waste waters from PIK Takovo and ZZ Lunovo Selo showed that the best purification of both waters was achieved with the K3 column with the removal efficiency ranging from 92 to 96 %.

The purification efficiency was confirmed by the addition of known concentrations of the corresponding OCIs standards (Tables VIII and IX).

#### CONCLUSIONS

The results obtained for two potable water samples and two waste water samples enabled the adsorption abilities of various types of commercially available active coals.

For both examined potable water samples (taken from the tap at the Public Health Institute in Kraljevo and from the Konarevo pumping station), which had similar physical properties and chemical compositions, as well both waste waters from two companies (PIK Takovo and ZZ Lunovo Selo), which had similar physical properties and chemical compositions, the best purification, *i.e.*, attainment of acceptable physical and chemical parameters and removal of the organochloric insecticides present, was achieved using the active coal of Swedish production - Norit Row-0.8.

Further research should be directed towards confirmation of the obtained results and finding a model for the efficient application of active coals with the ultimate goal of quality preservation of water resources.

The achievement of the prescribed physical and chemical parameters and the removal of organochloric insecticides present in potable waters and, especially, in

TABLE VIII. The results of gas chromatographic analysis of OCl waste water in spiked waste water sample taken at PIK Takovo, prior to and after having it passed through active coals containing columns

OCl, $\mu\text{g l}^{-1}$	Sample	Columns				Standard	Sample + standard	Columns			
		K1	K2	K3	K4			K1	K2	K3	K4
$\alpha$ -HCH	0.0	0.0	0.0	0.0	0.0	0.10	0.12	0.074	0.025	0.0	0.092
Lindane	0.0	0.0	0.0	0.0	0.10	0.10	0.12	0.10	0.045	0.0	0.023
Heptachlor	0.60	0.14	0.46	0.034	0.41	0.10	0.62	0.12	0.11	0.050	0.10
Aldrin	0.11	0.020	0.085	0.0	0.066	0.10	0.20	0.065	0.081	0.037	0.055
Dieldrin	0.382	0.065	0.095	0.010	0.12	0.10	0.48	0.065	0.15	0.0	0.13
Endrin	0.12	0.040	0.035	0.0	0.052	0.20	0.29	0.074	0.040	0.0	0.055
DDT	0.0	0.0	0.0	0.0	0.0	0.50	0.48	0.11	0.20	0.0	0.10
$\Sigma$	1.20	0.24	0.67	0.044	0.64	1.20	2.31	0.61	0.65	0.087	0.56
Adsorption, %	–	80.0	44.2	96.4	46.5	–	–	73.7	71.8	96.2	75.8

TABLE IX. The results of gas chromatographic analysis of OCl waste water in spiked waste water sample taken from ZZ Lunovo Selo, prior to and after having it passed through active coals containing columns

OCl, $\mu\text{g l}^{-1}$	Sample	Columns				Standard	Sample + standard	Columns			
		K1	K2	K3	K4			K1	K2	K3	K4
$\alpha$ -HCH	0.51	0.11	0.14	0.061	0.18	0.10	0.58	0.034	0.052	0.015	0.089
Lindane	0.0	0.0	0.0	0.0	0.0	0.10	0.075	0.066	0.056	0.025	0.045
Heptachlor	0.46	0.18	0.22	0.025	0.14	0.10	0.55	0.14	0.071	0.015	0.12
Aldrin	0.11	0.030	0.040	0.010	0.060	0.10	0.19	0.057	0.075	0.030	0.045
Dieldrin	0.0	0.0	0.0	0.0	0.0	0.10	0.095	0.0	0.0	0.0	0.0
Endrin	0.095	0.020	0.035	0.0	0.052	0.20	0.28	0.025	0.050	0.010	0.031
DDT	0.0	0.0	0.0	0.0	0.0	0.50	0.45	0.0	0.0	0.0	0.0
$\Sigma$	1.18	0.34	0.43	0.096	0.43	1.20	2.22	0.32	0.30	0.095	0.34
Adsorption, %	–	70.7	63.4	91.9	63.3	–	–	85.5	86.3	95.7	84.9

waste waters will be increasingly required if Serbia wished to join Europe and meet the European standards of waste water discharge into city collectors and rivers. The European standards are much stricter than the Serbian ones, which will impose the necessity of increased efficiency in waste waters purification.

## ИЗВОД

## ПРЕЧИШЋАВАЊЕ ВОДА И УКЛАЊАЊЕ ОРГАНОХЛОРИХ ИНСЕКТИЦИДА АКТИВНИМ УГЉЕМ

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Истраживања у овом раду односила су се на налажење задовољавајућих поступака пречишћавања вода контаминираних органохлорним инсектицидима, а да се, при томе, не промене органолептичка својства воде. У том циљу, за анализу су коришћени узорци пијаћих и отпадних вода. За одређивање концентрације ОНІ у узорцима воде коришћена је EPA-608 метода и принцип течност-течна екстракције. Поступак одстрањивања органохлорних инсектицида урађен је пропуштањем воде преко четири колоне, напуњене различитим активним угљевима: KRF, K-81/B, Norit Row-0.8 и Aqua Sorb CS. Ови активни угљеви су карбонизоване љуске кокосовог ораха активирани различитим поступцима. Добијени резултати указују на то да се најбољи ефекат пречишћавања пијаћих и отпадних вода постиже коришћењем колоне са Norit Row-0.8 пуњењем. Истраживања показују да се коришћењем колоне напуњене активним угљем Norit Row-0.8 могу ефикасно уклонити и мале количине органохлорних инсектицида, а да се при том не промене органолептичка својства воде, што задовољава захтеве процеса пречишћавања вода.

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