

The Studies of the Sorption Properties of Soils at the Base of the Ash Storage of the Projected Power Station on Sakhalin Island

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Abstract—The soil sorption properties were determined for the base of ash storage at a proposed power station on Sakhalin Island. The analyses of aqueous extracts of the coal ashes that are intended for use at the station resulted in the identification of potential pollutant elements that might be transferred with the infiltrate of atmospheric precipitation. The composition of the infiltrate-modeling solution was selected based on the data. The sorption capacity of the covering soil by identified pollutants was evaluated at static and dynamic conditions, along with the degree of potential desorption of these pollutants.

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INTRODUCTION

Any industrial activity at the current stage of technological development causes the formation of large amounts of wastes, including those containing harmful substances. The migration of harmful components of liquid wastes, as well as the infiltration of atmospheric precipitation through solid wastes, may result in the pollution of natural waters. This takes place because of inadequate protective properties of a waste-storage facility to prevent the pollution of groundwaters. Thus, even at the design stage, the evaluation of the natural level of protection at the sites of planned waste storage facilities depending on the waste composition is of great importance. In the case of an inadequate natural level of protection, improvement measures and engineering decisions must be provided.

Various approaches to the protection of groundwaters are known. As a rule, in modeling the transfer of pollutants and predicting the time that the soil mass functions as a geochemical barrier, the soil sorption of pollutants is considered by including the distribution coefficient (K_d) and sorption capacity calculated from the equilibrium isotherms of sorption (Belousova, 2001; Varlamova, 2005, Tsang and Lo, 2006). However, the K_d values of pollutants and soil capacities determined under static conditions are of limited utility for modeling mass transfer and forecasting for definite objects because of the variety of factors that affect the processes in actual practice.

Only the quantitative estimation of the protective ability of the soil mass as a geochemical barrier, including hydrodynamic parameters, may be a reliable

basis to consider the advisability of a type of protective shield. During the recent decades, studies using the data of dynamic experiments for modeling the transfer of pollutants in the soil were published (Buszewski and Kowalkowski, 2006; Fonseca et al., 2009).

The integrated method for characterization of the efficiency of a definite soil mass as a geochemical barrier was created and tested on several objects by V.I. Sergeev et al. (Petrova and Sergeev, 1996; Sergeev et al., 2009). The method includes the analysis of engineering-geological and hydrogeological conditions of the region, laboratory studies on sorption ability of soils in the aeration zone at dynamic conditions, mathematical modeling of pollutant mass transfer, and predicting the distribution of pollutants within the soil mass (by experimental data) at any moment of time.

The author's goal was to examine the possibility of the placement of ash wastes of the Sakhalin power station (the GRES 2 station) at an area assigned by the project. The protective properties of the natural soil mass at the basement of the waste storage were evaluated for this purpose. The main difficulty consisted in the lack of real waste samples, or any analogue, because the station would utilize the coal from local as yet unexplored deposits. Due to this, an adequate composition of the solution must be selected to simulate the infiltrate of the ash storage at the projected power station. The model solution was based on the liquid phase of ash wastes from a thermal power station in the Moscow region (the TETs 22 station).

Table 1. The grain-size composition of the soils

Sample no. (depth, m)	Soil (classified by Kachinsky)	Fractions, %						
		>0.25	0.5–0.1	0.1–0.05	0.05–0.01	0.01–0.005	0.005–0.001	<0.001
1 (2.1)	Light clay	3.3	5.3	6.7	24.2	12.1	20.2	28.2
						60.5		
3 (0.7)	Mean loam	5.5	21.9	32.4	4.1	8.0	8.0	20.1
						36.1		
4 (1.3)	Mean loam	5.4	22.3	6.9	28.6	12.3	12.2	12.3
						33.8		
5 (1.0)	Mean loam	15.1	12.8	7.0	28.5	8.1	8.2	20.3
						36.6		

Table 2. The mineral composition of the soils, %

Minerals	Light clay, sample 1		Mean loam, sample 3		Mean loam, sample 4		Mean loam, sample 5	
	1	2	1	2	1	2	1	2
Smectite with Mg-exchange complex	5	41	14	62	11	51	2	2
Smectite with Ca-exchange complex	—	—	8	—	7	—	—	—
Mixed-layered mica—smectite	1	15	2	7	8	5	2	2
Mixed-layered chlorite—smectite	—	—	—	4	—	—	2	4
Hydromica	1	5	6	7	3	1	4	15
Zeolite	1	1	2	—	1	—	—	1
Chlorite	3	7	—	4	1	1	—	1
Quartz	56	24	40	9	40	29	72	59
Potassic feldspar	12	—	13	—	13	—	—	—
Plagioclase	21	5	15	7	15	13	18	14
Dolomite	—	—	—	—	1	—	—	—

1, total composition; 2, clayey fraction.

Subject of the studies. The thermal power station is planned on Sakhalin Island, which should utilize the coal from the local Gornozavodskoe and Solntsevskoe deposits. The project includes the pneumatic removal of ash wastes. The wastes are intended to be stored in a 85-ha area. If the collector of ash wastes is located 1 km or nearer to the bay shore, there is a potential risk of pollution of the marine aquatic area.

MATERIALS AND METHODS

Substantiation of the selection of the soil for the experiments to evaluate protective properties. Based on the information on the geological structure of the area along with the data on the drilling at the site intended for the disposal of ash wastes, it was found that the covering mass considered as a geochemical barrier was constituted by a soil-vegetation layer (0.2 m), peat (bQ_{IV}, 0–2.7 m), and loams (a-dQ and dQ, 2.0–9.0 m).

Over the area and along the basement depth of the projected storage, the soil samples were collected and the grain-size and mineral compositions were determined. The standard certified procedures were used. The grain-size composition of the soils was examined by the pipette method (*Practicum...*, 1993). The mineral composition was determined using X-ray diffraction using DRON 3M and Ultima IV devices. The results are presented in Tables 1 and 2.

To characterize the protective properties of a soil mass, two kinds of samples were required. First, soil with the probable minimum sorption capacity for evaluating the allowed time for the exploration of a natural mass as a geochemical barrier. Second, soil characterized by maximum sorption of pollutants and suitable to use if necessary for the construction of artificial protective shields.

A high sorption capacity of soils is usually due to a considerable content of clayey fractions (<0.01 grain

Table 3. The results of the analyses of aqueous extracts of ashes of Sakhalin coal and of the TETs 22 station

Elements, pH	MAC, mg/L	Element content, mg/L		
		Sakhalin coal ashes		TETs 22 ash
		Gornozavodskoe deposit	Solntsevskoe deposit	
As	0.05 (0.01)*	0.02	0.01	0.01
Be	0.0003	0.0001	<0.0001	0.00001
Cd	0.005	0.0005	0.0010	0.0001
Co	0.01 (0.005)	0.0004	0.0007	0.0001
Cr	0.02	0.11	0.03	0.04
Cu	0.001 (0.005)	0.004	0.006	<0.0001
Mn	0.01 (0.05)	0.0001	0.0001	<0.0001
Mo	0.001	0.30	0.57	0.08
Ni	0.01	0.0056	0.0082	0.0009
Pb	0.006 (0.01)	0.0001	<0.0001	<0.0001
Se	0.002	0.003	0.004	0.02
V	0.001	1.05	0.45	0.06
W	0.0008	0.05	0.03	0.01
Zn	0.01 (0.05)	0.002	0.003	<0.0001
pH	6.5–8.5	9.68	8.4	6.02

In parenthesis, the levels according to the Federal Fishery Agency for marine basins, order no. 96, April 28, 1999.

size) along with the occurrence of the minerals of either a mobile crystal lattice (smectites) or a porous structure (zeolites), as well as of Fe and Mn oxides, carbonates, and organic matter. Due to this, the following samples were used in the studies.

(1) The Q_{IV} soil (sample 6) and the bQ_{IV} peat (sample 2), i.e., soils of potentially high sorption capacity owing to the presence of humate compounds. The content of organic matter (OM) in the peat samples equaled 72%; the soil contained 0.5% organic carbon (C_{org}).

(2) The light clay $a-dQ_{IV}$ (sample 1), the mean loams $a-dQ_{IV}$ (samples 3 and 4) and dQ_{IV} (sample 5): loamy varieties with quite a high dispersion (Table 1). The content of the less than 0.01 fraction equals 61% in the sample 1 and 34–37% in samples 3–5. The composition of all these soils includes minerals that determine good protective properties: smectites, mixed-layered species, and zeolites (Table 2).

The bulk specimens of samples 3 and 4 contain 24 and 26%, respectively, of the sum of smectites and mixed-layered species, as well as 2 and 1% zeolites. The clayey fraction of sample 3 contains as much as 73% smectites; therefore, one may assume that this loam should show the highest sorption capacity towards pollutant elements. The bulk compositions of other soils are characterized by low contents of the minerals of the mobile crystal lattice (6%). However,

one can expect that the clay (sample 1) may nevertheless show a pronounced sorption capacity owing to the high dispersion.

Thus, based on the results of analyses of the grain-size and mineral compositions of the samples, one may assume that among the selected soils, the light clay (sample 1) and mean loam (sample 3) must show a pronounced sorption capacity towards the pollutants, and the mean loam (sample 5) should be characterized by the worst sorption parameters.

The wastes of the GRES 2 station. Ashes. To obtain the initial data on the probable chemical composition of the wastes of the Sakhalin GRES 2 station, the ashes were prepared of the coals from the Gornozavodskoe and Solntsevskoe deposits. The ashes were obtained by the combustion of these coals in a muffle furnace. The ashing was carried out in the following way: heating to 500, ashing at 500, heating to 800, and ashing at 800°C; each stage lasted for 1 h. The chemical composition of the ash was determined with a PW 2400 Philips Analytical X-ray fluorescence spectrometer via sequential operation.

The aqueous extracts of the obtained ashes, as well as those of the ash from the TETs 22 station (Dzerzhinsky, Moscow Region), were prepared at the ash–water ratio of 1 g per 10 mL. The ratio was selected considering the projected waste volumes, storage areas, and annual precipitation in the region. The data on chemical composition of the ash extracts are given in Table 3.

Table 4. The chemical composition of liquid phases of wastes of thermal power stations

Elements, pH, mineralization	MAC, mg/L	Element content, mg/L		
		aqueous extract of the TETs 22 ash	liquid phase of the TETs 22 wastes	modeling solution (the GRES 2 station)
As	0.05 (0.01)*	0.01	0.04	0.04
Cr	0.02	0.04	0.01	0.11
Mo	0.001	0.08	0.04	0.56
Se	0.002	0.02	0.01	0.01
V	0.001	0.06	0.03	1.17
W	0.0008	0.009	0.006	0.05
pH	6.5–8.5	6.02	8.48	8.46
Total mineralization	<1000	—	826.2	

* The levels according to the Federal Fishery Agency for marine basins, order no. 96, April 28, 1999.

The modeling solution. The lack of actual wastes of the projected GRES 2 station determined the need to prepare a modeling solution for studying the sorption capacity of rocks within the soil mass at the basement of the ash storage. As a basis of the modeling solution, the waste liquid phase was taken from the TETs 22 station operating on coal, which allowed us to simulate a matrix similarly to the true wastes. The modeling solution for the experiments on sorption at dynamic conditions was prepared by adding the calculated amounts of water-distilled compounds of vanadium (NH_4VO_3), tungsten (Na_2WO_4), chromium ($\text{K}_2\text{Cr}_2\text{O}_7$), and molybdenum ($(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$) to the liquid phase of the TETs 22 pulp. The final composition of the modeling solution of the elements of the concentrations exceeding the maximum allowable concentrations (MAC) is presented in Table 4.

The evaluation of the protective ability of the soils against pollutants. The studies of the sorption capacity were carried out under static and dynamic conditions using the procedure by (Zashchita..., 1992; Sergeev et al., 2002).

The soil–solution ratio in the static experiments was 1 : 100 (1 g of a soil per 100 mL of the liquid phase of the TETs 22 pulp); the contact continued for 24 h.

Dynamic experiments were carried out using columns with a 1.8 cm² cross-section with samples with a 2-cm height through which the modeling solution was filtered at the steady rate of 1.1 m/day. The concentrations of pollutant elements, along with pH values, were determined in successive portions of the filtrate. The filtration continued up to the saturation of the soil sample with all the pollutant elements. To perform the experiment on the clay (sample 1) with a low filtration coefficient (<0.001 m/day) the sample was mixed with quartz sand (an inert material in terms of sorption) at a 1 : 1 ratio. The clay sorption capacity was calculated per half the volume of the sample.

After the saturation, desorption of pollutant elements with distilled water was studied with the same columns. These experiments were performed to reveal the potential of the pollution of soilwaters caused by the filtration of atmospheric precipitation through the storage facility base after finishing the testing of the waste collectors.

The chemical compositions of the ash aqueous extracts, the liquid phase of the TETs 22 wastes, and modeling solution, as well as the concentrations of pollutant elements in the filtrate portions during the experiment on sorption and desorption, were evaluated using mass spectrometry with inductively coupled plasma (a Thermo Scientific device, series XII).

RESULTS AND DISCUSSION

The identification of potential pollutants of natural waters in the disposition area of waste collectors of the projected Sakhalin GRES 2 station and preparation of the modeling solution. The data on the chemical composition of the ash showed that the ashes of Sakhalin coals were somewhat different in the concentrations of some elements. The coal ash of the Gornozavodskoe deposit was characterized by higher contents of most heavy metals. Hence, the composition of potential pollutants in the wastes should be considerably different depending on the selected deposit for functioning of the GRES 2 station. The ash of the TETs 22 station showed lower concentrations of V, Ni, Cu, Sr, Ba, As, and Sc compared to those of Sakhalin coal.

The data on the chemical composition of aqueous extracts of Sakhalin coals (Table 3) showed the concentrations over the TLVs for marine basins for V, Mo, W, Cr, Se, and As. The excesses were 1050 times for V, 572 times for Mo, 57 times for W, 5 times for Cr, 2.7 times for Se, and 1.7 times for As. The extract of the TETs 22 ash contained considerably lower amounts of all of the mentioned elements, excluding Se. The results allowed us to reveal the elements that most

Table 5. Evaluation of the sorption capacity of the soils under static conditions

Grounds	pH of solutions		Adsorbed pollutants, mg/100 g					
	1*	2*	V	Mo	W	Cr	Se	As
Clay, sample 1	8.48	7.79	0.22 (717)	0.02 (5)	0.05 (248)	0.03 (95)	0.06 (161)	0.36 (1327)
Peat, sample 2		5.40	0.23 (1137)	0.35 (895)	0.06 (3152)	0.05 (574)	0.03 (57)	0.11 (41)
Loam, sample 3		7.40	0.22 (706)	0.06 (18)	0.05 (263)	0.01 (16)	0.06 (143)	0.36 (1744)
Loam, sample 4		7.83	0.22 (859)	0.04 (13)	0.04 (222)	0.01 (14)	0.05 (134)	0.36 (1310)
Loam, sample 5		7.93	0.22 (752)	0.01 (3)	0.03 (88)	0.002 (4)	0.05 (101)	0.34 (704)
Soil, sample 6		7.52	0.16 (184)	0.03 (9)	0.04 (150)	0.02 (60)	0.01 (15)	0.17 (76)

* 1, initial solution; *2, equilibrium solution; in parenthesis, K_d values, mg/g.

probably would be the water pollutants near the ash storage of the Sakhalin power station: V, Mo, W, Cr, Se, and As.

The analysis of the liquid phase of the TETs 22 wastes showed lower concentrations of Cr, Mo, V, Se, and W and a higher content of As compared to the aqueous extract of the ash (Table 4). To consider the worst-case scenario of the composition of the GRES 2 liquid wastes, the contents of pollutant elements in the modeling solution were brought to the level that conforms to the maximum concentrations in aqueous extracts of Sakhalin coals. Thus, the modeling solution for the experiments on the sorption capacity of the soils was prepared by adding the calculated amounts of V, W, Mo, and Cr to the liquid phase of the TETs 22 pulp. During this stage of the studies, a solution was obtained that simulated the infiltrate in the soil mass of the ash collector basement of the GRES 2 station and was intended to evaluate the sorption properties of the soils in laboratory experiments. The concentrations of pollutant elements in the modeling solution considerably exceeded the MACs by of the Federal Fishery Agency standard for seawaters (Table 4).

Evaluation of the sorption capacity of the soils. Experiments under static conditions were carried out on all six soils that characterize the cover sediments of the zone of ash waste storage. The objective was a preliminary comparative evaluation of the sorption capacity of the selected soils for the pollutant elements. As only approximate data were required, the studies used the liquid phase of the TETs 22 wastes with no additions. Note that the prevailing forms of the occurrence of all the considered pollutant elements in neutral and alkaline solutions are negative oxoanions. The surfaces of most of the soils are partially negatively charged, which prevents interactions

with anions. Another factor that limits the sorption of these pollutants by soils is competition by macrocomponents. Thus, it is known that sulfate and phosphate ions of similar structures to those of the V, Cr, W, As, and Se oxoanions are competitive to them for binding centers (Selim, 2013). Due to this, the authors did not initially expect a high sorption capacity of the soils towards these elements. However, the task was to evaluate the potential of soils of the ash storage base as barriers against the migration of revealed pollutants. The amounts of adsorbed pollutants per soil mass unit and K_d values were calculated according to the data from static experiments and are presented in Table 5.

In general, the obtained K_d estimates are in good agreement with the tabulated average values for natural waters and soils under natural conditions (Allison and Allison, 2005) and were caused by the quite low concentrations of all of the considered elements in the liquid phase of the TETs 22 wastes (the concentrations are close to the range for polluted natural waters). Comparing the obtained K_d values, one may note as well that peat adsorbs most of the revealed pollutant elements well, excepting its low efficiency for Se and As. The loamy soils absorb Se and As better compared to peat and are not efficient for Mo and Cr. The loam (sample 5) adsorbs V, Se, and As quite well, W worse, with no sorption of Mo and Cr. The soil is characterized by low sorption capacity towards all the treated elements. One must note as well that the pH value of equilibrium solutions is considerably lower for peat compared to loamy soils. This is due to the high buffer capacity of peat caused by the occurrence of humic acids, which are natural polyelectrolytes of variable composition that contain both acidic and basic functional groups.

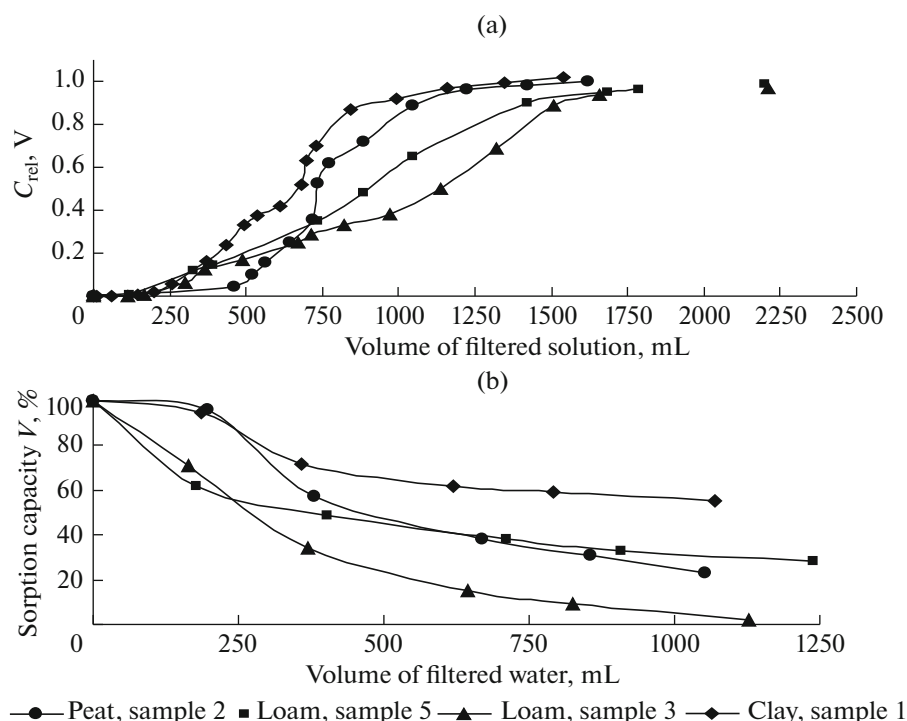


Fig. 1. The output curves for vanadium (a) and V desorption curves (b). The vanadium content in the modeling solution is 1.17 mg/L.

Based on the static examination, the soil samples were collected for studies under dynamic conditions; this should allow one to obtain the initial data for modeling the transfer of pollutants within the soil mass by depth and time. The series for experimental rating of the sorption capacity at dynamic conditions included four samples: peat (sample 2), loams (samples 5 and 3), and clay (sample 1). The samples were selected for the following reasons:

- peat occurs everywhere over the location area of the ash storage and acts as a good sorbent under static conditions;

- loam (sample 5) characterizes the covering sediments with the minimum protective ability in the storage bed;

- clay (sample 1) and loam (sample 3), which have pronounced sorption capacity and low filtration characteristics, may be used if necessary to construct an additional artificial shield against migration and filtration;

- the soil is eliminated from further consideration because of its poor sorption properties. Hence, for economic reasons, it is better for agricultural uses. The loams (samples 3 and 4) are quite similar in their compositions and properties, so only sample 3 was treated in further studies.

The sorption experiments under dynamic conditions used the modeling solution (Table 4). The data of these experiments are presented in Figs. 1a and 2a as the curves of the dependence of the concentrations of pollutant elements in successive portions of filtrate on

the volume of the passed solution (the output curves). As an example, Figs. 1b and 2b present the V and Cr desorption curves obtained by the filtration of distilled water through samples saturated with pollutant elements. The other desorption curves were of a descending shape with no characteristic segments. The desorption experiments allowed us to make several conclusions on a mechanism of the sorption of pollutant elements and allowed us to evaluate the bond strengths. This enables us to characterize the risk of the pollution of soil and surface waters under the infiltration of atmospheric precipitation through the storage base after finishing the operation. The output curves are grouped by elements for better comparability and clarity because of the much different concentrations of elements in the model solution (from 0.04 to 1.2 mg/L). As seen from the diagrams, the views of output curves are considerably different for various soils and elements.

The variability of the pH values in the filtrate samples under studies of the sorption and desorption processes on different soils is shown in Figs. 7a and 7b, respectively.

The treated soils affect the pH values of filtered solutions differently during the filtration experiments on evaluating the sorption capacities because of the difference in the prevailing mechanisms of the fixation of pollutant elements.

The values of the sorption capacity of the soils for the pollutant elements calculated by experimental

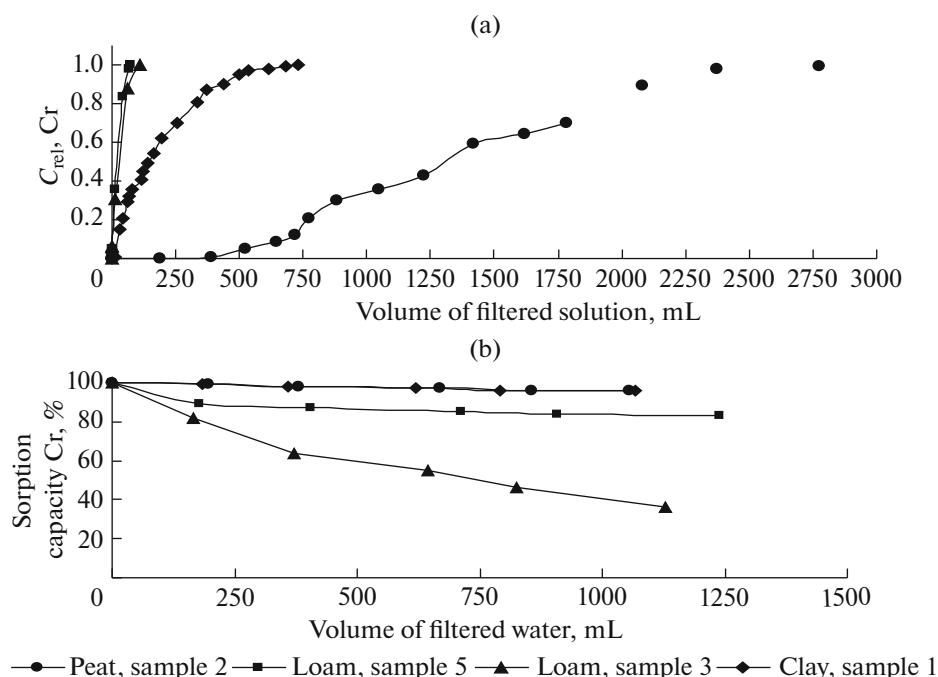


Fig. 2. The output curves for chromium (a) and Cr desorption curves (b).

curves, as well as the desorption percentages, are given in Table 6.

The maximum concentration in the model solution is that of vanadium, thus, its sorption may be a process that limits the efficiency of the soil mass as a protective barrier. According to the published data (Burke et al., 2012; Larson et al., 2013), the fixation of vanadium by soils and subsoils at neutral and low-alkaline conditions has a nonspecific nature (either physical sorption or the formation of surface outer complexes). Therefore, it is reasonable to assume that no specific binding of vanadium takes place as well under the conditions of the considered experiment. No pronounced correlation was found between V sorption and pH variability of the filtrate, which confirmed the assumption of non-specific fixation of vanadium.

The highest vanadium sorption (Table 6) was characteristic for clay (sample 1) and loam (sample 3), that is, for soils with high dispersion and a considerable smectite content. The key factor that determines the sorption properties towards vanadium is probably the presence of Fe(III). The oxide Fe(III) compounds may occur in soils as films and amorphous forms causing a partially positive charge of the soil surface and providing the sorption of vanadates and other anions (Larson et al., 2013). The results of analyses of 0.1 M HNO_3 -extracts of these soils support the hypothesis of a significant role of iron in the vanadium binding. (samples 1, 3, and 5 contained 2.2, 0.52, and 0.42 mg/g of Fe in amorphous form, respectively.)

The curves of vanadium desorption (Fig. 1b) and the data in Table 6 (from 45 to 97%) show the weakness of V fixation by all the tested soils. This indicates

Table 6. The sorption capacity of the soils and desorption characteristics (dynamic conditions)

Pollutant elements	Peat, sample 2		Clay, sample 1		Loam, sample 3		Loam, sample 5	
	1	2	1	2	1	2	1	2
V	0.405	77	0.244	45	0.260	97	0.178	72
W	0.011	49	0.003	34	0.004	60	0.002	50
Mo	0.086	7	0.008	13	0.022	12	0.007	10
Cr	0.064	1	0.008	4	0.0008	64	0.0007	18
Se	0.003	15	0.001	45	0.003	53	0.001	20
As	0.006	73	0.005	70	0.013	76	0.008	61

1, the adsorbed amount of a pollutant element per a soil mass unit (N_d), mg/g; 2, the total desorption of a pollutant element (D), %.

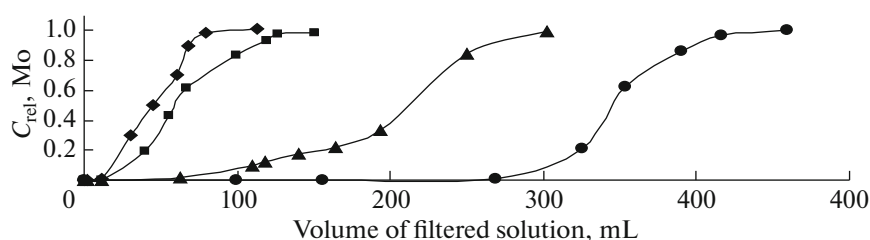


Fig. 3. Output curves for molybdenum.

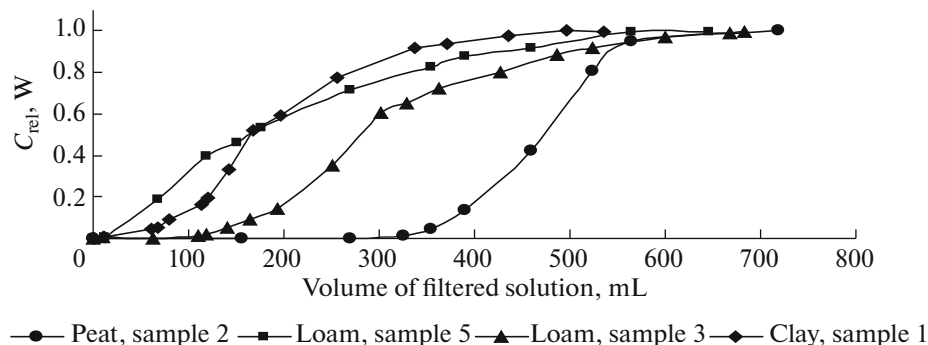


Fig. 4. Output curves for tungsten.

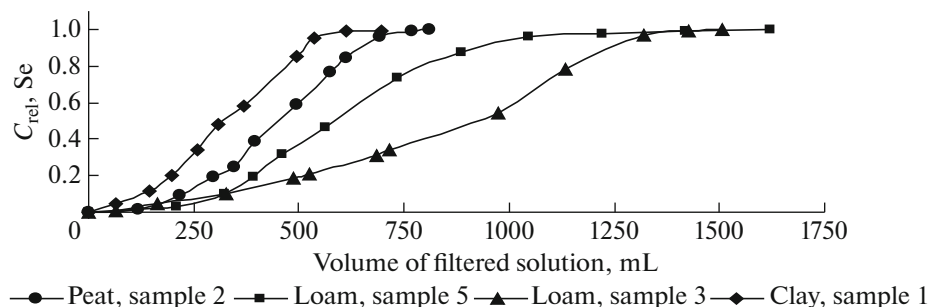


Fig. 5. Output curves for selenium.

the binding of vanadium mainly by the mechanism of physical sorption or of precipitation. The pronounced V desorption must be included in the course of predictive calculations.

Chromium, molybdenum, and tungsten are adsorbed well by peat. Studies on the sorption of these elements (Golberg, 1996; Balan et al., 2009) noted that the fixation of oxoanions in which Cr, Mo, and W occur in aqueous solution proceeds mainly owing to the formation of inner-sphere complexes. Comparison of the points where the Cr, Mo, and W output curves begin to increase for peat and corresponding curves for filtrate pH values (Fig. 7a) shows that complete sorption of these pollutants takes place during the filtration of 300 mL of the solution, with the filtrate pH value remaining at the level of 4.7. Tungstic acid is characterized by quite low solubility under acidic conditions, increasing with the increase of pH values (Bychkov and Zuikov, 2005), which explains

the W sorption by peat. A drastic increase of the filtrate pH value to 7.7 halts the sorption of Mo and then that of W.

The data on desorption of these elements from peat showed that peat strongly fixed chromium and molybdenum (the desorption was as low as 1 and 7%, respectively), with considerably worse fixation of tungsten (49%). The sorption by loamy soils was lower by 4–10 times for Mo and W and by one or two orders of magnitude for Cr compared to peat. The desorption was much pronounced (as high as 64%), i.e., the loams were not effective sorbents for these elements, as was expected.

Arsenic and selenium occurring as anion complexes in aqueous solutions (similarly to Cr, Mo, and W) were adsorbed by loamy material (samples 1, 3, and 4) better than by peat. This may indicate the difference in the prevailing mechanisms of the fixation. The sorption of arsenic and selenium was maximal for

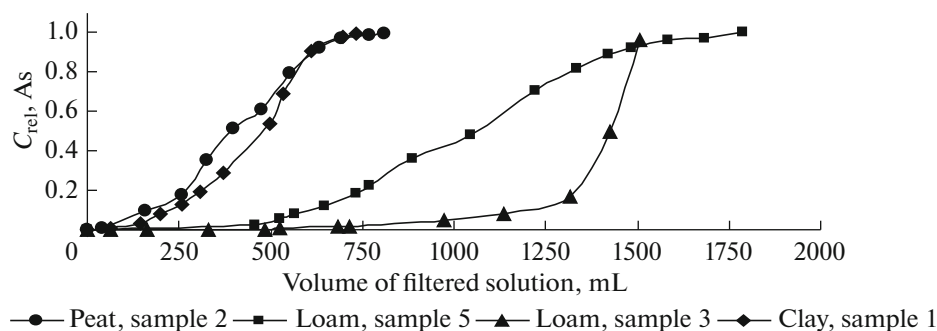


Fig. 6. Output curves for arsenic.

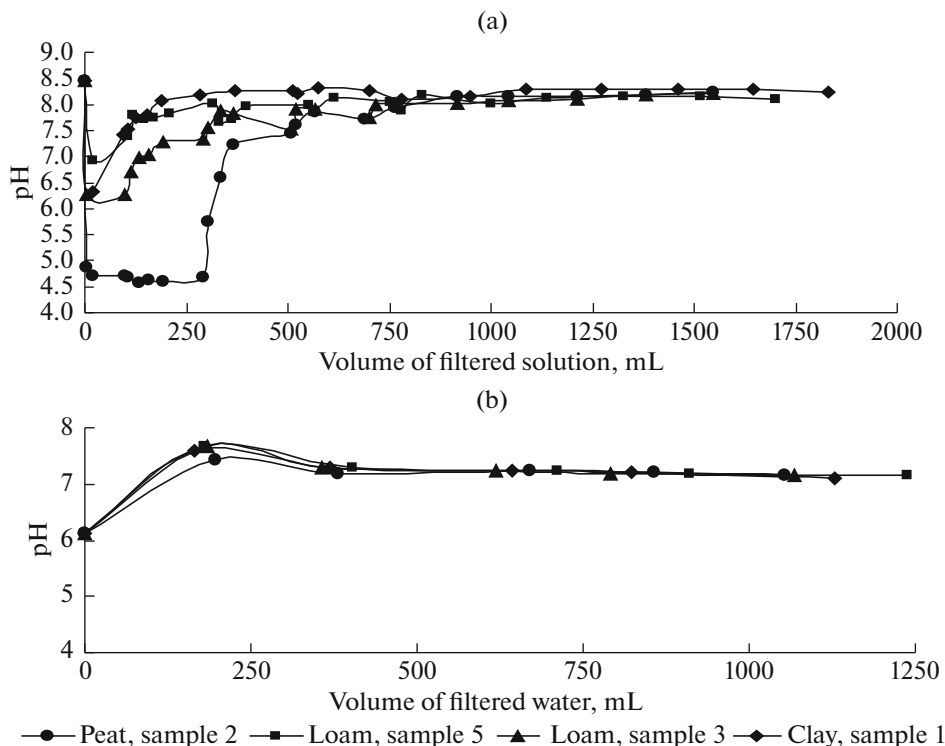


Fig. 7. The variability of the pH values in filtrate samples during the examination of sorption (a) and desorption (b) of pollutant elements for different soils.

loam (sample 3). It is thought that the main mechanism of the fixation of As, Se, Cr, Mo, and W by soils is the formation of inner-sphere complexes with Fe(III), Mn(IV), and Al(III) oxides. However, our experiments found no correlation between the Fe content in soils and the sorption of Se and As. Due to low concentrations of these elements in the model solution, it is not valid to make any conclusion on this subject.

The loamy soils affect the pH values of the filtered solution considerably less than peat (Fig. 7a). For the evaluation of the desorption, the curves of pH variability were practically the same for all the treated soils, asymptotically tending to the value of pH 7 after a small initial growth (Fig. 7b).

The calculations according to the model presented in (Petrova and Sergeev, 1996) showed that experimental curves for the most important pollutants (V, Cr, Mo, and W) agreed well with the calculated ones. Hence, these data may be quite a reliable basis for quantitative prediction of the efficiency of soil mass at the base of the ash collector at the Sakhalin GRES 2 station using the proposed model.

CONCLUSIONS

These studies showed the possible applicability of a method for evaluating and modeling the composition of power-station wastes that permits one to determine the sorption capacities of soils at the base of ash collec-

tors at the design stage of a station under dynamic conditions. The data were the basis for quantitative prediction of the character of the propagation of potential pollutants by depth and with time, as well as allowing the development of measures to prevent the pollution of the water resources of the region (Stepanova et al., 2015).

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