Supplement

Dry-column Vacuum Chromatographic Removal of Hg^{2+} from Wastewater Based on an Acridino-crown Ether-modified Spherical Silica Gel Adsorbent

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1 Additional information on instrumentation and measurement settings regarding the ICP-OES method

Sample solutions were measured in simultaneous, multielement mode by a Labtest Plasmalab ICP-spectrometer (Labtest Equipment Company, USA) with a 40-channel Paschen-Runge vacuum polychromator with photomultiplier detectors, using 27 MHz argon plasma. Instrument settings were the following, forward power: 1.3 kW, sample introduction with a "OneNeb" nebulizer (Agilent Technologies, USA), cyclonic spay chamber and Gilson peristaltic pump (Gilson Company, USA) at 1 $mL \cdot min^{-1}$ sample flow rate, observation height: 13.5 mm, integration time: 5 s. Limits of quantitation:

- for Ag was 0.025 $mg \cdot L^{-1}$, (wavelength: 328.068 nm),
- for Ca was 0.03 $mg \cdot L^{-1}$, (wavelength: 422.673 nm),
- for Co was 0.019 $mg \cdot L^{-1}$, (wavelength: 238.892 nm),
- for Cu was 0.025 $mg \cdot L^{-1}$, (wavelength: 224.700 nm),
- for Hg was 0.05 $mg \cdot L^{-1}$ (wavelength: 253.652 nm),
- for K was 0.05 $mg \cdot L^{-1}$, (wavelength: 766.491 nm),
- for Mg was 0.0005 $mg \cdot L^{-1}$, (wavelength: 279.553 nm),
- for Na was 0.19 $mg \cdot L^{-1}$, (wavelength: 589.592 nm),
- for Pb was 0.13 $mg \cdot L^{-1}$, (wavelength: 220.353 nm),
- and for Zn was 0.005 $mg \cdot L^{-1}$, (wavelength: 213.856 nm).

2 Ionic composition of the river- and untreated wastewater samples

The ionic compositions were determined by ICP-OES method (Table S1).

3 Removing Hg^{2+} from slightly contaminated wastewater using a regenerated adsorbent

The removal of Hg^{2+} from wastewater was also studied by using slightly contaminated (0.40 $\mu g \cdot mL^{-1}$ Hg^{2+}) river water samples. The applied adsorbent was fully regenerated (0.0% relative saturation). According to the results almost the total content of Hg^{2+} in wastewater could be adsorbed by the adsorbent and no leaching of Hg^{2+} was observed up to 10 L of elution volume / 1 g adsorbent. The Hg^{2+}-concentration in fractions of remediated wastewater was below 0.04 $\mu g \cdot mL^{-1}$ until reaching this critical upper limit of applicability. The ionic composition of the starting wastewater sample was determined by ICP-OES method (Table S2).

Table S1 Ionic composition of the samples applied for remediation studies starting from a highly contaminated wastewater

Elements	River water (μg·mL^{-1})	Hg^{2+}-spiked river water (μg·mL^{-1})
Ag	<0.02	<0.02
Al	0.25	1.15
As	<0.06	<0.06
Ba	0.06	0.04
Be	~0.00	~0.00
Bi	0.62	0.59
Ca	23.70	23.10
Cd	<0.01	<0.01
Co	<0.02	<0.02
Cr	<0.02	0.06
Cu	<0.03	<0.03
Fe	0.27	1.51
Hg	<0.04	637.00
K	3.49	14.10
Li	<0.04	<0.04
Mg	6.00	5.91
Mn	0.02	0.02
Mo	<0.02	<0.02
Na	10.50	28.00
Ni	<0.05	<0.05
Pb	<0.02	0.02
Sb	<0.13	<0.13
Se	<0.23	<0.23
Sn	5.89	35.20
Sr	0.11	0.11
Ti	<0.01	<0.01
V	<0.02	<0.02
W	<0.09	<0.09
Zn	0.03	0.12
Zr	<0.02	0.04

4 Studies on reusability

Reusability was studied by three subsequent removals of Hg^{2+} from wastewater. Regeneration was carried out according to the suggested procedure between each removal process. Results are shown in Fig. S1.

It can be clearly seen that the experiments showed an appropriate reproducibility. The deviation was within ± 8.0%.

5 Studies on the possible limitations caused by organic contaminants

Since the organic material content of the contaminated river water could not be exactly determined, additional studies were carried out on the possible

Table S2 Ionic composition of the samples applied for remediation studies starting from a sightly contaminated wastewater

Elements	Slightly contaminated wastewater (μg·mL^{-1})
Ag	<0.02
Al	0.15
As	<0.06
Ba	0.06
Be	~0.00
Bi	0.52
Ca	17.60
Cd	<0.01
Co	<0.02
Cr	<0.02
Cu	<0.03
Fe	0.19
Hg	0.40
K	2.63
Li	<0.04
Mg	4.46
Mn	0.01
Mo	<0.02
Na	7.85
Ni	<0.05
Pb	<0.02
Sb	<0.13
Se	<0.23
Sn	4.60
Sr	0.08
Ti	<0.01
V	<0.02
W	<0.09
Zn	0.02
Zr	<0.02

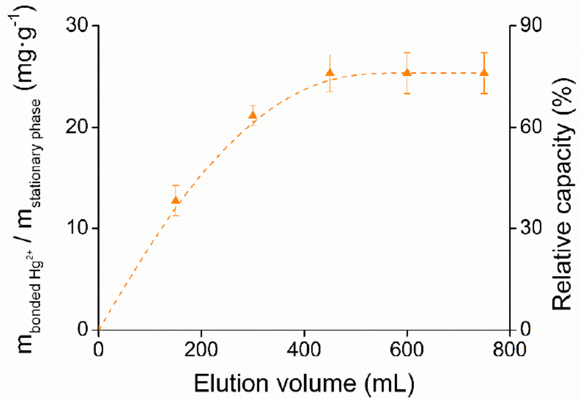

Fig. S1 Efficiencies of subsequent Hg^{2+}-removal processes (using regenerated adsorbent and wastewater samples of known composition (see Table S1) at pH = 3.0) limiting effects of organic components by using an amino acid mixture in wastewater remediation. The basis of the applied solution was the same Hg^{2+}-spiked highly contaminated river water, which was used for the other studies (Table S1). This test solution was additionally spiked with an amino acid mixture. These added amino acids were as follows: phenylalanine, histidine, glutamine, methionine, tryptophan, leucine, lysine, arginine, isoleucine, threonine with an initial concentration of 0.001 $mol \cdot L^{-1}$.

It was found that the added amino acids did not affect the separation of Hg^{2+}. All of the determined indicators were the same as reported in the case of studies using only Hg^{2+}-spiked river water samples.