Supplementary information

Composite membranes based on polyvinyl alcohol and lamellar solids for water decontamination

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2. Results and discussion

Synthesis and Characterization of the pristine powders

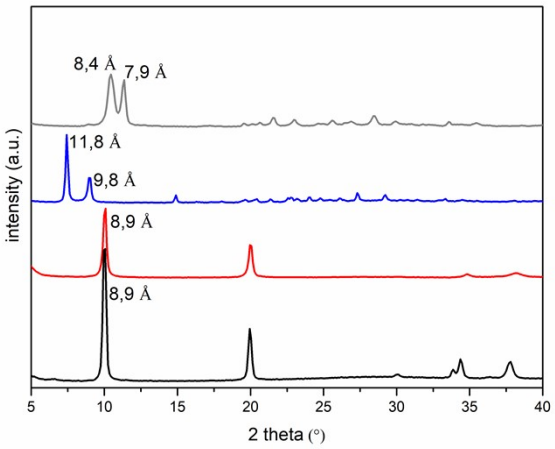


Figure S1. Black line corresponds to the spectrum of $ZnAlNO_3$ (dry sample), red line corresponds to the spectrum of $MgAlNO_3$ (dry sample), blue line corresponds to the spectrum of ZrP-Na (wet sample), grey line corresponds to the spectrum of ZrP-Na (dry sample).

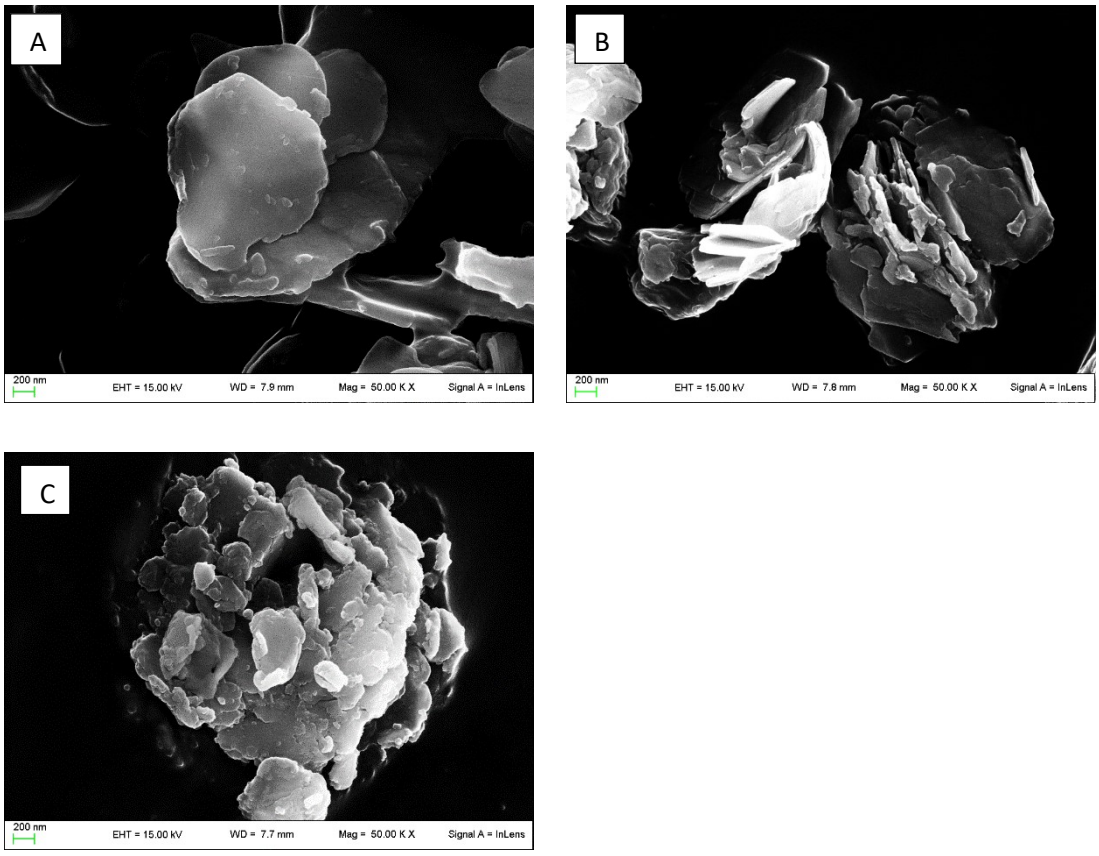


Figure S2. SEM micrographs of: ZrP-Na (A), $MgAlNO_3$ (B) and $ZnAlNO_3$ (C)

Adsorption of heavy metals by ZrP-Na

Table S1. Properties of heavy metal ions [1,2].

Metal ion	$\Delta_{hyd}G_{calc}$(kJ/mol)	First Hydrolysis constant (pK_1)
Pb^{2+}	-1345	7.71
Ni^{2+}	-2005	9.86
Cr^{3+}	-4965	8.30

Figure S3 shows XRPD spectra of the ZrP-Na after contact with heavy metals in different IEC ratios.

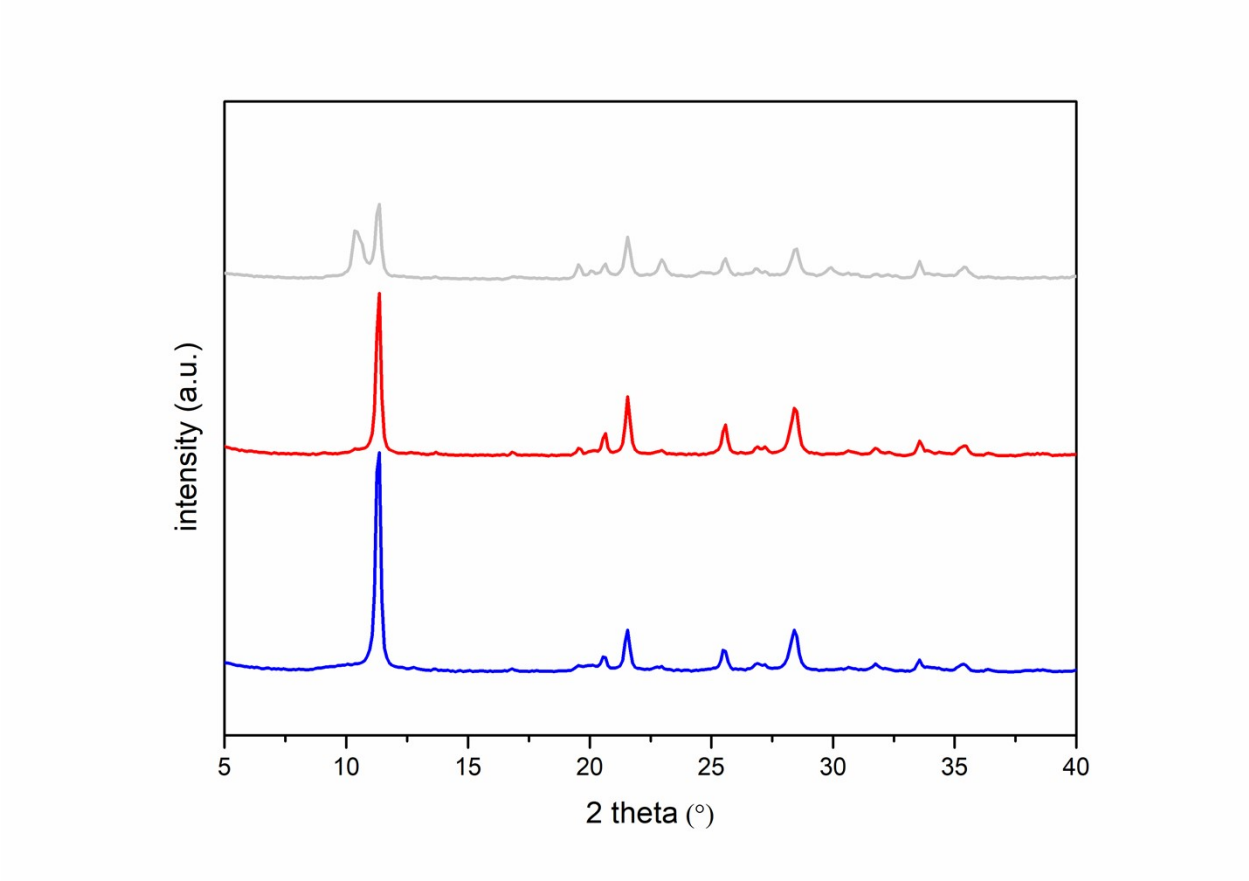


Figure S3. XRPD patterns of ZrP-Na after contact with heavy metals in different IEC ratios: blue line corresponds to the ZrP-Na 1:1 IEC, red line corresponds to the ZrP-Na 1:2 IEC, grey line corresponds to the ZrP-Na 1:10 IEC

Adsorption of DS by $MgAlNO_3$

XRPD are shown in Figure S4.

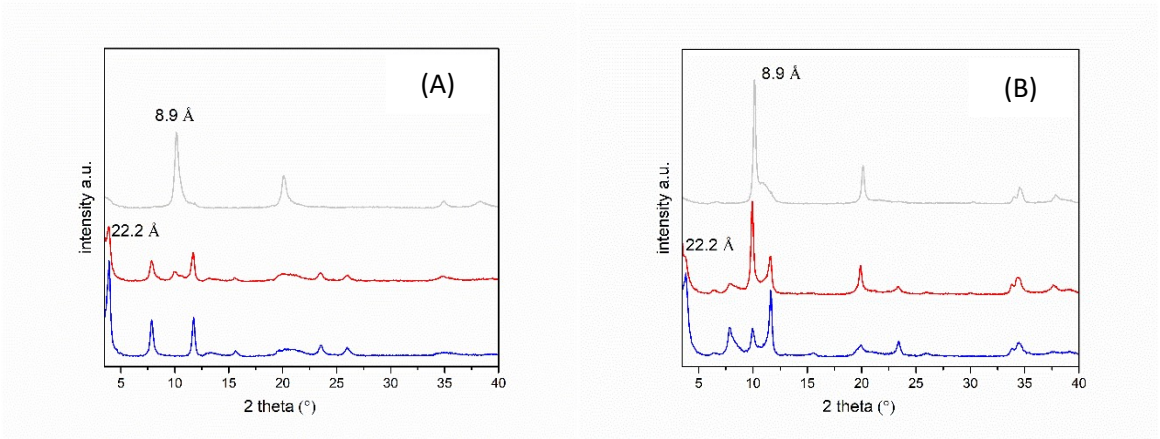


Figure S4. XRPD patterns of $MgAlNO_3$ (A) and $ZnAlNO_3$ (B) – after contact with DS in different IEC ratios: blue line corresponds to samples 1:1 IEC, red line corresponds to the samples 1:2 IEC, grey line corresponds to the samples 1:20 IEC

Preparation and Characterization of the composite membranes

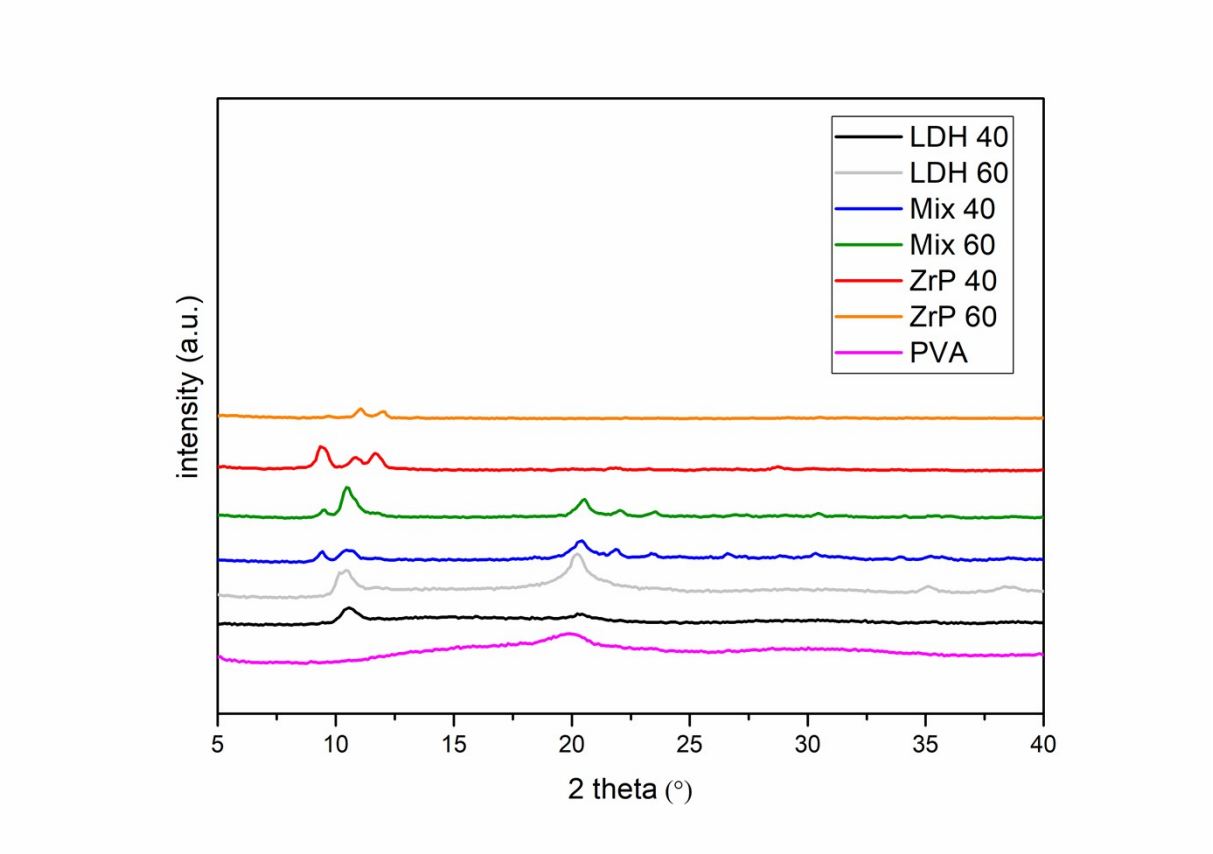
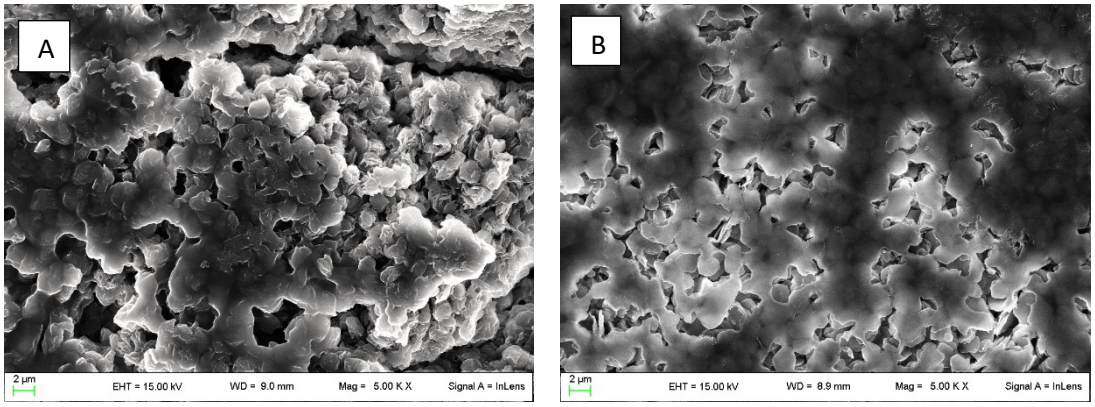


Figure S5. XRD patterns of composite membranes



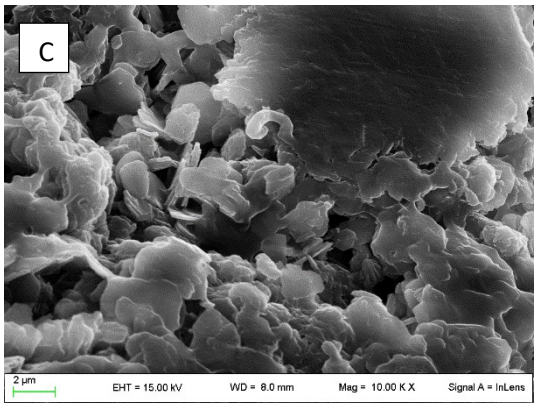


Figure S6. SEM micrographs of composite membranes: PVA/40MgAlNO$_3$ (A), PVA/40ZrP-Na (B) and PVA/20 MgAlNO$_3$/20ZrP-Na (C)

Table S2. Water uptake percentages and material loss during the swelling test for the membrane films

Membrane films	WU (%)	Mass loss (%)
PVA	78	1.84
PVA/40MgAlNO$_3$	143	7.10
PVA/40ZrP-Na	90	1.15
PVA/20MgAlNO$_3$/20ZrP-Na	102	3.51

The EDX mapping analysis of PVA/20MgAlNO$_3$/20ZrP-Na membrane after contact with solution containing mixture of heavy metals is shown in Figure S7.

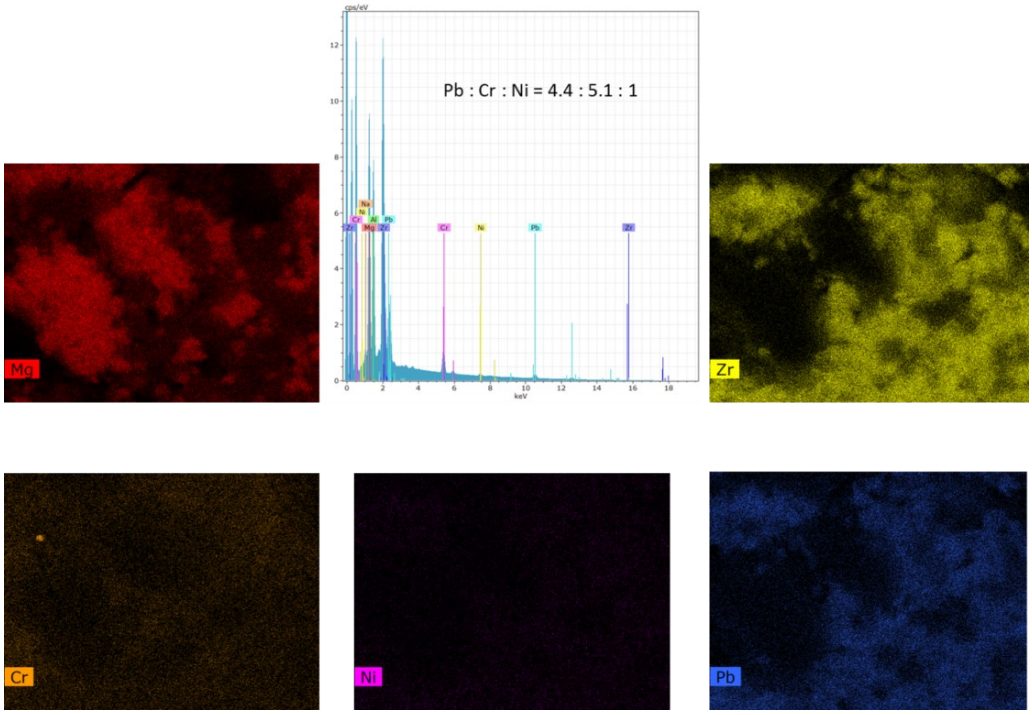


Figure S7. SEM-EDX mapping of Mg, Zr, Cr, Ni, Pb on PVA/20MgAlNO$_3$/20ZrP-Na membrane after contact with metal ions

4. Experimental section

Table S3. Amounts of materials used for the preparation of membranes

Label	Weight (mg)				Volume (mL)
	PVA	MgAlNO$_3$	ZrP-Na	GA	DI water
PVA/40MgAlNO$_3$	360	240	-	18	15
PVA/60MgAlNO$_3$	240	360	-	12	15
PVA/40ZrP-Na	360	-	240	18	15
PVA/60ZrP-Na	240	-	360	12	15
PVA/20MgAlNO$_3$/20ZrP-Na	360	120	120	18	15
PVA/30MgAlNO$_3$/30ZrP-Na	240	180	180	12	15

Table S4. Amounts of powders used in the decontamination tests of DS.

Label	Powder	Weight (g)	IEC considered (mmol/g)	Ratio
$MgAlNO_3$(x1)	$MgAlNO_3$	0.233	3.38	1:1
$MgAlNO_3$(x2)		1.165		1:2
$MgAlNO_3$(x5)		2.330		1:5
$MgAlNO_3$(x10)		4.660		1:10
$ZnAlNO_3$(x1)	$ZnAlNO_3$	0.302	2.60	1:1
$ZnAlNO_3$(x2)		0.604		1:2
$ZnAlNO_3$(x5)		1.208		1:5
$ZnAlNO_3$(x10)		2.416		1:10

Table S5. Amounts of powders used in the decontamination tests of heavy metals.

Heavy metal	Powder	Weight (g)	IEC considered (mmol Na^+/g)	Ratio
Pb^{2+}	ZrP-Na	0.055	4.49 4.49	1:1
		0.110		1:2
		0.275		1:5
		0.550		1:10
Ni^{2+}	ZrP-Na	0.190	4.49	1:1
		0.380		1:2
		0.950		1:5
		1.900		1:10
Cr^{3+}	ZrP-Na	0.322	4.49	1:1

		0.644		1:2
		1.610		1:5
		3.220		1:10
Pb^{2+}, Ni^{2+}, Cr^{3+}	ZrP-Na	0.227	4.49	1:1
		0.454		1:2
		1.135		1:5
		2.270		1:10

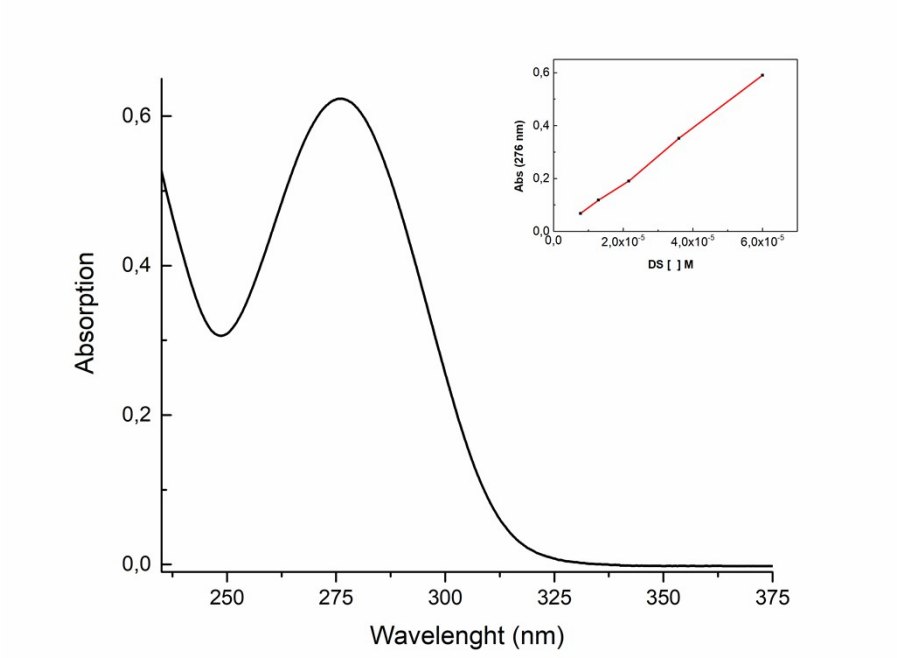


Figure S8: The DS absorption spectrum at 276 nm and the obtained regression curve

1. Marcus, Y. Thermodynamics of Solvation of Ions. *J. Chem. Soc., Faraday Trans.* **1993**, *89*, 713–718.

2. Barnum, D.W. Hydrolysis of Cations. Formation Constants and Standard Free Energies of Formation of Hydroxy Complexes. *Inorg. Chem.* **1983**, *22*, 2297–2305, doi:10.1021/ic00158a016.