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Appendix: Supplementary material

A Comprehensive approach towards efficient removal of fluoride along with co-existing pollutants from real groundwater using electrocoagulation process

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Table S1: Range of operating parameters considered for experiment conducted

Sl. No	Effect of Parameters studied	Range of Parameters considered	Parameters kept constant
1.	Electrode material	Al/Al, Fe/Fe, Al/Fe, Fe/Al	Electric potential: 12V Electrode mode: Bipolar EC time: 3600 s, ID: 0.5 cm, volume – 3L
2.	Electrode mode	Monopolar, Series monopolar, Bipolar	Electric potential: 12V Electrode material: Al/Al EC time: 3600 s, ID: 0.5 cm, volume – 3L
3.	Electric potential (volt)	6, 9, 12	Electric material: Al/Al Electrode mode: Bipolar EC time: 3600 s, ID: 0.5 cm, volume – 3L
4.	Electrode distance, ID (cm)	0.5, 1.0, 1.5, 2.0	Electric potential: 12V Electrode mode: Bipolar EC time: 3600 s, Electrode material: Al/Al, volume – 3L

Table S2: First-order rate constant (k) for different CD for all the samples after 3600 s of EC. [EC experiment conditions: ID: 0.5 cm, Electrode: Al/Al, Electrode mode: Bipolar]

Potential volt	CD, A/m^2	Value of k, min^{-1}					Value of R^2				
		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
6	17.24	0.024	0.031	0.051	0.041	0.032	0.99	0.99	0.99	0.99	0.98
9	43.10	0.036	0.038	0.052	0.043	0.034	0.99	0.99	0.99	0.99	0.99
12	68.96	0.039	0.043	0.056	0.045	0.036	0.99	0.98	0.99	0.99	0.99

Table S3: Water quality parameters at various adsorbent doses after 1800 s of adsorption. [EC experiment conditions: Electric potential: 12V, ID: 0.5 cm, Electrode: Al/Al, Electrode mode: Bipolar]

Adsorbent dose	**1g $3L^{-1}$**					**3g $3L^{-1}$**					**5g $3L^{-1}$**					**Permissible limit [1]**
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	
Fluoride (mg L^{-1})	0.334	0.044	0.212	0.75	0.593	0.309	0.034	0.204	0.431	0.364	0.301	0.031	0.201	0.402	0.341	1
Al (mg L^{-1})	0.15	0.12	0.52	0.189	0.178	0.12	0.1	0.25	0.13	0.13	0.11	0.09	0.22	0.15	0.13	0.2
Fe (mg L^{-1})	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.30-0.50
TDS (mg L^{-1})	452	250	441	221	451	423	221	423	203	434	418	214	384	155	421	500-700
Turbidity (NTU)	0.1	0.2	0.35	0.14	0.75	0.08	0.15	0.25	0.1	0.32	0.07	0.12	0.18	0.08	0.27	<1
Conductivity (µS cm^{-1})	541	532	654	421	672	524	514	611	403	623	502	473	587	475	594	200-2000
Salinity (mg L^{-1})	210	214	312	321	251	201	202	285	304	213	185	176	145	143	134	-
pH	7.02	7.12	7.41	7.21	7.31	7.01	7.1	7.38	7.18	7.28	7.01	7.3	7.11	7.12	7.19	6.5-8.5
Sulphate (mg L^{-1})	175	25	142	5	87	152	20	138	5	81	150	15	131	4	75	250
Nitrate (mg L^{-1})	2.2	1.12	1.78	1.02	1.21	1.8	1	1.42	0.94	1.03	1.6	1.3	0.85	1.1	0.87	10
Phosphate (mg L^{-1})	0.08	0.05	0.03	0.05	0.06	0.06	0.04	0.03	0.04	0.05	0.05	0.03	0.02	0.03	0.04	0.1
Chlorine (mg L^{-1})	0.25	0.17	0.1	0.08	0.12	0.18	0.15	0.08	0.06	0.09	0.21	0.12	0.06	0.06	0.18	4
Alkalinity (mg L^{-1})	195	105	196	87	154	155	95	186	78	148	145	84	164	62	129	200
Hardness (mg L^{-1})	80	25	65	15	154	75	20	51	11	123	70	18	47	9	114	200
Ca^{2+} (mg L^{-1})	58	5	11	3	58	50	15	24	9	94	50	8	12	8	92	60
Mg^{2+} (mg L^{-1})	22	20	54	12	96	25	5	27	2	29	21	10	35	1	22	30
K^{-}(mg L^{-1})	2.7	1	1.3	0.75	1.4	1.7	0.8	1.1	0.55	1.1	1.5	0.6	0.09	0.6	0.08	10

Table S4: Water quality parameters for various filtration medium after 1800 s of adsorption and EC. [EC experiment conditions: Electric potential: 12V, ID: 0.5 cm, Electrode: Al/Al, Electrode mode: Bipolar]

Filtration medium	**Filter paper**					**Ceramic filter**					**Gravity carbon filter**					**Permissible limit**
Parameters	**S 1**	**S2**	**S 3**	**S 4**	**S 5**	**S1**	**S 2**	**S 3**	**S4**	**S5**	**S 1**	**S 2**	**S 3**	**S 4**	**S 5**	
Fluoride (mg L^{-1})	0.334	0.044	0.212	0.75	0.593	0.278	0.021	0.172	0.54	0.332	0.33	0.042	0.21	0.73	0.591	1
Al (mg L^{-1})	0.15	0.12	0.52	0.189	0.178	0.13	0.11	0.19	0.16	0.12	0.1	0.11	0.15	0.12	0.13	0.2
Fe (mg L^{-1})	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.30-0.50
TDS (mg L^{-1})	452	250	441	221	451	455	260	451	231	456	441	239	410	203	420	500-700
Turbidity (NTU)	0.1	0.2	0.35	0.14	0.75	0.15	0.24	0.39	0.16	0.79	0.1	0.21	0.34	0.13	0.73	<1
Conductivity (µS cm^{-1})	541	532	654	421	672	551	537	664	432	676	540	530	652	420	671	200-2000
Salinity (mg L^{-1})	210	214	312	321	251	212	217	320	326	262	208	210	308	318	247	-
pH	7.02	7.12	7.41	7.21	7.31	7.03	7.21	7.43	7.23	7.35	7.12	7.23	7.45	7.2	7.13	6.5-8.5
Sulphate (mg L^{-1})	175	25	142	5	87	112	20	112	BDL	42	170	20	135	BDL	81	250
Nitrate (mg L^{-1})	2.2	1.12	1.78	1.02	1.21	1.8	1.02	1.04	0.75	0.94	1.9	1.1	1.42	0.98	1.03	10
Phosphate (mg L^{-1})	0.08	0.05	0.03	0.05	0.06	0.05	0.02	BDL	0.01	0.02	0.1	0.06	0.05	0.07	0.09	0.1
Chlorine (mg L^{-1})	0.25	0.17	0.1	0.08	0.12	0.18	0.23	0.19	0.13	0.2	0.15	0.12	BDL	BDL	0.06	4
Alkalinity (mg L^{-1})	195	105	196	87	154	175	75	124	62	112	197	101	192	82	149	200
Hardness (mg L^{-1})	80	25	65	15	154	101	45	89	36	173	45	12	42	BDL	112	200
Ca^{2+}(mg L^{-1})	18	5	41	3	18	54	25	22	15	29	BDL	BDL	BDL	BDL	BDL	60
Mg^{2+}(mg L^{-1})	62	20	24	12	136	47	20	67	21	144	ND	ND	ND	ND	ND	30
K^{-}(mg L^{-1})	2.7	1	1.3	0.75	1.4	2.9	1.2	1.5	1.1	1.7	2.4	1.1	1.4	0.87	1.5	10

#BDL: Below detection limit, ND: Not detectable

Table S5: Compositional analysis of the produced sludge during EC experiments.

Elements	Atomic %					Remarks/ Origin
	S1	S2	S3	S4	S5	
C	10.41	7.80	15.43	11.00	17.17	Carbon tape used during analysis
O	62.32	65.25	61.14	64.16	54.72	Hydroxides present in flocs
F	1.24	0.62	0.42	0.55	7.54	Fluoride ions trapped in flocs/sludge
Na	0.58	0.82	1.09	0.73	1.52	Predominant Na in sample trapped in flocs
Mg	0.17	1.43	0.69	1.43	17.32	Hardness of water
Al	24.19	21.56	17.55	18.17	0.24	Al electrode used in EC/ predominant Al present in sample trapped in flocs.
Si	0.62	0.40	1.84	1.01	0.60	Predominant Si in sample trapped in flocs
Cl	0.35	0.81	0.65	0.49	0.51	Predominant Cl in sample trapped in flocs
Ca	0.13	1.22	1.14	2.23	0.32	Predominant Na in sample trapped in flocs
Fe	0.10	0.10	0.05	0.15	0.06	Predominant Fe in sample trapped in flocs
K	Traces	Traces	Traces	0.07	Traces	Predominant K in sample trapped in flocs

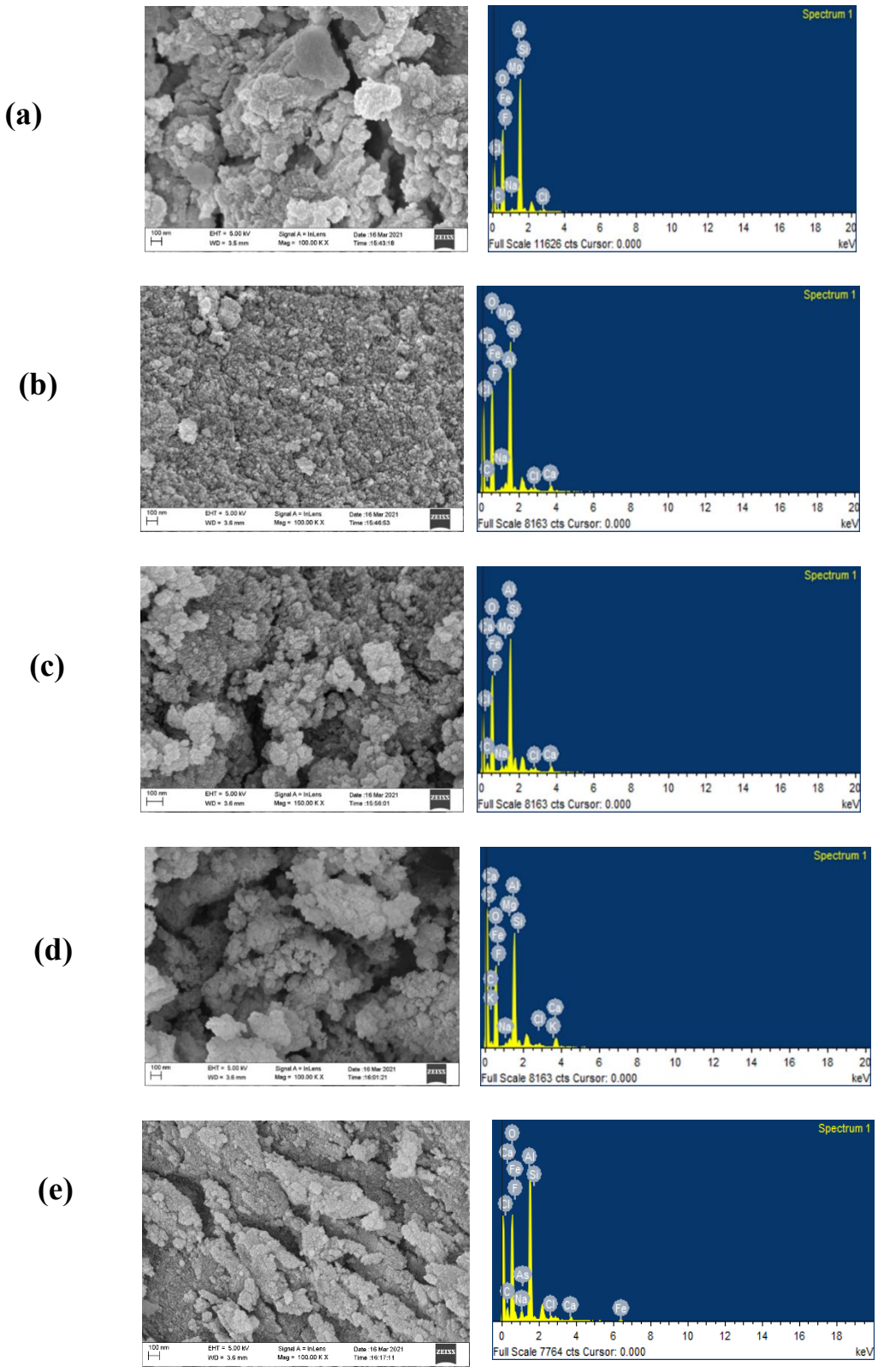
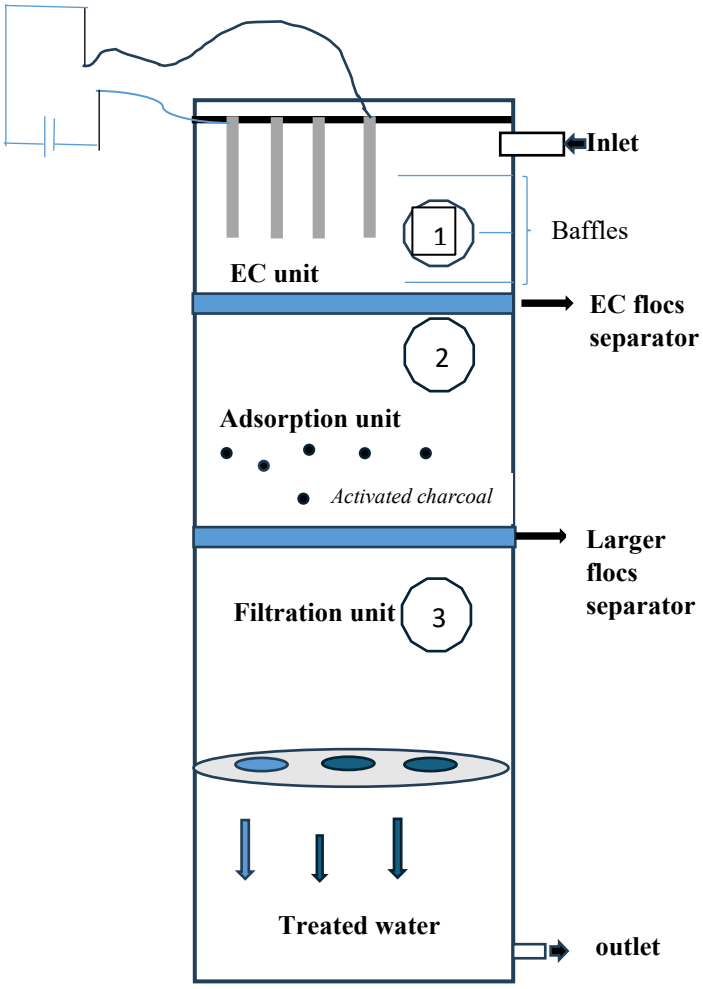


Fig. S1: FESEM and EDAX of the EC generated sludge for (a) S1 (b) S2 (c) S3 (d) S4 (e) S5



Chamber 1: EC unit comprises Al electrodes in bipolar connection mode, baffles to maintain homogeneity and contact time between electrons and electrolyte and inlet for water

Chamber 2: Adsorption unit, where activated charcoal is used as adsorbent for enhanced removal of secondary pollutants and comprises a floc separator to remove the lager-flocs to prevent pore blocking of the ceramic membranes.

Chamber 3: The filtration unit comprises of ceramic candles for separating the flocs and outlet for treated

Fig. S2: Schematic illustration of an EC based treatment unit for potable water based on the investigation of the present work.