ELECTRONIC SUPPLEMENTARY MATERIAL

Recent advances in the modification of electrodes for trace metal analysis: a review

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Analyte	Electrode type and modification	Supporting electrolyte	Technique used	LOD	Linear/Dynamic concentration range	RSD at certain concentration (%)	Recovery (%)	Observations	Ref.
Cu(II), Hg(II), Pb(II), and Cd(II)	Al₂NiCoO₅ nanoflakes modified GCE	0.1 M ABS (pH = 4.5)	ASDPV	^a Cu ²⁺ : 0.00261 ppb; Pb ²⁺ : 0.00154 ppb; Hg ²⁺ : 0.00232 ppb; Cd ²⁺ : 0.00114 ppb	1 · 10 ⁻⁵ –1.0 ppm for all analytes	NR	$\begin{array}{c} Cu^{2+}:\\ 100.3-105.1\%;\\ Pb^{2+}:\\ 99.1-108.3\%;\\ Hg^{2+}:\\ 101.9-102.3\%;\\ Cd^{2+}:\\ 98.1-101.6\%\end{array}$	No significant interference of Na ⁺ , K ⁺ , Cl ⁻ , Ca ²⁺ , Zn ²⁺ , Mn ²⁺ , Cr ²⁺ , Ni ²⁺ , and Fe ²⁺ was observed in the simultaneous determination of 10 ppb Cd ²⁺ and Pb ²⁺ , 50 ppb Cu ²⁺ , and 1 ppb Hg ²⁺ . The modified electrode was successfully employed in the determination of Cu ²⁺ , Pb ²⁺ , Hg ²⁺ , and Cd ²⁺ in tap and drinking water, and simulated blood serum samples.	
Cu(II), Pb(II), and Cd(II)	Ag-NPs, graphene nanoplates modified graphite electrode	0.1 M ABS (pH = 5.0)	SWASV	^a Cu ²⁺ : 4.1 ng L ⁻¹ ; Pb ²⁺ : 1.0 ng L ⁻¹ ; Cd ²⁺ : 5.0 ng L ⁻¹	0.5–120 μg L ⁻¹ for all analytes	At 50 μM of the analytes: 3.01% for Cu ²⁺ ; 2.26% for Pb ²⁺ ; 4.97% for Cd ²⁺	Cu ²⁺ : 97.83–105.16%; Pb ²⁺ : 93.31–103.50%; Cd ²⁺ : 98.83–102.37%	No significant interference of 2 times the concentration of Zn^{2+} and Hg^{2+} was observed in the determination of 50 μ M of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ , Pb ²⁺ , and Cd ²⁺ in tap water samples.	2
Cu(II), Zn(II), Pb(II), and Cd(II)	Bi-NPs decorated on Na-montmorillonite- MWCNT modified PGE	0.1 M ABS (pH = 4.5)	SWASV	$Zn^{2+}:$ 0.707 μ M; Cd ²⁺ : 0.097 μ M; Pb ²⁺ : 0.008 μ M; Cu ²⁺ : 0.157 μ M	$\begin{array}{c} {\rm Zn}^{2+}:\\ 2.36-40.0 \mbox{ and } 40.0-\\ 180.0 \mu {\rm M};\\ {\rm Cd}^{2+}:\\ 0.32-2.0 \mbox{ and } 2.0-240.0 \\ \mu {\rm M};\\ {\rm Pb}^{2+}:\\ 0.03-5.0 \mbox{ and } 5.0-80.0 \\ \mu {\rm M};\\ {\rm Cu}^{2+}:\\ 0.52-10.0 \mbox{ and } 10.0-\\ 40.0 \mu {\rm M} \end{array}$	At 20 μM of each analyte: 3.13% for Zn ²⁺ ; 4.23% for Cd ²⁺ ; 3.64% for Pb ²⁺ ; 1.79% for Cu ²⁺	Zn ²⁺ : 99.5%; Cd ²⁺ : 99.2%; Pb ²⁺ : 95.9%; Cu ²⁺ : 97.6%	No significant interference of 10 times the concentration of Mn^{2+} , Al^{3+} , Ni^{2+} , Sb^{3+} , Co^{2+} , Fe^{2+} , Cr^{3+} , Ca^{2+} , Mg^{2+} , and Na_3PO_4 was observed in the simultaneous determination of the analytes. The modified electrode was successfully employed in the determination of Cu^{2+} , Pb^{2+} , Zn^{2+} , and Cd^{2+} in tap water samples.	3
Pb(II)	EDTA-functionalized MWCNTs modified GCE	ABS (pH = 5.2)	SWV	0.6 µg L ⁻¹	2.0–470 μg L ⁻¹	At 200 μg L ⁻¹ : 11.2%	96.5%	No significant interference of co-existing Cu^{2+} and Cd^{2+} was observed in the determination of the analyte in solution containing 0.5 mg L^{-1} of the ions. The modified electrode was successfully employed in the determination of Pb ²⁺ in lake water samples.	4
Pb(II)	3-(Triethoxysilyl)propyl isocyanate, 2-picolinyl	0.1 M ABS (pH = 5.0)	DPASV	0.03 µM	1–100 μΜ	At 60 μM: 5.02%	NR	No significant interference of 5 times the concentration of Na ⁺ was observed in the	5

	hydrazide-functionalized MWCNTs modified GCE							determination of the analyte. Significant interference of NO_3^- , SO_4^{2-} and Cl^- was observed in the determination	
Cd(II) and Pb(II)	Shuttle-like α-Fe ₂ O ₃ -NPs decorated β-Bi ₂ O ₃ microspheres modified GCE	0.1 M ABS (pH = 5.0)	SWASV	^a Cd ²⁺ : 0.56 nM; Pb ²⁺ : 0.36 nM	0.002–4.0 μM for both analytes	At 0.30 μM of each analyte: 3.85% for Cd ²⁺ ; 5.46% for Pb ²⁺	Cd ²⁺ : 100.3–107.0%; Pb ²⁺ : 98.00–100.7%	No significant interference of the same concentration of Na ⁺ , K ⁺ , Zn ²⁺ , Mg ²⁺ , Ca ²⁺ , Ni ²⁺ and Fe ³⁺ , and 100 times the concentration of citric acid and ascorbic acid was observed in the simultaneous determination of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in milk, tap and lake water samples	6
Hg(II)	Co ₃ O ₄ nanopolyhedron anchored on N-doped rGO modified GCE	0.1 M $\text{NH}_3 \cdot \text{H}_2\text{OH}$ - NH_4Cl buffer (pH = 4.0)	SWASV	0.03 μM	0.1–1.0 μM	At 0.2 μM: 1.51%	102.70%	No significant interference of 10 times the concentration of Zn^{2+} , Cu^{2+} , Mn^{2+} , Ni^{2+} , Cr^{3+} , Mo^{5+} , Mg^{2+} , Mn^{2+} , NO_3^- , SO_4^{2-} , CO_3^{2-} , and Hg^{2+} was observed in the determination of 0.3 μ M of the analyte. Slight interference of 10 times the concentration of glucose, and significant interference of 10 times the concentration of Cu^{2+} and albumin was observed in the determination of 0.3 μ M of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in reservoir and human serum samples.	7
Cu(II), Cd(II), and Hg(II)	NiCo ₂ O ₄ -NPs decorated N, S co-doped rGO composites modified GCE	0.1 M ABS (pH = 5.0)	DPASV	^a Cd ²⁺ : 59 nM; Cu ²⁺ : 77 nM; Hg ²⁺ : 164 nM	0.15–1.50 μM for all analytes	At 1.50 μM of the analytes: 0.57% for Cd ²⁺ ; 1.01% for Cu ²⁺ ; 1.93% for Hg ²⁺	NR	No significant interference of 2 times the concentration of K^+ , Na ⁺ , Al ³⁺ , Li ⁺ , Ca ²⁺ , Mg ²⁺ , and Mn ²⁺ was observed in the simultaneous determination of 5 μ M of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ , Cd ²⁺ , and Hg ²⁺ in reservoir water samples.	8
Pd(II)	Bi ₂ O ₃ nanosheets modified SPCE	0.1 M acetate/ 1 M KCl buffer	DPV	1.4 ppb	40–400 ppb	NR	NR	Significant interference of 10 and 100 times the concentration of Cu^{2+} and As^{3+}	9

		(pH = 4.0)						was observed in the determination of 100 ppb of the analyte. The modified electrode was successfully employed in the determination of Pd ²⁺ in pharmaceutical wastewater samples.
Cd(II) and Pb(II)	Ru(II) bipyridine complex ([Ru(bpy) ₃] ²⁺), Nafion and GO nanocomposite modified SPAuE	0.1 M ABS (pH = 5.0)	SWASV	^a Pb ²⁺ : 5.3 ppb; Cd ²⁺ : 4.2 ppb	50–350 ppb for both analytes	At 200 ppb of the analytes: 1.3% for Cd ²⁺ ; 1.5% for Pb ²⁺	Pb ²⁺ : 103%; Cd ²⁺ : 90%	No significant interference of ¹⁰ 20 times the concentration of Cu^{2+} , Fe^{3+} , Hg^{2+} , Ni^{2+} , and Zn^{2+} was observed in the determination of Pb^{2+} in 200 ppb of the analytes. Significant interference of 20 times the concentration of Cu^{2+} , Fe^{3+} , Hg^{2+} , Ni^{2+} , and Zn^{2+} was observed in the determination of Cd^{2+} in 200 ppb of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} and Pd^{2+} in tap and river water samples.
Cd(II) and Pb(II)	Ru(II) bipyridine complex ([Ru(bpy) ₃] ²⁺), citrate-capped Au-NPs, Nafion and GO nanocomposite modified SPAuE	0.1 M ABS (pH = 5.0)	SWASV	^a Pb ²⁺ : 2.5 ppb; Cd ²⁺ : 12.01 ppb	10–300 ppb for both analytes	At 200 ppb of the analytes: 3.17% for Cd ²⁺ ; 2.19% for Pb ²⁺	Pb ²⁺ : 105.8%; Cd ²⁺ : 117.3%	No significant interference of ¹⁰ 20 times the concentration of Cu^{2+} , Fe^{3+} , Hg^{2+} , Ni^{2+} , and Zn^{2+} was observed in the determination of Pb^{2+} in 200 ppb of the analytes. No significant interference of 20 times the concentration of Fe^{3+} , Ni^{2+} , and Zn^{2+} was observed in the determination of Cd^{2+} in 200 ppb of the analytes. Slight interference of 20 times the concentration of Cu^{2+} , and Hg^{2+} was observed in the determination of Cd^{2+} in 200 ppb of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} and Pd^{2+} in tap and river water samples.
Cd(II) and Pb(II)	Bismuthene (Bi metallene) nanosheets modified GCE	0.1 M ABS (pH = 4.0)	SWASV	*Pb ²⁺ : 3.4 nM; Cd ²⁺ : 1.8 nM	Pb ²⁺ : 0.0060–0.68 μM; Cd ²⁺ : 0.010–0.68 μM	At 0.4 μM Pb ²⁺ : 2.15%	Pb ²⁺ : 104%; Cd ²⁺ : 99.3%	No significant interference of ¹¹ 10 times the concentration of Co^{2+} , Ca^{2+} , K^+ , Fe^{3+} , Zn^{2+} , Ni^{2+} , Mn^{2+} , Mg^{2+} , PO_4^{3-} , and Cl^- was observed in the determination of 0.4 μ M of the analytes. The modified electrode was

								successfully employed in the determination of Pb^{2+} and Cd^{2+}	
								in tap water samples.	
Pb(II), Cd(II), and Zn(II)	<i>In situ</i> plating Bi, MWCNTs modified PGE	0.1 M ABS (pH = 4.5)	SWASV	^a Cd ²⁺ : 0.068 μg L ⁻¹ ; Pb ²⁺ : 0.27 μg L ⁻¹ ; Zn ²⁺ : 1.63 μg L ⁻¹	Сd ²⁺ : 5–80 µg L ⁻¹ ; Pb ²⁺ : 1–80 µg L ⁻¹ ; Zn ²⁺ : 10–80 µg L ⁻¹	At 80 μg L ⁻¹ : lower than 10%	NR	No significant interference of 100 times the concentration of Na ⁺ , K ⁺ , Mg ²⁺ , Ca ²⁺ , NH ₄ ⁺ , NO ₃ ⁻ , Mn ²⁺ , Fe ²⁺ , and PO ₄ ³⁻ was observed in the simultaneous determination of the analytes. Significant interference of 2 times the concentration of Ni ²⁺ and Cu ²⁺ was observed in the simultaneous determination of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ and Zn ²⁺ in certified Canadian water and industrial effluent contaminated water samples.	12
Cd(II) and Pb(II)	rGO supported (Au-Bi)- NPs modified GCE	0.1 M ABS (pH = 4.5)	DPASV	^a Cd ²⁺ : 0.02 μM; Pb ²⁺ : 0.05 μM	Сd ²⁺ : 0.1–300 µg L ⁻¹ ; Pb ²⁺ : 0.1–500 µg L ⁻¹	NR	Pb ²⁺ : 98.2–104.9%; Cd ²⁺ : 97.6–102.3%	No significant interference of 100 times the concentration of K^+ , Ca^{2+} , Fe^{3+} , Fe^{2+} , Co^{2+} , Al^{3+} , Mg^{2+} , Mn^{2+} , Ni^{2+} , and Hg^{2+} was observed in the determination of 100 µg L^{-1} of the analytes. Significant interference of 100 times the concentration of Cu^{2+} was observed in the determination of 100 µg L^{-1} of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} and Cd^{2+} in river water, honey, and orange juice samples.	13
Pb(II)	GO-decorated Bi ₂ O ₃ -MnO ₂ nanocomposites modified GCE	0.1 M ABS (pH = 5.5)	SWASV	0.41 μg L ⁻¹	2.07–2072 μg L ⁻¹	At 10 μM: 4.59%	95.5–105%	No significant interference of 100 times the concentration of Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺ , Zn ²⁺ , Fe ²⁺ , Co ²⁺ , Cu ²⁺ , Al ³⁺ , Cl ⁻ , NO ₃ ⁻ , SO ₄ ²⁻ , and PO ₄ ³⁻ was observed in the determination of 1.0 μ M of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap and lake water samples.	14
Hg(II)	N, S co-doped carbon/sepiolite clay	0.1 M ABS (pH = 5.0)	DPASV	$0.1~\mu g~L^{-1}$	$0.4-85.0 \ \mu g \ L^{-1}$	At 20.0 μg L ⁻¹ : 3.4%	96.5–103.5%	No significant interference of 5 times the concentration of Ag^+ ,	15

	hybrid nanostructure modified CPE							Cd ²⁺ , Co ²⁺ , Ni ²⁺ , Zn ²⁺ , Mn ²⁺ , and Cr ³⁺ was observed in the determination of 20.0 μ g L ⁻¹ of the analyte. Significant interference of 5 times the concentration of Cu ²⁺ and Pb ²⁺ was observed in the determination of 20.0 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in tap, dam, and well water samples.	
Pb(II) and Hg(II)	Carbon-supported NiMn ₂ O ₄ nanocomposite modified GCE	0.1 M ABS (pH = 6.0)	SWASV	^a Pb ²⁺ : 0.050 μM; Hg ²⁺ : 0.027 μM	Ρb ²⁺ : 1.4–7.7 μM; Hg ²⁺ : 0.70–6.7 μM	At 8.570 μM of each analyte: 1.75% for Pb ²⁺ ; 2.008% for Hg ²⁺	Pb ²⁺ : 92.93–105.70%; Hg ²⁺ : 96.50–105.30%	No significant interference of the same, 10 and 100 times the concentration of Ba^{2+} , Cd^{2+} , Cu^{2+} , Fe^{2+} , Mn^{2+} , Ni^{2+} , Ga^{2+} , Na^{+} , and K^+ was observed in the determination of 10 μ M of each analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ and Hg ²⁺ in river water samples.	16
Pb(II) and Hg(II)	Carbon-supported ZnMn₂O₄ nanocomposite modified GCE	0.1 M ABS (pH = 6.0)	SWASV	^a Pb ²⁺ : 0.080 μM; Hg ²⁺ : 0.040 μM	Ρb ²⁺ : 1.0–7.7 μM; Hg ²⁺ : 1.4–8.4 μM	At 8.570 μM of each analyte: 1.232% for Pb ²⁺ ; 0.7412% for Hg ²⁺	Pb ²⁺ : 92.58–98.10%; Hg ²⁺ : 93.21–106.90%	No significant interference of the same, 10 and 100 times the concentration of Ba^{2+} , Cd^{2+} , Cu^{2+} , Fe^{2+} , Mn^{2+} , Ni^{2+} , Ga^{2+} , Na^{+} , and K^+ was observed in the determination of 10 μ M of each analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ and Hg ²⁺ in river water samples.	16
Pb(II), Cd(II), and Hg(II)	Mixed metal (Fe-Al) oxide NPs and chitosan modified GCE	0.1 M ABS (pH = 5.0)	DPV	aCd ²⁺ : 0.068 ppt; Pb ²⁺ : 0.034 ppt; Hg ²⁺ : 0.053 ppt	5–125 ppt for all analytes	At 100 ppt of each analyte: 3% for Cd ²⁺ ; 4% for Pb ²⁺ ; 5% for Hg ²⁺	NR	No significant interference of 100 times the concentration of Na ⁺ , K ⁺ , Mg ²⁺ , Cu ²⁺ , Co ²⁺ , Ca ²⁺ , Zn ²⁺ , Ni ²⁺ , Fe ³⁺ and Al ³⁺ was observed in the simultaneous determination of 5 ppt of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ , and Hg ²⁺ in river water samples.	17
Pb(II)	Trichloro(octadecyl) silane grafted bentonite impregnated with	0.1 M ABS (pH = 4.0)	DPASV	0.81 μg L ⁻¹	1.00–60.0 µg L^{-1}	At 50 μg L ⁻¹ : 3.05%	91.6–98.2%	No significant interference of 10 times the concentration of Hg^{2+} , Zn^{2+} , Ca^{2+} , Cu^{2+} , Fe^{2+} and	18

	biosynthesized Au-NPs modified GCE							Mn^{2+} was observed in the determination of 30.0 µg L ⁻¹ of the analyte. Significant interference of 10 times the concentration of Cd ²⁺ was observed in the determination of 30.0 µg L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in river and spring water samples.	
Hg(II)	3D-rGO doped with Ag-NPs modified GCE	0.1 M ABS (pH = 5.0)	DPV	0.0049 μg L ⁻¹	0.01–100 µg L ⁻¹	At 20 μg L ⁻¹ : 3.55%	89.09–116.39%	No significant interference of 10 times the concentration of Ba^{2+} , Ca^{2+} , K^+ , Mn^{2+} , Na^+ , Ni^{2+} , Fe^{2+} , Cu^{2+} , Zn^{2+} , Cd^{2+} , Co^{2+} , Pd^{2+} , Cr^{3+} , Fe^{3+} , and Mg^{2+} was observed in the determination of 20 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in fish and human blood samples.	19
Cd(II)	SnO2-NPs bioconjugated rGO nanocomposite modified GCE	0.1 M HEPES buffer (pH = 7.0)	DPV	1 · 10 ⁻⁴ ppm	0.001–0.4 ppm	NR	98.40%	No significant interference of 10 times the concentration of NaCl, Al(NO ₃) ₃ , BaCl ₂ , HgCl ₂ , KCl, Pb(CH ₃ COO) ₂ , MgSO ₄ , MnCl ₂ , Na ₂ CO ₃ , NaNO ₂ , Na ₃ AsO ₄ was observed in the determination of the analyte.	20
Pb(II), Cu(II), and Hg(II	Single-crystalline Co ₃ O ₄ nanocubes modified SPCE	0.1 M ABS (pH = 5.0)	DPV	^a Pb ²⁺ : 4.14 nM; Cu ²⁺ : 0.93 nM; Hg ²⁺ : 0.13 nM	Pb ²⁺ : $0.001-6.09 \mu$ M; Cu ²⁺ : $0.002-18.0 \mu$ M; Hg ²⁺ : $0.001-32.65 \mu$ M	At 50 μM of the analytes: 2.7631%	Pb ²⁺ : 97.5–101.5%; Cu ²⁺ : 98.7–100.8%; Hg ²⁺ : 98.5–100.3%	No significant interference of 150 μ M As ³⁺ , 100 μ M Cd ²⁺ , 130 μ M Cr ³⁺ , 400 μ M Fe ²⁺ , 480 μ M Co ²⁺ , and 320 μ M Zn ²⁺ , as well as 3 times the concentration of 4-nitroaniline, carbendazim, and metribuzin, 5 times the concentration of 4- nitrophenol, aminophenol, nitrobenzene, and acetaminophen was observed in the simultaneous determination of 2 μ M Pb ²⁺ , 10 μ M Cu ²⁺ , and 20 μ M Hg ²⁺ . The modified electrode was successfully employed in the determination of Pb ²⁺ , Cu ²⁺ , and Hg ²⁺ in tap and pond water samples.	21
Cr(VI)	rGO, NiS and Au nanocubes modified GCE	0.1 M ABS (pH = 5.0)	SWV	0.09 µg L ⁻¹	$2-14 \ \mu g \ L^{-1}$	NR	Higher than 96%	No significant interference of up to 500 times the	22

								concentration of Pb ²⁺ , Cd ²⁺ , As ³⁺ , Ca ²⁺ , and Mg ²⁺ was observed in the determination of 5 μ g L ⁻¹ of the analyte. A new peak developed close to the Cr ⁶⁺ peak in the presence of Cu ²⁺ concentrations higher than 300 μ g L ⁻¹ . The modified electrode was successfully employed in the determination of Cr ⁶⁺ in real ground water samples.	
Cd(II) and Pb(II)	Tetra–ethyl-1H-indazol- 3-carboxamide cobalt(II) phthalocyanine and MWCNTs modified GCE	PBS (pH = 7.0)	DPV	Cd ²⁺ : 10 nM; Pb ²⁺ : 9 nM	100–1000 nM for both analytes	At 400 nM of the analytes: 0.474% for Cd ²⁺ ; 2.04% for Pb ²⁺	Cd ²⁺ : 106.5%; Pb ²⁺ : 100.5%	No significant interference of 400 nM of Ca^{2+} , Mg^{2+} , Al^{3+} , Mn^{2+} , Cu^{2+} , Zn^{2+} , Fe^{3+} , Cr^{3+} , and As^{3+} was observed in the determination of 300 nM of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in river water samples.	23
Cd(II), Pb(II), and Hg(II)	S-doped C₃N₄ tube bundles with hierarchical pores and graphene nanosheets modified GCE	0.1 M ABS (pH = 5.0)	SWASV	^a Cd ²⁺ : 1.17 nM; Pb ²⁺ : 0.38 nM; Hg ²⁺ : 0.61 nM	0.25–3 µM for all analytes	At 1 μM of the analytes: 1.83% for Cd ²⁺ ; 1.18% for Hg ²⁺ ; 1.33% for Pb ²⁺	NR	No significant interference of 10 times the concentration of Mg^{2+} , Ca^{2+} , Ba^{2+} , Al^{3+} , Mn^{2+} , Fe^{2+} , Co^{2+} , Ni^{2+} , Zn^{2+} , Bi^{3+} , and In^{3+} was observed in the simultaneous determination of 1 µM of the analytes. Significant interference of 10 times the concentration of Cu^{2+} was observed in the simultaneous determination of 1 µM of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} , Pb^{2+} , and Hg^{2+} in tap and river water samples.	24
Cu(II)	Amino-containing organosilica gel nanofibers, (3-mercaptopropyl)- trimethoxysilane modified Au electrode	0.1 M PBS (pH = 7.0)	SWSV	2.6 · 10 ⁻¹² M	7.5 · 10 ⁻¹² _ 1.5 · 10 ⁻⁹ M; 1.5 · 10 ⁻⁹ -7.5 · 10 ⁻⁸ M	At 1.6 · 10 ⁻⁸ M: 8.0%	113.6%	No significant interference of 1000 times the concentration of Na ⁺ , K ⁺ , and Cl ⁻ , 100 times the concentration of Mg ²⁺ , Ca ²⁺ , and Zn ²⁺ , and 50 times the concentration of Pb ²⁺ and Cd ²⁺ was observed in the determination of 7.5 \cdot 10 ⁻¹¹ M of the analyte. Significant interference of 1.56 \cdot 10 ⁻⁹ M Hg ²⁺ was observed in the	25

Cd(II) and Pb(II)	Porous graphitic carbon nitride decorated with CoMn ₂ O ₄ nanocomposite modified GCE	0.1 M ABS (pH = 5.0)	SWASV	Cd ²⁺ : 0.021μM; Pb ²⁺ : 0.014 μM	Cd ²⁺ : 0.5–7.0 μM; Pb ²⁺ : 0.2–4.4 μM	At 2 μM Cd ²⁺ : 2.5%	Cd ²⁺ : 95.5–106.0%	determination of the analyte. The modified electrode was successfully employed in the determination of Cu^{2+} in tap and lake water samples. No significant interference of 20 times the concentration of Cu^{2+} , Fe^{2+} , Na^+ , Ni^{2+} , Zn^{2+} , and Fe^{3+} was observed in the determination of 1 μ M of Cd ²⁺ . The modified electrode was successfully employed in the determination of Cd ²⁺ in tap,	26
Cd(II) and Pb(II)	Fe ₃ O ₄ , Bi ₂ O ₃ , C ₃ N ₄ nanocomposite modified GCE	0.1 M ABS (pH = 4.5)	SWASV	${}^{a}Cd^{2+}:$ $3 \cdot 10^{-9} M;$ $Pb^{2+}:$ $1 \cdot 10^{-9} M$	0.01–3 μM	At 0.1 μM of the analytes: 5.5% for Cd ²⁺ ; 4.2% for Pb ²⁺	Cd ²⁺ : 97.7–103.8%; Pb ²⁺ : 97.8–101.1%	river, and lake water samples. No significant interference of 100 times the concentration of Ca^{2+} , Mg^{2+} , Mn^{2+} , Al^{3+} , Co^{2+} , Fe^{2+} , and Fe^{3+} was observed in the determination of 0.5 μ M of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in river water samples.	27
Pb(II), Hg(II), and Cu(II)	Magnetic ZnFe ₂ O ₄ spinel structure NPs modified GCE	0.1 M ABS (pH = 5.0)	DPASV	^a Hg ²⁺ : 0.92 nM; Pb ²⁺ : 5.11 nM; Cu ²⁺ : 7.84 nM	$\begin{array}{c} Hg^{2*}:\\ 0.05{-}1.0\ \mu\text{M};\\ Pb^{2+}:\\ 0.1{-}2.0\ \mu\text{M};\\ Cu^{2+}:\\ 0.1{-}1.0\ \mu\text{M} \end{array}$	At 1 μM Hg ²⁺ : 0.871%	Hg ²⁺ : 97.7–103.4%	No significant interference of 10 times the concentration of Mn^{2^+} , Ca^{2^+} , K^+ , Co^{2^+} , Ni^{2^+} , Na^+ , Al^{3^+} was observed in the determination of 1 μ M of the analytes. The modified electrode was successfully employed in the determination of Hg ²⁺ in reservoir water samples.	28
Cd(II) and Pb(II)	Bi, glutathione, Au-NPs, amino-rGO modified GCE	0.1 M ABS (pH = 4.5) containing 200 $\mu g L^{-1} Bi^{3+}$	DPASV	$\begin{tabular}{l}{l} $^{a}Cd^{2+}$:\\ 0.09\ \mu g\ L^{-1}$;\\ Pb^{2+}$:\\ 0.38\ \mu g\ L^{-1}\end{tabular}$	1–120 μg L ⁻¹ for both analytes	At 15 µg L ⁻¹ of the analytes: 1.48% for Cd ²⁺ ; 3.34% for Pb ²⁺	Cd ²⁺ : 95.73–98.32%; Pb ²⁺ : 95.60–98.84%	No significant interference of 20 times the concentration of Mg^{2+} , Cu^{2+} , Zn^{2+} , Mn^{2+} , Fe^{3+} , Ca^{2+} , Na^+ , K^+ , Cl^- , NO_3^- and SO_4^{2-} was observed in the determination of Cd^{2+} and Pb^{2+} . The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in tap water samples.	29
Cu(II) and Hg(II)	Au-NPs deposited on Au substrate	0.1 M ABS (pH = 4.7)	SWASV	Cu ²⁺ : 0.138 mg kg ⁻¹ ; Hg ²⁺ : 1.510 mg kg ⁻¹	$\begin{array}{c} Cu^{2+}:\\ 0.001-0.010 \text{ and}\\ 0.010-0.100 \ \mu g \ mL^{-1};\\ Hg^{2+}:\\ 0.020-0.100 \ \mu g \ mL^{-1}\end{array}$	At 0.05 μg mL ⁻¹ Cu ²⁺ : 2.87%	Cu ²⁺ : 81.25–113.67%; Hg ²⁺ : 93.13–115.83%	The modified electrode was successfully employed in the determination of Cu^{2+} and Hg^{2+} in real <i>Laminariae thallus</i> samples	30

Cu(II)	Polyurethane-doped Pt-NPs modified CPE	10 mM HNO ₃ -NaCl (pH = 1.4)	CV	16.72 ng mL ⁻¹	100–1000 ng mL ⁻¹	NR	95–107%	No significant interference of 10 times the concentration of ascorbic acid, uric acid, Hg^{2+} , Cd^{2+} , Pb^{2+} , and Ag^+ was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Cu^{2+} in digested serum, urine, and acidified tap water samples.	31
Pb(II)	High index facets-Ag nanoflower modified GCE	0.2 M ABS (pH = 4.5)	SWASV	0.74 ррb	10–700 ррb	At 50 ppb: 2.8%	93–105%	No significant interference of 100 ppb of each Cu^{2+} , Fe^{2+} , Mg^{2+} , Ni^{2+} , K^+ and Na^+ was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Pb^{2+} in human blood serum and cosmetic (eye liner and liquid lipstick) samples.	32
Cd(II)	Mn-loaded TiO ₂ nanotube arrays modified titanium foil electrode	0.1 M ABS (pH = 6.0)	Electrochemical preconcentratio n supported laser-induced breakdown spectroscopy	0.01 μM	0.02–0.4 μM	At 0.05 μM: 4.7%	57.4–136.3%	No significant interference of the same concentration of $Hg^{2+}, Zn^{2+}, K^+, Ca^{2+}, Mg^{2+}, CI^-$ was observed in the determination of 0.05 µM of the analyte. Significant interference of the same concentration of Pb^{2+} and Cu^{2+} was observed in the determination of 0.05 µM of the analyte. The modified electrode was successfully employed in the determination of Cd ²⁺ in water, soil, and tea samples.	33
Pb(II) and Cd(II)	3 wt.% Sb ₂ O ₃ modified MWCNTs paste electrode	ABS (pH = 4.0)	LSASV	^a Pb ²⁺ : 6.12 ppb; Cd ²⁺ : 16.77 ppb	Pb ²⁺ : 80–150 ppb; Cd ²⁺ : 5–35 ppb	At 10 ppb of Pb ²⁺ and 20 ppb Cd ²⁺ : 4.15% for Pb ²⁺ ; 3.06% for Cd ²⁺	NR		34
Pb(II), Cu(II), and Hg(II)	Zr/ZrO ₂ nanotube electrode	0.1 M ABS (pH = 6.0)	DPV	$\begin{tabular}{l}{l} $^{a}Pb^{2+}$: $$5\cdot10^{-8} M$; $$Cu^{2+}$: $$4\cdot10^{-8} M$; $$Hg^{2+}$: $$10^{-7} M$$\end{tabular}$	$\begin{array}{c} Pb^{2+}:\\ 8\cdot 10^{-8}10^{-5}\text{ M};\\ Cu^{2+}:\\ 5\cdot 10^{-8}2\cdot 10^{-6}\text{ M};\\ Hg^{2+}:\\ 4\cdot 10^{-8}10^{-5}\text{ M} \end{array}$	NR	NR		35
Hg(II)	Pd-NPs, graphite carbon nitride porous nanosheets modified GCE	$0.5 \text{ mM H}_2\text{SO}_4$ (pH = 2.0)	DPV	$0.009 \ \mu g L^{-1}$	$0.01{-}15~\mu g L^{-1}$	At 10 μgL ⁻¹ : 3.2%	95.3–104.5%	No significant interference of 10 times the concentration of Bi ³⁺ , Fe ³⁺ , Co ²⁺ , Ni ²⁺ , and Cu ²⁺ ,	36

								and 50 times the concentration of K ⁺ and Na ⁺ was observed in the determination of 10 μ gL ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in tap, lake, and river water samples.	
Cd(II), Pb(II), Cu(II), and Hg(II	Orthorhombic phase aluminium ferrite nanoflakes modified GCE	0.1 M ABS (pH = 4.5)	DPASV	${}^{a}Cu^{2+}$: 0.5 nM; Pb ²⁺ : 1.6 nM; Hg ²⁺ : 1.5 nM; Cd ²⁺ : 4 nM	0.010–1 μM for all analytes	At 1 μM of each analyte: 1.95% for Cu ²⁺ ; 1.89% for Pb ²⁺ ; 2.15% for Hg ²⁺ ; 3.91% for Cd ²⁺	$\begin{array}{c} Cu^{2+}:\\ 100.3-105.1\%;\\ Pb^{2+}:\\ 99.1-108.3\%;\\ Hg^{2+}:\\ 101.9-102.3\%;\\ Cd^{2+}:\\ 98.1-101.6\% \end{array}$	No significant interference of Na ⁺ , Cl ⁻ , Ca ²⁺ , Zn ²⁺ , and Fe ²⁺ was observed in the simultaneous determination of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ , Pb ²⁺ , Hg ²⁺ , and Cd ²⁺ in simulated blood serum samples.	37
Pb(II)	rGO, graphite nitride carbon nanosheet composite modified GCE	0.1 M ABS (pH = 5.5)	SWASV	1.07 · 10 ⁻¹² M	0.01–1000 nM	At 1 · 10 ⁻⁷ M: 3.5%	96–106.4%	No significant interference of 1 \cdot 10 ⁻⁵ M NO ₃ ⁻ , F ⁻ , Cl ⁻ , and Br ⁻ , and 1 \cdot 10 ⁻⁷ M Mg ²⁺ , Mn ²⁺ , Fe ³⁺ , Co ²⁺ , Hg ²⁺ , and Cd ²⁺ was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap, lake, and river water samples.	38
Sn(II)	Fe(II) exchanged clinoptilolite-NPs modified CPE	HCl (pH = 2.0)	SWV	0.1 μΜ	10–400 µM	NR	97.5–106.5%	The modified electrode was successfully employed in the determination of Sn ²⁺ in river water samples.	39
Cu(II)	N-doped carbon spheres, and MWCNTs modified GCE	0.1 M ABS (pH = 5.5)	DPASV	0.092 μg L ⁻¹	0.5–200 μg L ⁻¹	At 50 μg L ⁻¹ : 4.57%	90–106%	No significant interference of 100 times the concentration of Cu^{2+} , Ca^{2+} , Mg^{2+} , Cd^{2+} , Al^{3+} , Zn^{2+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Ni^{2+} , and Pb^{2+} , 20 times the concentration of CTAB, and 15 times the concentration of SDS was observed in the determination of 50 µg L ⁻¹ of the analyte. Significant interference of 10 times the concentration of EDTA was observed in the determination of 50 µg L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Cu^{2+} in lake water and saliva samples.	40

Cd(II) and Pb(II)	Acid treated-MWCNTs functionalized with hyaluronic acid and L-cysteine modified GCE	0.1 M ABS (pH = 4.5)	SWASV	Pb ²⁺ : 0.015 μg L ⁻¹ ; Cd ²⁺ : 0.032 μg L ⁻¹	0.4–4 μg L ⁻¹ for both analytes	At 4 μg L ⁻¹ of each analyte: 3.8%	Pb ²⁺ : 90.2–95%; Cd ²⁺ : 90.1–96.2%	No significant interference of 100 times the concentration of NO ₃ ⁻ , SO ₃ ²⁻ , Cl ⁻ , Na ⁺ , Al ³⁺ , Mg ²⁺ , K ⁺ , Fe ²⁺ , and Ca ²⁺ was observed in the determination of 2.25 μ gL ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd ²⁺ and Pb ²⁺ in honey. <i>Corcos nusifera</i> and	41
Cd(II) and Pb(II)	Acid treated-MWCNTs functionalized with hyaluronic acid and L-serine modified GCE	0.1 M ABS (pH = 4.5)	SWASV	Рb ²⁺ : 0.034 µg L ⁻¹ ; Cd ²⁺ : 0.057 µg L ⁻¹	0.4–4 μg L ^{–1} for both analytes	At 4 μg L ⁻¹ of each analyte: 4.1%	Pb ²⁺ : 87.5–97.5%; Cd ²⁺ : 88.1–93.8%	No significant interference of 100 times the concentration of NO_3^- , SO_3^{2-} , CI^- , Na^+ , AI^{3+} , Mg^{2+} , K^+ , Fe^{2+} , and Ca^{2+} was observed in the determination of 2.25 µgL ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in honey, <i>Cocos nusifera</i> , and egg white samples.	41
Hg(II)	Ruthenium-loaded cerium dioxide nanocubes modified GCE	$\begin{array}{c} 0.1 \text{ M} \\ \text{NH}_3 \cdot \text{H}_2 \text{OH-} \\ \text{NH}_4 \text{Cl buffer} \\ (\text{pH} = 5.0) \end{array}$	SWASV	0.019 μΜ	0.04–0.8 μM	At 0.2 μM: 2.70%	99.43–102.75%	No significant interference from the simultaneous addition of 0.8–1 μ M Cd ²⁺ , 0.6–0.8 μ M Cu ²⁺ , and 0.9–1.3 μ M Pb ²⁺ was observed in the determination of 0.3 μ M Hg ²⁺ . The modified electrode was successfully employed in the determination of Hg ²⁺ in reservoir and tap water samples.	42
Pb(II) and Cd(II)	FeNi3, CuS and BiOCl NPs modified CPE	0.1 M ABS (pH = 4.6)	SWASV	^a Pb ²⁺ : 0.1 μg L ⁻¹ ; Cd ²⁺ : 0.4 μg L ⁻¹	Pb ²⁺ : 0.5–120.0 μ g L ⁻¹ ; Cd ²⁺ : 1.0–150.0 μ g L ⁻¹	At 50.0 μg L ⁻¹ of the analytes: 3.33% for Pb ²⁺ ; 3.7% for Cd ²⁺	Pb ²⁺ : 97.0–104.1%; Cd ²⁺ : 96.3–104.4%	No significant interference of the same concentration of Cu^{2+} and 10 times the concentration of K ⁺ , Na ⁺ , Ba ²⁺ , Mn ²⁺ , Ca ²⁺ , Zn ²⁺ , As ³⁺ , and Co ²⁺ was observed in the simultaneous determination of 50.0 µg L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd ²⁺ and Pb ²⁺ in drinking water, raw milk, cheese, rice, and black tea samples.	43
Pb(II) and Hg(II)	5-Aminotetrazole and 3- (triethoxysilyl)propyl isocyanate functionalized SiO ₂ coated MgO-NPs modified GCE	0.1 M ABS (pH = 5.0)	SWASV	Pb ²⁺ : 0.019 μM; Hg ²⁺ : 0.041 μM	0.5–10 μM for both analytes	At 20 μ M of the analytes: 2.52% for Pb ²⁺ ; 2.01% for Hg ²⁺	Pb ²⁺ : 108.31%; Hg ²⁺ : 116.80%	No significant interference of 10 times the concentration of Na ⁺ , K ⁺ , Ca ²⁺ , Ni ²⁺ , Co ²⁺ , Cd ²⁺ , Cu ²⁺ , and Fe ³⁺ was observed in the determination of 20 μ M of	44

Pb(II) and	Bi-NPs and Nafion	0.1 M NaCl	ASV	Pb ²⁺ :	Pb ²⁺ :	NR	NR	the analytes. The modified electrode was successfully employed in the determination of Hg^{2+} and Pb^{2+} in tap and pond water samples. The modified electrode was	45
Cd(II)	modified SPGE			0.28 ppb; Cd ²⁺ : 40.34 ppb	4–10 ppb; Cd ²⁺ : 300–900 ppb			successfully employed in the determination of Cd^{2+} and Pb^{2+} in filtered and unfiltered tap water, treated wastewater and bay water samples.	1
Cd(II), Pb(II) and Cu(II)	Pd-NPs uniformly decorated porous activated carbon modified GCE	0.1 M ABS (pH = 4.8)	SWASV	^a Cd ²⁺ : 20.9 nM; Pb ²⁺ : 9.19 nM; Cu ²⁺ : 14.78 nM	25–500 nM for all analytes	At 500 nM Pb ²⁺ : 1.21%	NR	No mutual interference of the analytes was observed in their simultaneous determination. The modified electrode was successfully employed in the determination of Cd^{2+} , Pb^{2+} and Cu^{2+} in real water samples.	46
Fe(II)	rGO, leucomethylene blue, and Pt-NPs modified GCE	0.1 M ABS (pH = 4.5) containing 60 µM 2,2'-bipyridyl	SWV	3 nM	0.01–2 μΜ	At 2 μM: 4.0%	92–101%	No significant interference of 50 times the concentration of Cr^{3+} , Zn^{2+} , and Ag^+ , 40 times the concentration of Co^{3+} , Pb^{2+} and Mg^{2+} , 20 times the concentration of Cd^{2+} and Hg^{2+} , and 10 times the concentration of Cd^{2+} and Hg^{2+} , and 10 times the concentration of Cu^{2+} and Bi ³⁺ was observed in the determination of 2 μ M Fe ²⁺ . The modified electrode was successfully employed in the determination of Fe ²⁺ in seawater samples.	47
Pb(II) and Cd(II)	(BiO)2CO3, SWCNT nanocomposite incorporating Nafion modified GCE	0.2 M ABS (pH = 5.0)	SWASV	Pb ²⁺ : 0.05 μg L ⁻¹ ; Cd ²⁺ : 0.03 μg L ⁻¹	0–60 µg L ⁻¹ for both analytes	At 15 µg L ⁻¹ of the analytes: 1.95% for Pb ²⁺ ; 0.82% for Cd ²⁺	Pb ²⁺ : 98.40–100.50%; Cd ²⁺ : 98.20–104.07%	No significant interference of 10 times the concentration of Na ⁺ , As ³⁺ , Zn ²⁺ , K ⁺ , Cr ²⁺ , and Ca ²⁺ was observed in the determination of 20 μ g L ⁻¹ of the analytes. Significant interference of 10 times the concentration of Cu ²⁺ was observed in the determination of 20 μ g L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd ²⁺ and Pb ²⁺ in extracts of soil samples.	48
Pb(II) and Cu(II)	Ce-carbon nanofiber modified GCE	0.1 M ABS (pH = 5.0)	DPV	Pb ²⁺ : 0.6 ppb; Cu ²⁺ : 0.3 ppb	Pb ²⁺ : 0.9–2.1 ppb; Cu ²⁺ : 0.6–1.8 ppb	NR	NR	The modified electrode was successfully employed in the determination of Cu^{2+} and Pb^{2+} in river water samples.	49

Hg(II)	Tungsten carbide nanosheets modified SPCE	0.1 M PBS (pH = 7.0)	DPV	0.18 nM	0.002–655 μM	At 50 nM: 3.24%	97.52–99.41%	No significant interference of 5 μ M of Hg ²⁺ , Cu ²⁺ , Na ⁺ , I ⁻ , Ni ²⁺ , Zn ²⁺ , Cl ⁻ , Cd ²⁺ , Fe ²⁺ , Cr ³⁺ , Pb ²⁺ and As ³⁺ was observed in the determination of 5–125 nM of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in human blood serum, fish extract and industrial wastewater samples.	50
Hg(II)	Magnesium ferrite (MgFe ₂ O ₄) NPs modified GCE	0.1 M HCl	DPASV	0.037 ppb	2–120 ррв	NR	96.7–102.5%	No significant interference of 10 ppm Na ⁺ and Cr ³⁺ , 8 ppm K ⁺ , 10.5 ppm Mg ²⁺ , 0.15 ppm Pb ²⁺ , 0.1 ppm Cd ²⁺ and Cu ²⁺ , 0.4 ppm Cr ⁶⁺ , 6 ppm NO ₃ ⁻ , 15 ppm SO ₄ ²⁻ , 50 ppm CO ₃ ²⁻ and 20 ppm ClO ₄ ⁻ was observed in the determination of 0.1 ppm of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in wastewater and industrial effluent samples.	51
Cd(II)	Graphitic carbon nitride ultrathin nanosheets modified GCE	0.1 M ABS (pH = 5.5)	SWASV	0.35 nM	0.001–0.1 μM; 0.1–5 μM; 5–18 μM	At 10 μM: 5.29%	94.6–104.7%	No significant interference of 50 μ M Fe ³⁺ , Co ²⁺ , and Zn ²⁺ , 100 μ M Al ³⁺ , 500 μ M Ca ²⁺ , and 1000 μ M K ⁺ , Na ⁺ , Mg ²⁺ , and Mn ²⁺ was observed in the determination of 10 μ M of the analyte. The modified electrode was successfully employed in the determination of Cd ²⁺ in tap, lake, and river water samples.	52
Pb(II) and Cd(II)	Porous rGO, Au-NPs, salicylaldehyde-L- cysteine ligand modified GCE	0.1 M ABS (pH = 4.5)	SWASV	^a Pb ²⁺ : 0.04 nM; Cd ²⁺ : 0.06 nM	1–10 nM for both analytes	At 2 nM of each analyte: 2.4% for Cd ²⁺ ; 2.2% for Pb ²⁺	NR	No significant interference of the same concentration of Zn^{2+} , Cu^{2+} , and Hg^{2+} was observed in the simultaneous determination of 30 nM of each analyte. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in ground, lake, tap, and sewage water samples.	53
Pb(II) and Cd(II)	Polyamidoamine dendrimer functionalized	0.1 M ABS (pH = 5.5)	SWASV	^a Pb ²⁺ : 0.17 ng mL ⁻¹ ;	0.5–80 ng mL ⁻¹ for both analytes	At 0.5 ng mL ⁻¹ of the analytes:	Pb ²⁺ : 96.0–103.5%;	No significant interference of 300 times the concentration of	54
	magnetic Fe₃O₄-NPs modified CPE			Cd ²⁺ : 0.21 ng mL ⁻¹		3.1% for Pb ²⁺ ; 2.6% for Cd ²⁺	Cd ²⁺ : 96.5–102.0%	Co^{2+} , Mn^{2+} , Ni^{2+} , Cr^{3+} , 250 times the concentration of Cu^{2+}	

								and Hg^{2+} , and 100 times the concentration of Zn^{2+} was observed in the determination of 20.0 ng mL ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in wastewater, lake, and river water samples	
Cd(II), Pb(II), Cu(II), and Hg(II)	Fe ₃ O ₄ -NPs, fluorinated- MWCNTs modified GCE	0.1 M ABS (pH = 5.0)	SWASV	^a Pb ²⁺ : 0.08 nM; Cu ²⁺ : 0.02 nM; Cd ²⁺ : 0.05 nM; Hg ²⁺ : 0.05 nM	$\begin{array}{c} Pb^{2+}:\\ 0.5-30.0\ \mu\text{M};\\ Cu^{2+}:\\ 0.5-30.0\ \mu\text{M};\\ Cd^{2+}:\\ 0.5-30.0\ \mu\text{M};\\ Hg^{2+}:\\ 0.5-20.0\ \mu\text{M} \end{array}$	At 10 μM of the analytes: 2.24% for Cd ²⁺ ; 2.55% for Pb ²⁺ ; 3.02% for Cu ²⁺ ; 2.64% for Hg ²⁺	Pb ²⁺ : 97.33.–99.00%; Cu ²⁺ : 98.50–103.00%; Cd ²⁺ : 96.00–98.75%; Hg ²⁺ : 96.50–98.75%	No significant interference of 10 times the concentration of K^+ , Ca^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Mn^{2+} , and Zn^{2+} was observed in the simultaneous determination of 10 μ M of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} , Cu^{2+} , Hg^{2+} , and Pb^{2+} in soybean and river water samples.	55
Cd(II)	Bimetal oxide (Bi ₂ O ₃ /Fe ₂ O ₃)-NPs decorated GO modified PGE	0.5 M PBS (pH = 5.0)	SWV	1.85 ng L ⁻¹	6.2–1160.2 ng L ⁻¹	At 121.95 ng L ⁻¹ : 0.5%	97.68–99.65%	No significant interference of 123.45 ng L^{-1} of Cr^{2+} , Fe^{2+} , Fe^{3+} , Mn^{2+} , Ni^{2+} , Pb^{2+} , Pb^{4+} , Zn^{2+} , Cd^{2+} , ascorbic acid, and citric acid was observed in the determination of 121.95 ng L^{-1} of the analyte. The modified electrode was successfully employed in the determination of Cd^{2+} in food (potato, lemon, and apple), soil, biological samples (blood serum and urine) and water (tap, drinking and chemical laboratory wastewater) samples.	56
Cd(II), Pb(II), Zn(II), and Hg(II)	<i>In situ</i> incorporated oxidized MWCNTs on porous graphitic nitride nanosheets modified SPE	0.1 M ABS (pH = 5.0)	DPV	$\begin{tabular}{l} {}^{a}Pb^{2+}:\\ 0.008\ \mu g\ L^{-1};\\ Zn^{2+}:\\ 0.06\ \mu g\ L^{-1};\\ Cd^{2+}:\\ 0.03\ \mu g\ L^{-1};\\ Hg^{2+}:\\ 0.04\ \mu g\ L^{-1} \end{tabular}$	$\begin{array}{c} Pb^{2+} \colon \\ 0.35-6.5 \ \mu g \ L^{-1} \ and \\ 6.5-110 \ \mu g \ L^{-1} \colon \\ Zn^{2+} \colon \\ 4.2-202.0 \ \mu g \ L^{-1} \colon \\ Cd^{2+} \colon \\ 4.25-79.0 \ \mu g \ L^{-1} \ and \\ 79.0-251 \ \mu g \ L^{-1} \colon \\ Hg^{2+} \colon \\ 4.8-93.0 \ \mu g \ L^{-1} \end{array}$	At 25 μg L ⁻¹ Pb ²⁺ , and 50 μg L ⁻¹ of Hg ²⁺ , Cd ²⁺ , and Zn ²⁺ : 0.97% for Zn ²⁺ ; 0.98% for Cd ²⁺ ; 0.95% for Pb ²⁺ ; 0.93% for Zn ²⁺	$\begin{array}{c} Pb^{2+}:\\ 99.8-101.8\%;\\ Zn^{2+}:\\ 99.6-101.4\%;\\ Cd^{2+}:\\ 98.8-101.4\%;\\ Hg^{2+}:\\ 98.9-103.2\%\end{array}$	No significant interference of 10 times the concentration of F^- , SO_4^{2-} , 50 times the concentration of NO_3^- and NH_4^+ , Mg^{2+} , Ca^{2+} , Ba^{2+} , and Al^{3+} was observed in the simultaneous determination of the analytes. Significant interference of Cu^{2+} was observed in the determination of Pb^{2+} . The modified electrode was successfully employed in the determination of Cd^{2+} , Zn^{2+} , Hg^{2+} , and Pb^{2+} in	57

								noodle and vegetables (capsicum and cabbage) samples.)
Pb(II)	Au-NPs and N-deficient- C₃N₄ nanocomposite modified GCE	0.1 M ABS (pH = 5.0)	SWASV	0.029 μΜ	0.2–0.8 µM	At 0.8 μM: 4.90%	99.4–100.8%	No significant interference of 50 times the concentration of Cd^{2+} , slight interference of 10 times the concentration of Cd^{2+} and interference of 10 times the concentration of Hg^{2+} was observed in the determination of 0.4 μ M of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in reservoir and tap water samples.	58
Pb(II) and Cd(II)	Zinc ferrite-NPs modified GCE	0.1 M ABS (pH = 6.0)	DPASV	Pb ²⁺ : 0.56 ppb; Cd ²⁺ : 1.26 ppb	10–130 ppb for both analytes	NR	Pb ²⁺ : 96.20–101.63%; Cd ²⁺ : 97.43–102.70%	No significant interference of 2.0 ppm Na ⁺ and NH ₄ ⁺ , 1.0 ppm As ³⁺ , 0.3 ppm Cr ⁶⁺ , 0.05 ppm Cr ³⁺ and Ni ²⁺ , 1.2 ppm K ⁺ , 0.02 ppm Cu ²⁺ , 0.06 ppm Mg ²⁺ , 5.5 ppm SO ₄ ²⁻ , 6.0 ppm NO ₃ ⁻ , 4.5 ppm CO ₃ ²⁻ and 8.0 ppm ClO ₄ ⁻ was observed in the determination of 100 ppb of each analyte. The modified electrode was successfully employed in the determination of Cd ²⁺ and Pb ²⁺ in wastewater and industrial sewage water samples	
Pb(II) and Cd(II	Ag-NPs, MWCNTs, and Nafion modified GCE	0.1 M NaCl	ASV	Pb ²⁺ : 0.216 ppb; Cd ²⁺ : 0.481 ppb	Pb ²⁺ : 0.493–157.2 ppb; Cd ²⁺ : 1.864–155.1 ppb	NR	NR	The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in organic and non-organic vegetable samples.	60
Cd(II) and Zn(II)	Sparked Sn-NPs modified GSPE	0.1 M ABS (pH = 4.5) containing 0.2 M KBr	SWV	$\begin{array}{c} Cd^{2+}:\\ 0.5\ \mu g\ L^{-1};\\ Zn^{2+}:\\ 0.3\ \mu g\ L^{-1} \end{array}$	1–30 μg L ⁻¹ for both analytes	NR	Cd ²⁺ : 103.3%; Zn ²⁺ : 106.8%	Significant interference of Cu^{2+} was observed in the determination of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Zn^{2+} in tap and bottled water samples.	61
Ni(II)	Phenylamide-oxime and phenylamide nanolayer covalently grafted carbon modified GCE	0.1 M ammonium acetate buffer (pH = 8.2)	SWV	0.9 μΜ	0–50 μΜ	At 10 μM: 16%	NR	No significant interference of 5 and 50 μ M of Pb ²⁺ , Mg ²⁺ , Ca ²⁺ , K ⁺ , and Na ⁺ was observed in the determination of 50 μ M of the analyte. The modified electrode was successfully	62

								employed in the determination of Ni ²⁺ in doped natural mineral water samples.	
Pb(II)	Glutathione- functionalized Au-NPs MWCNTs modified GCE	0.1 M ABS (pH = 5.0)	SWASV	0.01 μM	20–350 nM	At 0.1 μM: 4.5%	NR	No significant interference of coexisting 10849 μ M K ⁺ , 1632 μ M Na ⁺ , 907 μ M Mg ²⁺ , 850 μ M Ca ²⁺ , 0.28 μ M Zn ²⁺ , 3.42 μ M Fe ³⁺ , 72 μ M Mn ²⁺ , and 0.096 μ M Cu ²⁺ was observed in the determination of 0.1 μ M of the analyte. No significant interference of individually adding 1000 times the concentration of K ⁺ , Mg ²⁺ , Ca ²⁺ , and Mn ²⁺ was observed in the determination of 0.1 μ M of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in real rice phloem sap samples.	63
Cr(VI)	Au-NPs modified SPCE	0.3 M HNO ₃ (pH = 0.5)	LSV	5.4 μg L ⁻¹	20–200 µg L ⁻¹	At 50 μg L ⁻¹ : 6.1%	99%	No significant interference of 10000 times the concentration of Ca^{2+} and Mg^{2+} , 1000 times the concentration of Ni^{2+} , Hg^{2+} , and Cu^{2+} , 100 times the concentration of Fe^{3+} , Cd^{2+} , Pb^{2+} , and Cr^{3+} was observed in the determination of 50 µg L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Cr^{6+} in river water samples.	64
Pb(II) and Cd(II)	Magnetic GO and Fe ₃ O ₄ functionalized with benzothiazole-2- carboxaldehyde modified GCE	0.1 M ABS (pH = 5.5)	SWASV	^a Pb ²⁺ : 0.02 ng mL ⁻¹ ; Cd ²⁺ : 0.03 ng mL ⁻¹	Pb ²⁺ : 0.0003–0.072 μM and 0.072–0.43 μM; Cd ²⁺ : 0.0007–0.13 μM and 0.13–0.8 μM	At 0.2 ng mL ⁻¹ of the analytes: 3.6% for Pb ²⁺ ; 2.4% for Cd ²⁺	Pb ²⁺ : 94.2–99.6%; Cd ²⁺ : 91.4–99.8%	No significant interference of 40 times the concentration of Cr^{3+} , Mg^{2+} , Cu^{2+} , $K+$, Zn^{2+} , Ni^{2+} , Hg^{2+} , and Na^+ was observed in the determination of 5 ng mL ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in wastewater, tap, and river water samples.	65
Pb(II) and Cd(II)	Graphene-CuZrO ₃ nanocomposites modified GCE	0.1 M ABS (pH = 4.6)	SWASV	Pb ²⁺ : 0.10 μg L ⁻¹ ; Cd ²⁺ : 0.50 μg L ⁻¹	$\begin{array}{c} {\rm Pb}^{2+}{\rm :}\\ 0.5{\rm -80~\mu g~L^{-1}}{\rm ;}\\ {\rm Cd}^{2+}{\rm :}\\ 1{\rm -100~\mu g~L^{-1}}\end{array}$	At 20 μg L ⁻¹ of the analytes: 2.73% for Pb ²⁺ ; 1.46% for Cd ²⁺	Pb ²⁺ : 97.60–102.73% Cd ²⁺ : 99.34–105.17%	No significant interference of ;10 times the concentration of As^{3+} , Hg^{2+} , Zn^{2+} , Cr^{6+} , and K^+ was observed in the determination of 10 µg L ⁻¹ of each analyte. Significant	66

			interference of 10 times the
			concentration of Cu ²⁺ was
			observed in the determination
			of 10 μ g L ⁻¹ of each analyte.
			The modified electrode was
			successfully employed in the
			determination of Cd ²⁺ and Pb ²⁺
			in soil samples.

 $^{a}-$ simultaneous determination of the analytes; NR – not reported by the authors

Table S2: Analytical performance parameters (as reported by the authors) of various types of electrodes for trace heavy metal analysis developed in the last five years (i.e. 2018–2022, including the research work published so far in 2023) using different polymers as modifiers.

Analyte	Electrode type and modification	Supporting electrolyte	Techniqu e used	LOD	Linear/Dynamic concentration range	RSD at certain concentration (%)	Recovery (%)	Observations	Ref.
Pb(II)	<i>In situ</i> polymerized phytic acid functionalized PPy modified SPCE	0.1 M ABS (pH = 5.6)	DPASV	0.43 nM	10–600 nM	NR	93.2–98.9%	No significant interference of 10 times the concentration of K ⁺ , Na ⁺ , Ni ²⁺ , Cr ⁶⁺ , Zn ²⁺ , NH ₄ ⁺ , Cl ⁻ , NO ₃ ⁻ and SO ₄ ²⁻ was observed in the determination of the analyte. Significant interference of 10 times the concentration of Hg ²⁺ and Cu ²⁺ was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap water samples.	67
Cr(II) and Cu(II)	2-(5"-hexyl-[2,2':5'2" terthiophen]-5-yl) methylene)-1H-indene- 1,3(2H) dione oligomer and GO modified GCE	0.1 M PBS (pH = 7.0)	CV	Cr ²⁺ : 3.65 μM; Cu ²⁺ : 2.25 μM	1–100 μM for both analytes	At $1-100 \mu$ M of the analytes: 10% for Cr ²⁺ ; 6.40% for Cu ²⁺	NR	The modified electrode was successfully employed in the determination of Cr^{2+} and Cu^{2+} in tap water samples.	68
Cd(II)	Prussian blue, poly(3,4- ethylenedioxythiophene) polystyrene sulfonate- loaded laser-scribed graphene nanocomposite modified GCE	0.1 M ABS (pH = 5.0)	DPV	0.85 nM	1 nM–10 μM	At 500 μM: 1.97%	93.2–103.2%	No significant interference of 10 times the concentration of Mn^{2+} , Pb^{2+} , Ca^{2+} , and Zn^{2+} was observed in the determination of 500 μ M of the analyte. The modified electrode was successfully employed in the determination of Cd^{2+} in tap and drinking water samples.	69
Pb(II)	Magnetic NiFe ₂ O ₄ -NPs and PPy modified GCE	0.1 M ABS (pH = 5.0)	SWASV	3.9 nM	0.1–2.1 µМ	At 0.5 μM: 0.66%	98.0–105.3%	No significant interference of 20 times the concentration of Cd^{2+} , Fe^{3+} , Zn^{2+} , Ni^{2+} , Cu^{2+} , and Na^+ was observed in the determination of 0.5 μ M of the analyte. Slight interference of concentrations of Cd^{2+} and Cu^{2+} higher than 10 μ M was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap, lake, and river water samples.	70
Pb(II) and Cd(II)	Bi, MWCNTs and poly(thionine) modified GCE	0.1 M ABS (pH = 3.5) and 800.0 µg L ⁻¹ Bi ³⁺	SWASV	Pb ²⁺ : 0.6 nM; Cd ²⁺ : 0.4 nM	2.0–400.0 nM for both analytes	At 40 nM of the analytes: 4.7% for Pb ²⁺ ; 4.5% for Cd ²⁺	NR	No significant interference of 1000 times the concentration of Na ⁺ , SO ₄ ²⁻ , K ⁺ , NO ₃ ⁻ , HCOO ⁻ , PO ₄ ³⁻ , CO ₃ ²⁻ , Cl ⁻ and Ca ²⁺ , 700 times the concentration of Sn ²⁺ , 400 times the concentration of Al ³⁺ and Cr ³⁺ , 300 times the concentration of Ba ²⁺ and Zn ²⁺ , 200 times the concentration of Fe ³⁺ , Co ²⁺ and Ni ²⁺ , and 100 times the concentration of Fe ³⁺ , Co ²⁺ and Ni ²⁺ , and 100 times the concentration of 40 nM of the analytes. Significant interference of 30 times the concentration of Cu ²⁺ was observed in the determination of 40 nM of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in rainwater, industrial effluent, seawater, tap and well water samples.	71

Hø(II)	Ag-NPs and block	0.1 M PBS	CV	157 nM	2–25 µM	NR	NR		72
118(11)	copolymer from poly	(pH - 7.0)	0.	10, 1101	2 20 pm				
	(methyl methacrylate) and	(p11 - 7.0)							
	noly(2-acrylamido-2-								
	methylpropane sulfonic								
	acid) modified GCE								
T1(I) and	PDA-functionalized	0.1 M ABS	SWASV	T1+:	T1+:	At 75 ppb of	Tl+:	No significant interference of the same	73
Pb(II)	MWCNTs, Bi-NPs	(pH = 5.0)		0.04 ppb;	0.4–100 ppb;	the analytes:	95.2-103.2%;	concentration of As ³⁺ , Ni ²⁺ , Fe ²⁺ , Hg ²⁺ , Cu ²⁺ ,	
× /	nanocomposite modified	'u '		Pb^{2+} :	Pb ²⁺ :	3.1% for Tl ⁺ :	Pb ²⁺ :	SO_4^{2-} , and hydrazine was observed in the	2
	GCE			0.07 ppb	100-400 ppb	2.7% for Pb ²⁺	98.4-103.9%	simultaneous determination of 75 ppb of the	2
								analytes. Significant interference of the same	2
								concentration of Cd^{2+} was observed in the	
								simultaneous determination of the analytes	
								The modified electrode was successfully	
								employed in the determination of Tl ⁺ and Pb ²⁺	
								in wastewater, tap, and mineral water samples.	
Pb(II) and	$Polv(melamine)/g-C_2N_4$	0.1 M ABS	DPV	^a Pb ²⁺ : 0.008	0.1-1.0 µM for	At 0.5 uM of	Pb ²⁺ :	No significant interference of 50 times the	74
Cd(II)	nanonetwork modified	(pH = 5.0)		$\mu M: Cd^{2+}$	both analytes	the analytes:	92.50-106.40%	concentration of SO_4^{2-} , NO_2^{-} , F^- , CO_2^{2-} , NH_4^+ ,	
	pre-anodized SPCE	(F-1 - 1.0)		0.02 µM		1.1%	Cd ²⁺ :	Li^+ , K^+ , Na+, Ca^{2+} , Ba^{2+} , and Al^{3+} was	
	F						90.00-102.60%	observed in the determination of $1.0 \mu\text{M}$ of the	
								analytes. Significant interference of 3 times the	2
								concentration of Cl ⁻ and 4 times the	2
								concentration of Cu ²⁺ was observed in the	2
								determination of the analytes. The modified	
								electrode was successfully employed in the	2
								determination of Pb^{2+} and Cd^{2+} in tap, river.	
								and lake water samples.	
Pb(II) and	Mesoporous silica-	0.1 M ABS	DPV	Pb ²⁺ :	Pb ²⁺ :	At 300 µg L ⁻¹	Pb ²⁺ :	No significant interference of 10 times the	75
Cd(II)	nanochannel films and	(pH = 5.5 or		$4.0 \ \mu g \ L^{-1};$	4–150 µg L ⁻¹ ;	of the analytes:	93.7-103.4%;	concentration of Fe3+, glycine, glucose,	,
	polydimethylsiloxane	6.0)		Cd^{2+} :	Cd^{2+} :	2.9% for Pb ²⁺ ;	Cd ²⁺ :	fructose, sucrose, vitamin C, glutamate, citric	
	modified indium tin oxide			2.0 $\mu g L^{-1}$	$30-900 \ \mu g \ L^{-1}$	3.6% for Cd ²⁺	95.3-102.9%	acid, and starch was observed in the	
	electrode							determination of 100 µg L ⁻¹ of each analyte.	
								The modified electrode was successfully	
								employed in the determination of Pb2+ and	
								Cd ²⁺ in grape and apple juice and beverage as	
								well as in rice fermented beverage samples.	
Pb(II)	rGO, CNT, Fe ₂ O ₃ and PPy	0.1 M ABS	SWASV	$1 \cdot 10^{-4} \mu M$	0.02–26 µM	At 0.2 µM:	99.2-100.4%	No significant interference of 5-250 times the	, 76
	modified GCE	(pH = 4.5)				4.30%		concentration of Zn ²⁺ , As ³⁺ , Cr ⁶⁺ , Cd ²⁺ , Cu ²⁺ ,	
								and Hg ²⁺ was observed in the determination of	
								$0.2 \mu\text{M}$ of the analyte. The modified electrode	
								was successfully employed in the	
								determination of Pb ²⁺ in tap water samples.	
Cr(VI)	PANI/sulfated zirconium	0.1 M PBS	DPV	64.3 nM	0.55–13.7 and	At 7.5 μM:	98.9–100.9%	No significant interference of 500 times the	77
	dioxide/MWCNTs	(pH = 7.0)			13.7–39.5 μM	2.64%		concentration of Ca ²⁺ , Mg ²⁺ , Na ⁺ , K ⁺ , CO ₃ ²⁻ ,	
	nanocomposite modified							HCO_3^- , Cl^- , SO_4^{2-} and 250 times the	
	GCE							concentration of Pb ²⁺ , Ni ²⁺ , and Co ³⁺ was	1
								observed in the determination of the analyte.	
								Significant interference of 65.0 μ M of Fe ³⁺ and	1
								$\beta 0.0 \mu M$ of $Cu^{2\tau}$ was observed in the	
1								determination of the analyte. The modified	

								electrode was successfully employed in the determination of Cr ⁶⁺ in industrial wastewater samples.	
Pb(II)	Conductive PDA doped PPy hydrogel modified SPCE	0.1 M ABS (pH = 4.5)	SWASV	0.15 μg L ⁻¹	3–50 μg L ^{–1} and 50–300 μg L ^{–1}	At 100 μg L ⁻¹ : 1.5%	96.06–104.66%	No significant interference of 10 times the concentration of Hg^{2+} , Cd^{2+} , Cu^{2+} , Cr^{6+} , As^{3+} , Ni^{2+} , and Co^{2+} was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap and river water samples.	78
Zn(II), Pb(II), and Cu(II)	Au-NPs, PANI, MWCNTs modified SPCE	0.1 M ABS (pH = 5.0)	SWASV	Zn ²⁺ : 0.039 μg L ⁻¹ ; Pb ²⁺ : 0.037 μg L ⁻¹ ; Cu ²⁺ : 0.017 μg L ⁻¹	1–180 μg L ^{–1} for all analytes	At 150 μ g L ⁻¹ of the analytes: 2.82% for Zn ²⁺ ; 2.96% for Pb ²⁺ ; 2.36% for Cu ²⁺	$\begin{array}{c} Zn^{2+}:\\ 96.0-106.5\%;\\ Pb^{2+}:\\ 94.0-106.0\%;\\ Cu^{2+}:\\ 95.0-105.0\% \end{array}$	No significant interference of 50 times the concentration of Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺ , Cd ²⁺ , Co ²⁺ , Ni ²⁺ , Fe ²⁺ , Fe ³⁺ was observed in the determination of 150 µg L ⁻¹ of the analytes. Significant interference of 50 times the concentration of Hg ²⁺ was observed in the determination of the analytes. The modified electrode was successfully employed in the determination of Zn ²⁺ , Pb ²⁺ , and Cu ²⁺ in water samples.	79
Cd(II)	IIP chitosan-N-doped rGO modified GCE	1 M ABS (pH = 5.0)	DPV	3.51 · 10 ^{−9} M	1 · 10 ⁻⁸ -1 · 10 ⁻⁷ M	At 0.08 μM: 2.29%	97.4–102%	No significant interference of 10 times the concentration of Zn^{2+} , Cu^{2+} , Cd^{2+} , Hg^{2+} , Mn^{2+} , and Ni^{2+} was observed in the determination of 0.05 μ M of the analyte. The modified electrode was successfully employed in the determination of Cd^{2+} in tap and lake water samples.	80
Pb(II)	Fe ₃ O ₄ -PDA-MnO ₂ core-shell magnetic nanocomposites modified magnetic GCE	1 M HCl (pH = 3.0)	DPV	$0.03 \ \mu g \ L^{-1}$	$0.1-150 \ \mu g \ L^{-1}$	At 20 μg L ⁻¹ : 2.52%	98.0–100.8%	No significant interference of 1000 times the concentration of K ⁺ , Na ⁺ , Mg ²⁺ , Ca ²⁺ , NH ₄ ⁺ , Br ⁻ , Cl ⁻ , NO ₃ ⁻ , and SO ₄ ²⁻ , 400 times the concentration of Fe ²⁺ , Fe ³⁺ , Hg ²⁺ , and Zn ²⁺ , and 100 times the concentration of Cd ²⁺ , Cu ²⁺ , Al ³⁺ , Ni ²⁺ , and Ni ³⁺ was observed in the determination of 20 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in lake water samples.	81
Pb(II)	Magnetic Fe ₃ O ₄ and SiO ₂ NPs, IIP (4-vinyl pyridine monomer and 2-(2- aminophenyl)-1H- benzimidazole Pb-binding ligand) modified GCE	0.1 M ABS (pH = 5.6)	DPV	0.05 ng mL ⁻¹	0.1–80 ng mL ⁻¹	NR	95.0–105.0%	No significant interference of 500 times the concentration of Ca^{2+} , Mg^{2+} , Zn^{2+} , Ni^{2+} , Cr^{3+} , Ag^+ , Hg^{2+} , Na^+ , K^+ , and 50 times the concentration of Cd^{2+} and Cu^{2+} was observed in the determination of 0.1 M of the analyte. The modified electrode was successfully employed in the determination of Pb^{2+} in rainwater, tap, river water and fruit juice samples.	82
Cd(II)	IIP (poly(o- phenylenediamine)), electrochemical rGO modified GCE	0.1 M ABS (pH = 4.8)	SWASV	0.13 ng mL ⁻¹	1–50 ng mL ⁻¹	At 10 ng mL ⁻¹ : 3.5%	94–106.4%	No significant interference of 20 times the concentration of Hg^{2+} , Ni^{2+} , Cu^{2+} , Mn^{2+} , Zn^{2+} , Fe^{2+} , and Mg^{2+} was observed in the determination of 10 ng mL ⁻¹ of the analyte.	83

								The modified electrode was successfully employed in the determination of Cd^{2+} in river	
								and lake water samples.	
Hg(II)	Pt, g-C ₃ N ₄ , and PANI nanocomposites modified GCE	0.33 M PBS, 0.5 M NaCl and 0.1 M LiClO ₄ (pH = 7.0)	DPV	0.014 nM	1–500 nM	At 500 nM: 1.248%	97.738–98.997%	The nanocomposite is synthetized in the presence of L-cysteine as a reducing agent. No significant interference of 100 times the concentration of K ⁺ , Mn ²⁺ , Ni ²⁺ , Pb ²⁺ , Cd ²⁺ , Sn ²⁺ , Zn ²⁺ , Ag ⁺ , Cu ²⁺ , and Fe ²⁺ was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in wastewater samples.	84
Hg(II)	IIP-PPy and ZnO modifed Au electrode	0.1 M KCl	SWV	1 pM	NR	NR	NR	The polymerization of PPy was done in the presence of L-cysteine as a chelating agent.	85
Hg(II)	Pt, g-C ₃ N ₄ , and polythiophene nanocomposites modified GCE	0.33 M PBS, 0.5 M NaCl and 0.1 M LiClO ₄ (pH = 7.0)	DPV	0.009 nM	1–500 nM	At 500 nM: 0.573%	97.444–99.352%	The nanocomposite is synthetized in the presence of L-cysteine as a reducing agent. No significant interference of 100 times the concentration of K ⁺ , Mn ²⁺ , Ni ²⁺ , Pb ²⁺ , Cd ²⁺ , Sn ²⁺ , Zn ²⁺ , Ag ⁺ , Cu ²⁺ , and Fe ²⁺ was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in wastewater samples.	86
Pb(II) and Cd(II)	Glycine functionalized rGO/PANI nanocomposite modified GCE	0.1 M ABS (pH = 5.0)	SWASV	Pb ²⁺ : 0.072 nM; Cd ²⁺ : 0.07 nM	0.0001–1 µM for both analytes	At 1.4 μM of the analytes: 1.84% for Pb ²⁺ ; 1.24% for Cd ²⁺	Pb ²⁺ : 105%; Cd ²⁺ : 102%	No significant interference of 100 times the concentration of Cu^{2+} , Co^{2+} , Cl^- , and nitrobenzene was observed in the determination of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in tap water samples.	87
Pb(II) and Cd(II)	Poly(amidoamine) dendrimer functionalized magnetic Fe ₃ O ₄ and GO modified GCE	0.1 M ABS and 0.1 M KCl (pH = 4.5)	SWASV	Pb ²⁺ : 0.13 μ g L ⁻¹ ; Cd ²⁺ : 0.07 μ g L ⁻¹	Pb ²⁺ : 0.4–120 μ g L ⁻¹ ; Cd ²⁺ : 0.2–140 μ g L ⁻¹	At 20 μg L ⁻¹ of each analyte: 4.0% for Pb ²⁺ ; 3.5% for Cd ²⁺	Pb ²⁺ : 96.0–103.0%; Cd ²⁺ : 96.7–104.0%	No significant interference of 650 times the concentration of Mg ²⁺ and Ca ²⁺ , 350 times the concentration of Co ²⁺ , Mn ²⁺ , Ni ²⁺ , and Fe ²⁺ , 200 times the concentration of Zn ²⁺ , Hg ²⁺ , Cr ³⁺ , and In ³⁺ , 100 times the concentration of Tl ⁺ was observed in the determination of 20 μ g L ⁻¹ of the analytes. Significant interference of 10 times the concentration of Cu ²⁺ was observed in the determination of the analytes. The modified electrode was successfully employed in the simultaneous determination of the analytes.	88
Cd(II)	IIP (2,2':6',6"-terpyridine- based) NPs modified CPE	0.1 M ABS (pH = 5.0)	DPASV	1.94 nM	4–500 nM	NR	95.8–102.8%	No significant interference of 120 times the concentration of Mn^{2+} , Ni^{2+} , and Fe^{2+} , 100 times the concentration of Zn^{2+} , 40 times the concentration of Hg^{2+} and Ag^+ , 30 times the concentration of Pb^{2+} and SO_3^{2-} , and 20 times the concentration of Cu^{2+} was observed in the determination of Cd^{2+} in a 10 nM mixture with the interferents. The modified electrode was	89

Cd(II)	Core-shell self-doped PANI coated (UIO-66-NH ₂)-MOF modified SPCE	0.2 M ABS (pH = 6.0)	SWASV	0.17 μg L ⁻¹	$0.5 - 100 \ \mu g \ L^{-1}$	At 20 μg L ⁻¹ : 4.1%	96.6–108.1%	successfully employed in the determination of Cd^{2+} in river, tap and mineral water, rice, whole blood, and urine quality control material samples. No significant interference of 100 times the concentration of Mn^{2+} , Ca^{2+} , Na^+ , NH_4^+ , Li^+ , Fe^{2+} , Mg^{2+} , and Al^{3+} was observed in the determination of 15 µg L^{-1} of the analyte. Significant interference of concentration higher than 50 µg L^{-1} of Cu^{2+} was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Cd^{2+} in tap, lake water, and urine samples.	90
Cd(II) and Pb(II)	Bi-NPs, PPy and MWCNTs modified CPE	$\begin{array}{l} 0.1 \text{ M ABS} \\ (\text{pH} = 4.5) \\ \text{containing 350} \\ \mu \text{g } \text{L}^{-1} \text{ Bi}^{3+} \end{array}$	SWASV	^a Pb ²⁺ : 99 ng L ⁻¹ ; Cd ²⁺ : 157 ng L ⁻¹	Pb ²⁺ : 0.11–120 μg L ⁻¹ : Cd ²⁺ : 0.16–120 μg L ⁻¹	At 90 μgL ⁻¹ of the analytes: 3.2% for Pb ²⁺ ; 2.8% for Cd ²⁺	Pb ²⁺ : 98.0–104.4%; Cd ²⁺ : 98.4–102.5%	No significant interference of 25 times the concentration of Fe ²⁺ , Al ³⁺ , Zn ²⁺ , Mg ²⁺ , SO ₄ ²⁻ , CO ₃ ²⁻ , Ca ²⁺ , K ⁺ and Na ⁺ was observed in the determination of 90 μ g L ⁻¹ of the analytes. Significant interference of concentrations higher than 90 μ g L ⁻¹ of Cu ²⁺ was observed in the determination of 90 μ g L ⁻¹ of the analytes. The modified electrode was successfully employed in the simultaneous determination of Pb ²⁺ and Cd ²⁺ in tap water samples.	91
Pb(II) and Cu(II)	Poly(2,5-bis-(2,3- dihydrothieno[3,4- b][1,4]dioxyin-5- yl)pyridine) hollow nanosphere modified GCE	0.1 M ABS (pH = 4.0)	DPV	^a Pb ²⁺ : 0.005 μM; Cu ²⁺ : 0.012 μM	^a Pb ²⁺ : 0.012–4 μM; Cu ²⁺ : 0.016–4 μM	At 1 μ M of the analytes: 3.9% for Pb ²⁺ ; 4.5% for Cu ²⁺	Pb ²⁺ : 92.3–105.0%; Cu ²⁺ : 91.7–108.1%	No significant interference of 10 times the concentration of K ⁺ , Na ⁺ , Ni ²⁺ , Mn ²⁺ , Zn ²⁺ , Li ⁺ , Co ²⁺ and Cd ²⁺ , and 1000 times the concentration of methanol, ethanol, trichloromethane, tetrahydrofuran and n-hexane was observed in the determination of 1 μ M of the analytes. The modified electrode was successfully employed in the simultaneous determination of Pb ²⁺ and Cu ²⁺ in tap water samples.	92
Pb(II) and Cu(II)	poly(2,5-bis-(2,3- dihydrothieno[3,4- b][1,4]dioxyin-5- yl)pyridine) modified GCE	0.1 M ABS (pH = 4.0)	DPV	^a Pb ²⁺ : 0.004 μM; Cu ²⁺ : 0.01 μM	Pb ²⁺ : 0.02–3 μM; Cu ²⁺ : 0.04–3.8 μM	NR	NR		92
Pb(II) and Cu(II)	poly(3,6-bis(3,4- ethylenedioxythienylpyrid azine) hollow nanosphere modified GCE	0.1 M ABS (pH = 4.0)	DPV	^a Pb ²⁺ : 0.01 μM; Cu ²⁺ : 0.02 μM	Pb ²⁺ : 0.02–3.8 μM; Cu ²⁺ : 0.04–3.8 μM	NR	NR		92
Pb(II) and Cu(II)	poly(3,6-bis(3,4- ethylenedioxythienylpyrid azine) modified GCE	0.1M ABS (pH = 4.0)	DPV	^a Pb ²⁺ : 0.01 μM; Cu ²⁺ : 0.02 μM	Pb ²⁺ : 0.04–2.6 μM; Cu ²⁺ : 0.06–3.4 μM	NR	NR		92
Pb(II), Cu(II), and Hg(II)	1-(3-aminopropyl) imidazole modified sulphonamide-based	0.5 M HCl	SWAS	$\begin{array}{c} Pb^{2+}:\\ 5\ \mu g\ L^{-1};\\ Cu^{2+}: \end{array}$	Uper limit: $100 \ \mu g \ L^{-1}$ for $Pb^{2+};$	At 100 μg L ⁻¹ Pb ²⁺ : 3.52%	Pb ²⁺ : 96–110%; Cu ²⁺ :	No significant mutual interference of the analytes was observed in their simultaneous determination. The modified electrode was	93

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	porymetric resili modified			μgL; ng :	$500 \mu g L$ for		90-104%	successfully employed in the simulateous	
	CPE			14 μg L ⁻¹	Cu ² ⁺ ;			determination of Pb^{2+} and Cu^{2+} in tap water	
					300 µg L ⁻¹ for			and certified ground and wastewater pollution	
					Hg^{2+}			standard solution samples.	
Cu(II)	PPy-rGO hydrogel	0.1 M HCl and	SWASV	0.3 nM	0.5-450 nM	At 100 nM:	NR	The modified electrode was successfully	94
	composites modified GCE	0.3 M KCl			450-5000 nM	2.06%		employed in the determination of Cu2+ in lake	
	*							water samples.	
Cd(II)	IIP (co-precipitation	0.1 M ABS	DPV	$1 \cdot 10^{-4} \mu M$	0.008-0.05 µM;	At 5.0 µg L ⁻¹ :	93.181-101.576%	No significant interference of 100 times the	95
. ,	polymerization of	(pH = 5.5)			0.05-0.80 uM	2.7%		concentration of Zn ²⁺ , Cr ³⁺ , Pb ²⁺ , Ni ²⁺ , Ag ⁺ ,	
	4-vinylpyridine_ethylene	u						Hg^{2+} and K^+ 20 times the concentration of	
	glycol dimethacrylate							Cu^{2+} was observed in the determination of	
	$2 2'_{-}$							0.003 mg I^{-1} of the analyte. The modified	
	2,2 -							electrode was successfully employed in the	
	azobisisobutyrointine, 2-							determination of Cd^{2+} in westewater top and	
								determination of Cu in wastewater, tap and	
	core-shell Fe ₃ O ₄ /SlO ₂							river water samples.	
	nanomaterials modified								
	GCE								
Pb(II) and	Dandelion-like	0.1 M ABS	SWASV	^a Pb ²⁺ : 0.003	Pb ²⁺ :	At 0.48 µM	Pb ²⁺ :	No significant interference of 50 times the	96
Cu(II)	PANI-coated, Au-NPs	(pH = 4.5)		μM;	0.02–0.72 μM;	Pb ²⁺ and 1.57	102.3%;	concentration of Na ⁺ , K ⁺ , Ag ⁺ , Ca ²⁺ , Mg ²⁺ ,	
	composites modified GCE			Cu ²⁺ : 0.008	Cu ²⁺ :	μM Cu ²⁺ :	Cu ²⁺ :	$Mn^{2+}, Zn^{2+}, Cd^{2+}, Co^{2+}, Ni^{2+}, Fe^{2+}, and Fe^{3+} was$	
				μΜ	0.08–2.4 µM	3.4% for Pb ²⁺ ;	101.9%	observed in the simultaneous determination of	
						4.1% for Cu2+		the analytes. Significant interference of 50	
								times the concentration of Hg ²⁺ was observed	
								in the simultaneous determination of the	
								analytes The modified electrode was	
								successfully employed in the simultaneous	
								determination of $\mathbf{P}\mathbf{h}^{2+}$ and $\mathbf{C}\mathbf{u}^{2+}$ in lake water	
								and industrial offluents somplas	
								and industrial effluents samples.	

 $^{\mathrm{a}}-\mathrm{simultaneous}$ determination of the analytes; NR $-\operatorname{not}$ reported by the authors

Table S3: Analytical performance parameters (as reported by the authors) of various types of electrodes for trace heavy metal analysis developed in the last five years (i.e. 2018–2022, including the research work published so far in 2023) using metallic and polymeric-film modification.

Analyte	Electrode type and modification	Supporting electrolyte	Technique used	LOD	Linear/Dynamic concentration range	RSD at certain concentration (%)	Recovery (%)	Observations	Ref.
Pb(II)	Boron-doped diamond-film electrode on porous titanium substrate	NR	SWASV	2.62 ppb	5–30 ppb	NR	NR	No significant interference of the same concentration of Cd^{2+} , Cu^{2+} , and Zn^{2+} was observed in the determination of 30 ppb Pb ²⁺ .	97 \$
Pb(II) and Hg(II)	In situ Bi-film boron-doped diamond modified SPE	NR	SWV	Рb ²⁺ : 6.7 µg L ⁻¹ ; Hg ²⁺ : 7.5 µg L ⁻¹	31.25–2000 μg L ⁻¹ for both analytes	At 62.5 μ g L ⁻¹ : 5.61% for Pb ²⁺ ; 6.44% for Hg ²⁺	94–106%	No significant interference of 10 times the concentration of Cu^{2+} , Cd^{2+} , Co^{2+} , Fe^{3+} , Ni^{2+} , and Zn^{2+} was observed in the determination of 50 µg L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Hg ²⁺ in different beer samples.	98 , , , , , , , , , , , , , , , , , , ,
Pb(II) and Cd(II)	Poly(pyrrole-1-carboxylic acid)-film modified PGE	0.1 M ABS (pH = 6.0)	DPASV	^a Pb ²⁺ : 0.018 nM; Cd ²⁺ : 0.023 nM	0.1–1 nM for both analytes	At 1.0 nM of the analytes: 2.1% for Pb ²⁺ ; 1.8% for Cd ²⁺	Pb ²⁺ : 97.7–102.2%; Cd ²⁺ : 95.0–101%	No significant interference of 5–100 times the concentration of Cu^{2+} , Cr^{3+} , Bi^{3+} , Fe^{2+} , Co^{2+} , and Zn^{2+} was observed in the simultaneous determination of 0.5 nM of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in well water (before and after treatment) and lake water samples.	99 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
Pb(II), Cd(II), and Zn(II)	(Bi-Cu)-MOF-derived carbon film encapsulating BiCu alloy NPs modified SPE	0.1 M ABS (pH = 4.5)	SWASV	^a Cd ²⁺ : 0.95 ppb; Pb ²⁺ : 0.95 ppb; Zn ²⁺ : 45 ppb	Pb ²⁺ and Cd ²⁺ : 5–150 ppb and 150-800 ppb; Zn ²⁺ : 200–800 ppb	NR	$\begin{array}{c} {\rm Pb}^{2+}{\rm :}\\ 103.1{\rm -}108.8\%;\\ {\rm Cd}^{2+}{\rm :}\\ 104.0{\rm -}107.9\%;\\ {\rm Zn}^{2+}{\rm :}\\ 101.5{\rm -}107.6\% \end{array}$	No significant interference of 10 times the concentration of Ca^{2+} , Hg^{2+} , Cu^{2+} , In^{3+} , CI^- , SO_4^{2-} , dopamine, ascorbic acid, and uric acid was observed in the simultaneous determination of 200 ppb of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} , Cd^{2+} , and Zn^{2+} in tap, lake, and river water, as well as in urine and blood samples.	100 ; ; ;
Pb(II), Cd(II), and Zn(II)	Dendritic Bi and graphdiyne film modified GCE	0.1 M ABS (pH = 6.0)	DPASV	$\label{eq:cd2} {}^{a}Cd^{2+}: 0.171 \\ nM; \\ Pb^{2+}: 0.146 \\ nM; \\ Zn^{2+}: 0.115 \\ nM \\ \end{cases}$	10.0 nM–1.0 μM and 1.0–100.0 μM for all analytes	At 100.0 μM of the analytes: 1.57% for Pb ²⁺ ; 1.84% for Cd ²⁺ ; 2.03% for Zn ²⁺	$\begin{array}{c} {\rm Pb}^{2+};\\ 102.0-103.0\%;\\ {\rm Cd}^{2+};\\ 98.02-105.0\%;\\ {\rm Zn}^{2+};\\ 98.85-103.6\%\end{array}$	No significant interference of 10 times the concentration of Mn^{2+} , Ni^{2+} , Co^{2+} , Fe^{3+} , Fe^{2+} , Ca^{2+} , Mg^{2+} and K^+ was observed in the simultaneous determination of 100.0 μ M of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ , and Zn ²⁺ in seawater samples.	101 1 1 1 1 1 1
Hg(II) and Bi(III)	Poly(1,2- diaminoanthraquinone)-film modified Au electrode	0.1 M HCl and 0.2 M NaCl	SWASV	^a Hg ²⁺ : 0.29 μg L ⁻¹ ; Bi ³⁺ : 0.27 μg L ⁻¹	Hg ²⁺ : 1–50 µg L ⁻¹ ; Bi ³⁺ : 1–200 µg L ⁻¹	NR	Hg ²⁺ : 98.5–101.2%; Bi ³⁺ : 97.2–98.9%	No significant interference of 50 times the concentration of Na ⁺ and K ⁺ , 40 times the concentration of Ca ²⁺ , 30 times the concentration of Mg^{2+} , same concentration of Zn^{2+} , Fe ³⁺ , and Mn ²⁺ , and 0.8 times the concentration of Co ²⁺ was observed in the determination of 50 µg L ⁻¹ Hg ²⁺ and 100 µg L ⁻¹ Bi ³⁺ . The modified	

								electrode was successfully employed in the determination of Hg ²⁺ and Bi ³⁺ in tap, bottled, underground water and treated wastewater samples.	1 , 1
Hg(II), Zn(II), and Pb(II)	Poly(3,4- ethylenedioxythiophene) and $N\alpha$, $N\alpha$ -bis- (carboxymethyl)-L-lysine hydrate modified Pt electrode	0.2 M ABS (pH = 4.5)	SWV	$\begin{array}{c} Hg^{2+}:\\ 1.73\ \mu g\ L^{-1};\\ Zn^{2+}:\\ 2.33\ \mu g\ L^{-1};\\ Pb^{2+}:\\ 1.99\ \mu g\ L^{-1} \end{array}$	5–100 μg L ⁻¹ for all analytes	At 30 µg L ⁻¹ of the analytes: 2.9% for Hg ²⁺ ; 3.02% for Zn ²⁺ ; 2.8% for Pb ²⁺	NR	No significant interference of 50 times the concentration of K ⁺ , Na ⁺ , Mg ²⁺ , Ca ²⁺ , Ba ²⁺ , Co ²⁺ , Cu ²⁺ , Al ³⁺ , Fe ³⁺ , Ni ²⁺ , Cl ⁻ , Ca ²⁺ , and NO ₃ ⁻ was observed in the determination of a 25 μ g L ⁻¹ mixture of the analytes. The modified electrode was successfully employed in the determination of Hg ²⁺ , Zn ²⁺ , and Pb ²⁺ in tap water samples.	103
Pb(II) and Cd(II)	Bi-film coated gold ultramicroelectrode array	$\begin{array}{c} 0.001 \ M \\ ABS \\ (pH = 4.0) \\ containing \\ 900 \ \mu g \ L^{-1} \\ Bi^{3+} \end{array}$	SWASV	^a Pb ²⁺ : 5 μg L ⁻¹ ; Cd ²⁺ : 7 μg L ⁻¹	$\begin{array}{c} {}^{Pb^{2+}:}\\ 10{-}80\ \mu g\ L^{-1};\\ Cd^{2+}:\\ 20{-}100\ \mu g\ L^{-1} \end{array}$	NR	NR	Significant interference of 10 times the concentration of Ni ²⁺ , Cu ²⁺ , NaCl and benzene, was observed in the simultaneous determination of 30 μ g L ⁻¹ Pb ²⁺ and 50 μ g L ⁻¹ Cd ²⁺ in 0.05 M ABS containing 1 mg L ⁻¹ Bi ³⁺ .	
Pb(II)	Poly(1,5- diaminonaphthalene)-film modified SPE	0.1 M ABS (pH = 4.5)	SWASV	0.30 μg L ⁻¹	0.5–5.0 μg L ⁻¹	At 4.5 μg L ⁻¹ : 3.1%	94.5–101.2%	No significant interference of 100 times the concentration of Zn^{2+} , Mn^{2+} , Fe^{2+} , and AI^{3+} , as well as of 4 times the concentration of Cu^{2+} was observed in the determination of 5.0 µg L^{-1} of the analyte. Concentrations of Hg ²⁺ higher than 8 µg L^{-1} influenced the determination of Pb ²⁺ under the same conditions. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap water samples.	
Hg(II)	Electrochemically co-deposited Au-nanofilm modified SPCE	50 mM PBS and 50 mM ABS (pH = 3.5)	SWASV	$\begin{array}{c} 0.29 \ \mu g \ L^{-1}; \\ 0.16 \ \mu g \ L^{-1} \\ after \\ preemptively \\ adding \ 600 \\ mg L^{-1} \\ chloride \end{array}$	$1 - 40 \ \mu g \ L^{-1}$	At 5 µg L ⁻¹ : 3.9%	90.3–95.2%	No significant interference of 2–500 mg L^{-1} of $C_{76}H_{52}O_{46}$ (tannic acid), NaHCO ₃ , FeCl ₃ , MgCl ₂ , Ca(NO ₃) ₂ , and Na ₂ SO ₄ was observed in the determination of 5 µg L^{-1} Hg ²⁺ . The modified electrode was successfully employed in the determination of Hg ²⁺ in river and ground water samples.	
Pb(II), Cd(II), and Zn(II)	<i>Ex situ</i> Bi-film modified SPAuE	0.1 M ABS (pH = 5.5)	SWASV	$\label{eq:constraint} \begin{array}{c} {}^{a}Cd^{2+} : \\ 0.02\ \mu g\ L^{-1} ; \\ Pb^{2+} : \\ 0.04\ \mu g\ L^{-1} ; \\ Zn^{2+} : \\ 0.05\ \mu g\ L^{-1} \end{array}$	1–120 μg L ⁻¹ for all analytes	$\begin{array}{c} At \ 10 \ \mu g \ L^{-1} \\ Pb^{2+}, \ 20 \ \mu g \ L^{-1} \\ Cd^{2+} \ and \ 40 \ \mu g \\ L^{-1} \ Zn^{2+}: \ 1.38\% \\ for \ Pb^{2+}; \\ 2.42\% \ for \ Cd^{2+}; \\ 1.63\% \ for \ Zn^{2+} \end{array}$	NR	No significant interference of 200 times the concentration of Cr^{6+} , Mn^{2+} , Ag^+ , Fe^{3+} , Co^{2+} , Ni^{2+} , and Cu^{2+} was observed in the simultaneous determination of 20 µg L ⁻¹ of the analytes. Significant interference of 20 times the concentration of Hg ²⁺ was observed in the simultaneous determination of 20 µg L ⁻¹ of the analytes.	107 1 1 5 5
Al(III)	<i>In situ</i> Pb-film and cupferron modified GCE	0.1 M ammonia buffer (pH = 8.15)	SWASV	3.3 · 10 ⁻¹¹ M	$1 \cdot 10^{-10} - 2 \cdot 10^{-7} \mathrm{M}$	$\begin{array}{c} At \ 5 \cdot 10^{-8} \ M \\ Al^{3+}, \ 3 \cdot 10^{-4} \ M \\ cupferron, \ and \ 6 \\ \cdot \ 10^{-5} \ M \ Pb^{2+} \end{array}$	NR	No significant interference of up to $5 \cdot 10^{-6}$ M of Cu ²⁺ , Mg ²⁺ , Fe ³⁺ , Si ⁴⁺ , Mn ²⁺ , Cr ³⁺ , Cr ⁶⁺ and Ti ⁴⁺ was observed in the determination of $5 \cdot 10^{-8}$ M Al ³⁺ . The	108

						3.6%		modified electrode was successfully employed in the determination of Al ³⁺	
								created by the corrosion of AA2024 aluminum alloy in NaCl solutions.	
Cd(II) and Pb(II)	Nafion-film doped with Ag- Hg nanoalloys modified GCE	0.1 M ABS (pH = 4.5)	DPASV	$\begin{array}{c} Cd^{2+}:\\ 0.09\ \mu g\ L^{-1};\\ Pb^{2+}:\\ 0.19\ \mu g\ L^{-1} \end{array}$	10–120 μg L ⁻¹ for both analytes	NR	Cd ²⁺ : 102.52%; Pb ²⁺ : 105.03%	No significant interference of 4 times the concentration of Co^{2+} , Cr^{3+} , Cr^{6+} , Fe^{2+} and Ni^{2+} was observed in the determination of 50 µgL ⁻¹ of the analytes. Significant interference of 4 times the concentration of Fe ³⁺ and Cu ²⁺ was observed in the determination of 50 µgL ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd ²⁺ and Pb ²⁺ in marine sediment samples.	109
Cd(II) and Pb(II)	Nafion-film doped with Ag- Bi nanoalloys modified GCE	0.1 M ABS (pH = 4.5)	DPASV	$\begin{array}{c} Cd^{2+}:\\ 0.60\ \mu g\ L^{-1};\\ Pb^{2+}:\\ 0.36\ \mu g\ L^{-1} \end{array}$	10–120 µg L ⁻¹ for both analytes	NR	Cd ²⁺ : 96.32%; Pb ²⁺ : 100.74%	No significant interference of 4 times the concentration of Co^{2+} , Cr^{3+} , Cr^{6+} , Fe^{2+} and Ni^{2+} was observed in the determination of 50 µgL ⁻¹ of the analytes. Significant interference of 4 times the concentration of Fe ³⁺ and Cu ²⁺ was observed in the determination of 50 µgL ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd ²⁺ and Pb ²⁺ in marine sediment samples.	109
Hg(II)	Electropolymerized (Co(II) tetraamide benzimidazole phthalocyanine)-film modified GCE	0.1 M PBS (pH = 7.0)	DPV	3.8 nM	10–500 nM	At 60 nM: 2.9%	100.6–104.3%	No significant interference of 5000 times the concentration of Pb^{2+} , Cd^{2+} , Zn^{2+} , and K^+ was observed in the determination of 10 nM Hg ²⁺ . The modified electrode was successfully employed in the determination of Hg ²⁺ tap, drinking and river water samples, as well as in industrial effluent water and fish samples.	110
Cd(II), Pb(II), and Cu(II)	In situ electrodeposited Hg- on-rGO film modified GCE	0.01 M HNO ₃ and 0.02 M KNO ₃	DPASV	$\label{eq:constraint} \begin{array}{c} ^{a}Cd^{2+} \\ 0.17 \ \mu g \ L^{-1} \\ Pb^{2+} \\ 0.18 \ \mu g \ L^{-1} \\ Cu^{2+} \\ 0.69 \ \mu g \ L^{-1} \end{array}$	2–50 μg L ⁻¹ for Cd ²⁺ and Cu ²⁺ ; 5–100 μg L ⁻¹ for Pb ²⁺	NR	NR	No significant interference of $100 \ \mu g L^{-1}$ of Fe ³⁺ , As ²⁺ , Cr ³⁺ , Zn ²⁺ and Co ²⁺ was observed in the simultaneous determination of 15 $\mu g L^{-1}$ of each Cd ²⁺ and Cu ²⁺ and 30 $\mu g L^{-1}$ of Pb ²⁺ .	111
Pb(II) and Cd(II)	<i>In situ</i> Bi-film and Nafion modified SPAuE	0.1 M ABS (pH = 5.0)	SWASV	Pb ²⁺ : 3 ppb; Cd ²⁺ : 4 ppb	Pb ²⁺ : 20–300 ppb; Cd ²⁺ : 50–300 ppb	At 300 µg L ⁻¹ of the analytes: 5.33% for Pb ²⁺ ; 4.50% for Cd ²⁺	Cd ²⁺ : 98–103%; Pb ²⁺ : 86.6–90%	Significant interference of Fe ³⁺ and Ni ²⁺ was observed in the simultaneous determination of 10 or 100 μ g L ⁻¹ of each analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in tap and river water samples.	112
Cu(II)	Poly(4-vinyl pyridine)- wrapped MWCNTs anchored to a poly(ethylene terephthalate)-film modified Au electrode	0.1 M Na ₂ SO ₄	CV	0.5 ppm	1.1–13.8 ppm	At 1.3 ppm: 7.56%	94.0-103.2%	No significant interference of the same concentration of Pb^{2+} , Fe^{3+} and Ca^{2+} was observed in the determination of 50 ppm of the analyte. The modified electrode was successfully employed in the	113

								determination of Cu ²⁺ in tap, creek, ocean, and deionized water samples.	
Pb(II) and Cd(II)	Poly(8-aminonaphthalene- 2-sulphonic acid)/Bi-film modified GCE	0.1 M ABS (pH = 4.6)	SWASV	${}^{a}Cd^{2+}$: 0.08 µg L ⁻¹ ; Pb ²⁺ : 0.38 µg L ⁻¹	1.0–40.0 μg L ⁻¹ for both analytes	At 30 µg L ⁻¹ of the analytes: 2.3% for Cd ²⁺ ; 1.2% for Pb ²⁺	Cd ²⁺ : 90.9–106.3%; Pb ²⁺ : 92.0–102.1%	No significant interference of 3 times the concentration of As^{3+} , Cr^{3+} , Al^{3+} , Cu^{2+} , Zn^{2+} , Fe^{2+} , and K^+ was observed in the determination of 30 µg L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in industrial wastewater samples.	114
Pb(II) and Cd(II)	<i>In-situ</i> Bi-film modified GCE in the presence of 40.0 μM Alizarin Red S	0.03 M CH ₃ COOH containing 0.75 mgL ⁻¹ Bi ³⁺	DPASV	^а Рb ²⁺ : 0.16 µg L ⁻¹ ; Cd ²⁺ : 0.09 µg L ⁻¹	0.48–0.27 μg L ⁻¹	At 4.5 μg L ⁻¹ of the analytes: 8.2% for Pb ²⁺ ; 8.6% for Cd ²⁺	NR	Interference of 5 times the concentration of Al ³⁺ , Se ⁴⁺ , Hg ²⁺ , Ni ²⁺ , and W ⁶⁺ was observed for Pb ²⁺ , while interference of 5 times the concentration of Al ³⁺ , Co ²⁺ , Tl ⁺ , Hg ²⁺ , Ni ²⁺ , Sc ³⁺ , Se ⁴⁺ , Cu ²⁺ , Sn ⁴⁺ , Zr ⁴⁺ , Ti ⁴⁺ , Mo ⁶⁺ , W ⁶⁺ and Pb ²⁺ , was observed for Cd ²⁺ , in 5.0 µg L ⁻¹ of Pb ²⁺ and Cd ²⁺ solution. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in creek, river and tap water samples.	115
Cd(II), Pb(II), and In(III)	Bi-film modified paper-based electrode	$\begin{array}{c} 0.1 \text{ M ABS} \\ (\text{pH} = 4.5) \\ \text{and} \ 0.5 \text{ M} \\ \text{Na}_2 \text{SO}_4 \end{array}$	LSV	Cd ²⁺ : 1.0 µg mL ⁻¹ ; Pb ²⁺ : 0.7 µg mL ⁻¹ ; In ³⁺ : 0.6 µg mL ⁻¹	Cd ²⁺ : 2.5–10 μg mL ⁻¹ ; Pb ²⁺ : 1–10 μg mL ⁻¹ ; In ³⁺ : 1–4 μg mL ⁻¹	At 25 μg mL ⁻¹ of the analytes: 4.3% for Cd ²⁺ ; 14.6% for Pb ²⁺ ; 9.6% for In ³⁺	Cd ²⁺ : 99.2%; Pb ²⁺ : 98.8%	The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in sewage water samples.	116
Cd(II), Pb(II) In(III), and Cu(II)	Hg-film modified paper-based electrode	$\begin{array}{c} 0.1 \ M \ ABS \\ (pH = 4.5) \\ and \ 0.5 \ M \\ Na_2 SO_4 \end{array}$	LSV	$\begin{array}{c} Cd^{2+};\\ 0.4\ \mu g\ mL^{-1};\\ Pb^{2+};\\ 0.1\ \mu g\ mL^{-1};\\ In^{3+};\\ 0.04\ \mu g\ mL^{-1};\\ Cu^{2+};\\ 0.2\ \mu g\ mL^{-1}\end{array}$	$\begin{array}{c} Cd^{2+};\\ 0.5-10\ \mu g\ mL^{-1};\\ Pb^{2+};\\ 0.5-10\ \mu g\ mL^{-1};\\ In^{3+};\\ 0.1-5\ \mu g\ mL^{-1};\\ Cu^{2+};\\ 0.25-6.35\ \mu g\ mL^{-1}\end{array}$	At 10 μg mL ⁻¹ of the analytes: 6.4% for Cd ²⁺ ; 10.9% for Pb ²⁺ ; 9.1% for In ³⁺ ; 4.3% for Cu ²⁺	Cd ²⁺ : 86.3%; Pb ²⁺ : 89.2%	The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in sewage water samples.	116
Pb(II), Cd(II), and Zn(II)	In situ (Bi-Cu)-film modified GCE 0.5 mgL ⁻¹ total concentration of Bi ³⁺ and Cu ²⁺ ; Bi ³⁺ :Cu ²⁺ ratio of 8:2	0.1 M ABS (pH = 4.5)	SWASV	^a Cd ²⁺ : 19.5 μg L ⁻¹ ; Pb ²⁺ : 2.8 μg L ⁻¹ ; Zn ²⁺ : 38.2 μg L ⁻¹	Pb ²⁺ : 47.5–632.4 μg L ⁻¹	At 321 μg L ⁻¹ of each analyte: 9.3% for Zn ²⁺ ; 4.6% for Cd ²⁺ ; 16.9% for Pb ²⁺	Zn ²⁺ : 53.2%; Cd ²⁺ : 111.3%; Pb ²⁺ : 98.7%	Significant interference of Fe^{2+} was observed in the determination of Zn^{2+} when increasing the analyte to interferent ratio from 1:1 to 1:100. Significant interference of Sn^{2+} was observed in the determination of Cd^{2+} and Pb^{2+} for 1:10 and 1:100 ratios. The modified electrode was successfully employed in the determination of Pb^{2+} and Cd^{2+} in tap and river water samples.	117
Pb(II), Cd(II), and Zn(II)	<i>In situ</i> (Bi-Cu)-film modified GCE 1.0 mgL ⁻¹ total concentration of Bi ³⁺ and Cu ²⁺ ; Bi ³⁺ :Cu ²⁺ ratio of 2:8	0.1 M ABS (pH = 4.5)	SWASV	$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	NR	At 692.4 μ g L ⁻¹ of each analyte: 11.0% for Zn ²⁺ ; 7.2% for Cd ²⁺ ; 10.0% for Pb ²⁺	$\begin{array}{c} Zn^{2+}:\\ 54.7\%;\\ Cd^{2+}:\\ 51.3\%;\\ Pb^{2+}:\\ 65.6\%\end{array}$	No significant interference of Na ⁺ , K ⁺ , Mg ²⁺ , and NO ₃ ⁻ was observed in the determination of Zn^{2+} for 1:1 and 1:10 ratios between the analyte and the interferents but became significant for 1:100 ratio. Significant interference of	117

								Fe^{2+} , As^{3+} , Ca^{2+} , Mg^{2+} , Sn^{2+} , and Sb^{3+} was observed in the determination of Zn^{2+} when increasing the ratio from 1:1 to 1:100. Significant interference of Sn^{2+} was observed in the determination of Cd^{2+} and Pb^{2+} for 1:100 ratios. The modified electrode was successfully employed in the determination of Pb^{2+} and Cd^{2+} in tap and river water samples.	
Cu(II)	Electrosynthesised ion imprinted p-phenylenediamine and Cu ²⁺ as template modified SPPtE	50 mM ABS (pH = 5.2)	DPV	2.7 nM	0.95–244 nM	At 15 nM: 7.75%	95.2–105.5%	No significant interference of the same concentration of Ni ²⁺ , Ag ⁺ , Mn ²⁺ , Zn ²⁺ , Hg ²⁺ , Cd ²⁺ , Co ²⁺ , Pb ²⁺ , was observed in the determination of 30.5 nM of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ in drinking water samples.	118
Hg(II)	Monolayer-scale ultrathin pyridine-film and pyridine- Au nanocomposite modified GCE	0.1 M HCl	DPASV	12 ppt	0–10 ppb	At 10 ppb: 4.5%	98.0–104%	No significant interference of 10 times the concentration of Fe ³⁺ , Co ²⁺ , Ni ²⁺ , Cu ²⁺ , Zn ²⁺ , Pb ²⁺ , and Cd ²⁺ was observed in the determination of 10 ppb of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in spring and river water samples.	119
Zn(II)	<i>In situ</i> Bi-film, graphene oxide modified GCE	0.1 M ABS (pH = 5.0)	ASV	6 μg L ⁻¹	0.020–8.00 mg L ⁻¹	At 0.20–1.00 mg L ⁻¹ : 1.70–8.70%	96.1–102.6%	The modified electrode was successfully employed in the determination of Zn^{2+} in human seminal fluid on different materials (filter paper, toilet paper and white cotton) samples.	120
Mo(VI)	(Poly eriochrome black T)- film modified PGE	0.07 M PBS (pH = 6.75)	DPV	2.60 µg L ⁻¹	8.66–100 μg L ⁻¹	NR	99.3–103.8%	The modified electrode was successfully employed in the determination of Mo ⁶⁺ in food supplements and tap and drinking water samples.	121
Mo(VI)	(Poly xylenol orange)-film modified PGE	0.07 M PBS (pH = 6.75)	DPV	3.50 µg L ⁻¹	11.68–100 µg L ⁻¹	NR	98.7–102.3%	The modified electrode was successfully employed in the determination of Mo ⁶⁺ in food supplements and tap and drinking water samples.	121
Mo(VI)	(Poly methyl red)-film modified PGE	0.07 M PBS (pH = 6.75)	DPV	1.56 μg L ⁻¹	5.20–100 µg L ^{–1}	NR	98.6–102.1%	No significant interference of 30 times the concentration of SO ₄ ²⁻ , 20 times the concentration of Pb ²⁺ , 15 times the concentration of Na ⁺ , 10 times the concentration of K ⁺ , Cl ⁻ , NO ₃ ⁻ , Cr ³⁺ , 8 times the concentration of Ca ²⁺ , Mg ²⁺ , Sb ³⁺ , 4 times the concentration of Ca ²⁺ , Mg ²⁺ , Sb ³⁺ , 4 times the concentration of Cu ²⁺ and Se ⁴⁺ was observed in the determination of 200 µg L ⁻¹ of the analyte. No significant interference of 5 times the concentration of Fe ³⁺ , Co ²⁺ , 3 times the concentration of Zn ²⁺ , 4 times the concentration of Pa ²⁺ , No significant interference of 5 times the concentration of Pa ³⁺ , Co ²⁺ , 3 times the concentration of Zn ²⁺ , the concentration the concentration the concentration the concentration the concentration the concentration	121

								Al ³⁺ , and 2 times the concentration of As ³⁺ was observed in the presence of 0.01 M EDTA, in the determination of 200 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Mo ⁶⁺ in food supplements and tap and drinking water samples.	
Ni(II)	<i>In situ</i> Cu-film modified GCE	0.01 M ammonia buffer (pH = 9.2) in presence of dissolved O ₂	ASV	0.2 μg L ⁻¹	1–10 μg L ^{–1}	NR	102%	No significant interference of 10 and 50 times the concentration of Zn^{2+} , Pb^{2+} , Co^{2+} , and Fe^{3+} was observed in the determination of 10 µg L ⁻¹ Ni ²⁺ . Significant interference of 50 times the concentration of Cd ²⁺ , and 500 and 5000 times the concentration of SDS, CTAB and Triton X-100 surfactants was observed in the determination of 10 µg L ⁻¹ Ni ²⁺ . The modified electrode was successfully employed in the determination of Ni ²⁺ in seawater samples.	122
Pb(II), Cd(II), and Zn(II)	Bimetallic (Hg-Bi)-film incorporated with poly(1,2- diaminoanthraquinone) modified GCE	0.1 M ABS (pH = 5.3)	ASV	$\begin{tabular}{l}{}^{a}Cd^{2+}{:}\\ 0.107\ \mu g\ L^{-1}{:}\\ Pb^{2+}{:}\\ 0.105\ \mu g\ L^{-1}{:}\\ Zn^{2+}{:}\\ 0.037\ \mu g\ L^{-1} \end{tabular}$	0.0–50.0 μg L ⁻¹ for all analytes	At 50 μg L ⁻¹ of the analytes: 1.87% for Cd ²⁺ ; 4.97% for Pb ²⁺ ; 4.74% for Zn ²⁺	Zn^{2+} : 97–99%; Cd^{2+} : 88–103%; Pb^{2+} : 93–102%	No significant interference of 1.0 mg L ⁻¹ of Na ⁺ , Ca ²⁺ , Mg ²⁺ , and Al ³⁺ was observed in the simultaneous determination of 50 μ g L ⁻¹ of the analytes. Significant interference of Ag ⁺ , Mn ²⁺ , Ni ²⁺ , Cu ²⁺ , Fe ²⁺ , and Cr ⁶⁺ . This interference is reduced by the addition of 0.10 mM ferrocyanide. The modified electrode was successfully employed in the determination of Cd ²⁺ , Pb ²⁺ and Zn ²⁺ in tap water samples.	123
Cd(II) and Pb(II)	Monolayer-scale pyridine-2-sulfonic acid film modified GCE	0.1 M ABS (pH = 4.5) and 0.2 ppm Bi ³⁺	SWASV	Cd²+: 0.004 ppb; Pb²+: 0.007 ppb	Cd ²⁺ : 0–20 ppb; Pb ²⁺ : 0–30 ppb	At 20 ppb of each analyte: 1.0% for Cd ²⁺ ; 2.3% for Pb ²⁺	Cd ²⁺ : 96.5–97.0%; Pb ²⁺ : 102–103%	No significant interference of 20 ppm of Ca^{2+} and Mg^{2+} , 1.0 ppm of Zn^{2+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Mn^{2+} , SDS, and humic acid, 1.0 mM of Cl^- , Br^- , SO_4^{2-} , PO_4^{3-} , K^+ , and NH_4^+ was observed in the determination of 20 ppb of the analytes. Significant interference of 0.1 ppm Cu^{2+} and Ni^{2+} as well as 1.0 ppm Co^{2+} was observed in the determination of 20 ppb of the analytes. Significant interference of 20 ppb of the analytes. Simultaneous additions of $K_4Fe(CN)_6$ and Ga^{3+} are effective to eliminate the interferences of Cu^{2+} and Ni^{2+} . The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in spring and river water samples.	
Cd(II) and Pb(II)	Monolayer-scale pyridine- 2-carboxylic acid film modified GCE	$\begin{array}{c} 0.1 \text{ M ABS} \\ (pH = 4.5) \\ and \ 0.2 \text{ ppm} \\ \text{Bi}^{3+} \end{array}$	SWASV	Cd ²⁺ : 0.007 ppb; Pb ²⁺ : 0.011 ppb	0–35 ppb for both analytes	NR	NR		124

Zn(II),	In situ (Bi-Sn-Sb)-film	0.1 M ABS	SWASV	^a Cd ²⁺ :	Cd ²⁺ :	At 1357.7 μg L ⁻¹	NR	Significant interference of the same	125
Cd(II),	modified GCE; 1.00 mgL^{-1}			0.5 μg L ⁻¹ ;	4.0–19.8 μ g L ⁻¹ and	of each analyte:		concentration of Cu2+ and Fe2+ was	Ś
and Pb(II)	${\rm Bi}^{3+}$, 0.60 mgL ⁻¹ Sn ²⁺ , and			Pb ²⁺ :	39.3–225.6 μg L ⁻¹ ;	9.5% for Cd ²⁺ ;		observed in the determination of 1357.7	1
	$0.34 \text{ mgL}^{-1} \text{ Sb}^{3+}$			1.2 μg L ⁻¹ ;	Pb ²⁺ :	8.7% for Pb ²⁺ ;		$\mu g L^{-1}$ of each analyte.	
	_			Zn^{2+} :	19.8–386.8 µg L ⁻¹ ;	36.1% for Zn ²⁺			
				3.0 µg L ⁻¹	Zn^{2+} :				
					135.7–225.6 µg L ⁻¹				
Pb(II) and	rGO, L-cysteine, Bi-film	0.1 M ABS	DPV	Pb ²⁺ :	1.0-30.0 µg L ⁻¹ for	NR	Pb ²⁺ :	No significant interference of 10 times	\$ 126
Cd(II)	modified disposable SPE	(pH = 4.5)		0.08 µg L ⁻¹ ;	both analytes		95.71-106.64%	the concentration of Na ⁺ , K ⁺ , Cl ⁻ , NO ₃ ⁻	,
				Cd ²⁺ :			Cd ²⁺ :	Cu^{2+} , Zn^{2+} , Mg^{2+} , Fe^{3+} , and Al^{3+} was	\$
				$0.10 \ \mu g \ L^{-1}$			96.32-104.93%	observed in the determination of 25 μ g L ⁻¹	t j
								of the analytes. The modified electrode	•
								was successfully employed in the	•
								determination of Cd^{2+} and Pb^{2+} in	1
-								decorative materials samples.	
Pb(II) and	(Graphene/Bi	0.1 M ABS	SWASV	^a Pb ²⁺ :	$5-100 \ \mu g \ L^{-1}$ for both	At 100 µg L-1 of	NR	No significant interference of 2 times the	; 127
Cd(II)	nanocomposite)-film	(pH = 4.5)		0.12 μ g L ⁻¹ ;	analytes	the analytes:		concentration of Zn ²⁺ , Mn ²⁺ , Fe ²⁺ , BO ₃ ⁻	,
	modified PGE			Cd ²⁺ :		1.86% for Pb ²⁺ ;		and Ni ²⁺ , 100 times the interference of K ⁺ ,	,
	$(450 \ \mu g \ L^{-1} \ Bi^{3+})$			0.29 μg L ⁻¹		3.93% for Cd ²⁺		Na^+ , Mg^{2+} , Ca^{2+} , NH_4^+ was observed in the	•
								determination of 100 μg L ⁻¹ of the	•
								analytes. Significant interference of 2	4
								times the concentration of Cu^{2+} was	5
								observed in the determination of $100 \ \mu g$	5
								L^{-1} of the analytes. The modified	1
								electrode was successfully employed in	u j
								the determination of Pb^{2} and Cd^{2} in tap	,
								water and Canadian-certified reference	*
		0.1 14 4 10 0	DDV	api 2±	C 1 ²⁺	ND	D1 2±	water samples.	128
$Pb(II)$ and $C_1(II)$	(Poly methyl thymol blue)-	0.1 M ABS	DPV	"Pb ² ":	Cd ²⁺ :	NK	Pb21:	No significant interference of 100 times	120
	film modified PIGE	(pH = 5.0)		$0.18 \ \mu g L^{-1};$	$1.05 - 75.3 \mu g L^{-1};$		98./%;	the concentration of F, SO_4^2 , CO_3^2 ,	, c
				Cd ⁻¹ :	PD ⁻¹ :		104.00	NU_3 , and 500 times the concentration of NU_4 + M_2^{2+} C_2^{2+} D_2^{2+} E_3^{3+} A_1^{3+} and	-
				0.35 µg L	0.54–77.0 μg L		104.0%	NH_4^{-1} , Mg^{-1} , Ca^{-1} , Ba^{-1} , Fe^{-1} , AI^{-1} was	5 1
								Dh^{2+} Significant interference of 2 times	
								PD . Significant interference of 2 times the concentration of Cl^{-} was observed in	·
								the determination of $\mathbf{D}\mathbf{h}^{2+}$. The modified	4
								electrode was successfully employed in	
								the determination of $\mathbf{D}\mathbf{b}^{2+}$ and $\mathbf{C}\mathbf{d}^{2+}$ in ter	
								and see water and the determination of	é
								Pb^{2+} in human hair samples	
Ph(II) and	Au ND graphana	0.12 M ABS	SWASV	aph2+.	0.5.50 pph for both	NP	NP	No significant interference of 100 times	129
Cd(II) and	kelenocysteine composite Bi	(nH - 4.8)	SWASY	0.05 pph	o.5–50 pp0 for bour	INK	INK	the concentration of Ee^{3+} Cu ²⁺ Ni ²⁺ Co ²⁺	1
Cu(II)	ultrathin film modified GCE	(p11 = 4.0)		Cd^{2+}	anarytes			Ca^{2+} Zn^{2+} and Cr^{3+} was observed in the	, ,
		1		0.08 nnh				determination of 20 nmb of the analytes	1 !
				0.00 pp0				The modified electrode was successfully	,
								employed in the determination of Ph ²⁺ and	1
								Cd^{2+} in groundwater soil and Alhage	;
								maurorum plant samples	1
Pb(II) and	In-situ Sb-film modified	0.01 M HCl	ASV	^a Pb ²⁺ :	0–120 ug L ⁻¹	At 25 μg L ⁻¹ of	Pb ²⁺ :	No significant interference of 2 times the	130
Cd(II)	polymer electrode			0.95 μg L ⁻¹ ;		the analytes:	98%;	concentration of Sn2+, Zn2+, Tl+, In3+	,

				Сd ²⁺ : 1.3 µg L ⁻¹		4.2% for Pb ²⁺ ; 4.9% for Cd ²⁺	Cd ²⁺ : 97%	Hg ²⁺ , and As ³⁺ was observed in the determination of 25 μ g L ⁻¹ Pb ²⁺ and Cd ²⁺ . Significant interference of 2 times the concentration of Cu ²⁺ was observed in the determination of 25 μ g L ⁻¹ Pb ²⁺ and Cd ²⁺ . The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in phosphorite and lake water samples.	
Pb(II), Cd(II), and Zn(II)	Bi-film and 8-hydroxyquinoline modified GCE	0.01 M HEPES (pH = 6.5)	SqW-AdSV	^a Pb ²⁺ : 0.45 ppb; Cd ²⁺ : 0.17 ppb; Zn ²⁺ : 0.78 ppb	2–110 ppb for all analytes	At 10 ppb of each analyte: 9.3% for Pb ²⁺ ; 8.8% for Cd ²⁺ ; 5.5% for Zn ²⁺	Pb ²⁺ : 94–107%; Cd ²⁺ : 96–105%; Zn ²⁺ : 92–104%	No significant interference of up to 100 times the concentration of Na ₂ SO ₄ , KHCO ₃ , CaCl ₂ , Mg(NO ₃) ₂ was observed in the simultaneous determination of Pb ²⁺ , Cd ²⁺ , and Zn ²⁺ . Significant interference of concentrations of Cu ²⁺ and Co ²⁺ higher than 10 and 15 times was observed in the determination of Pb ²⁺ , Cd ²⁺ , and Zn ²⁺ . The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ , and Zn ²⁺ in lake and river water samples.	
Hg(II)	<i>In situ</i> Cu-film modified GCE	0.1 M HCl and 0.4 M NaCl	ASV	0.3 μg L ⁻¹	5–120 μg L ^{–1}	At 45 μg L ⁻¹ : 1.8%	98%	Significant interference of 2 times the concentration of Bi^{3+} , Sb^{3+} , As^{3+} , Sn^{4+} and Pb^{2+} was observed in the determination of 30 µg L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in seawater samples.	132
Pb(II), Cd(II), and Zn(II)	<i>In situ</i> (Bi-Sn)-film modified GCE 0.5 mgL ⁻¹ total concentration of Bi ³⁺ and Sn ²⁺ ; Bi ³⁺ :Sn ²⁺ ratio of 4:6	0.1 M ABS (pH = 4.5)	SWASV	$\begin{array}{c} Pb^{2+}:\\ 1.0\ \mu g\ L^{-1};\\ Cd^{2+}:\\ 1.0\ \mu g\ L^{-1};\\ Zn^{2+}:\\ 0.7\ \mu g\ L^{-1}\end{array}$	NR	At 19.6 μg L ⁻¹ of the analytes: 7.6% for Pb ²⁺ ; 2.8% for Cd ²⁺ ; 8.1% for Zn ²⁺	Pb ²⁺ : 94.11%; Cd ²⁺ : 99.17%; Zn ²⁺ : 113.33%	Significant interference of was 100 times the concentration of Fe ²⁺ , As ³⁺ , Na ⁺ , K ⁺ , Ca ²⁺ , Mg ²⁺ , Cu ²⁺ , Sb ³⁺ , and NO ₃ ⁻ observed in the simultaneous determination of 29.1 μ g L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ , and Zn ²⁺ in tap water samples.	133
Pb(II), Cd(II)	<i>In situ</i> Sb-film modified GCE	0.01 M HCl	SWASV	$\begin{array}{c} Pb^{2+}:\\ 6.0\ \mu g\ L^{-1};\\ Cd^{2+}:\\ 3.0\ \mu g\ L^{-1} \end{array}$	$\begin{array}{c} Pb^{2+}:\\ 14.8{-}267.7\ \mu g\ L^{-1};\\ Cd^{2+}:\\ 5.0{-}224.0\ \mu g\ L^{-1} \end{array}$	At 40 μg L ⁻¹ : 9.4% for Cd ²⁺ ; 21.3% for Pb ²⁺	Pb ²⁺ : 104.5%; Cd ²⁺ : 74.4%		134
Pb(II), Cd(II), and Zn(II)	<i>In situ</i> Sb-film modified GCE	0.1 ABS (pH = 4.5)	SWASV	$\begin{array}{c} {Pb}^{2+}:\\ 4.0\ \mu g\ L^{-1};\\ Cd^{2+}:\\ 7.0\ \mu g\ L^{-1};\\ Zn^{2+}:\\ 1.5\ \mu g\ L^{-1}\end{array}$	$\begin{array}{c} {\rm Pb}^{2+};\\ 7.0{-}1066.7\ \mu {\rm g}\ {\rm L}^{-1};\\ {\rm Cd}^{2+};\\ 7.9{-}254.5\ \mu {\rm g}\ {\rm L}^{-1};\\ {\rm Zn}^{2+};\\ 2.5{-}97.0\ \mu {\rm g}\ {\rm L}^{-1}\end{array}$	At 15 μg L ⁻¹ : 11.4% for Pb ²⁺ ; 8.0% for Cd ²⁺ ; 8.8% for Zn ²⁺	$\begin{array}{c} {\rm Pb}^{2+}{\rm :}\\ {\rm 60.9\%}{\rm ;}\\ {\rm Cd}^{2+}{\rm :}\\ {\rm 74.4\%}{\rm ;}\\ {\rm Zn}^{2+}{\rm :}\\ {\rm 60.9\%} \end{array}$		134
Hg(II)	Amino-functionalized	HCl (pH = 2.0)	DPASV	0.043 pM	1–4 pM	At 2.4 μg L ⁻¹ : 3.4%	95.28%	No significant interference of up to 1000 times the concentration Na ⁺ , K ⁺ , Cl ⁻ , SO_4^{2-} , NH ₄ ⁺ , and NO ₃ ⁻ was observed in	135

	attapulgite (Mg-Al phyllosilicate) organoclay- thin film modified GCE							the determination of 4 pM of the analyte. Significant interference of $1-200$ times the concentration Cu ²⁺ , Zn ²⁺ , and Cd ²⁺ was observed in the determination of 4 pM of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in tap water samples.	
Hg(II)	Amino-functionalized attapulgite (Mg-Al phyllosilicate) organoclay- thin film modified GCE	HCl (pH = 2.0)	DPASV	0.091 nM in presence of Cd ²⁺ and Pb ²⁺	0.25–1.5 nM in presence of Cd ²⁺ and Pb ²⁺	At 2.4 μ g L ⁻¹ Hg ²⁺ and 0.1 μ M Cd ²⁺ , Pb ²⁺ and Hg ²⁺ : 4.12%	NR		135
Cu(II)	Dopamine-film modified carbon ceramic electrode	0.1 M ABS (pH = 5.0)	ASV	0.03 μg L ⁻¹	0.1–250 μg L ⁻¹	NR	99.51–99.80%	No significant interference of up to 500 times the concentration of Ca^{2+} , Mg^{2+} , Hg^{2+} , Fe^{2+} , Pb^{2+} , Sn^{2+} , Na^+ , K^+ , and Cd^{2+} , as well as of 100 times the concentration of Ni^{2+} , Zn^{2+} , Bi^{3+} , and Mn^{2+} , and of 10 times the concentration of Co^{2+} was observed in the determination of 50 µgL ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Cu^{2+} in human hair and tap and well water samples.	136
Pb(II), Cd(II), and Cu(II)	Ag-NPs deposited on poly(1,8- diaminonaphthalene)-film modified GCE	0.1 M ABS (pH = 4.6)	ASV	^a Cu ²⁺ : 0.09 μM; Pb ²⁺ : 0.15 μM; Cd ²⁺ : 0.17 μM	Cu ²⁺ : 0.07 nM-12.0 μM; Pb ²⁺ : 0.13 nM-12.0 μM; Cd ²⁺ : 0.15 nM-0.17 μM	NR	$\begin{array}{c} {\rm Cu}^{2+};\\ 108.0\%;\\ {\rm Pb}^{2+};\\ 105.0\%;\\ {\rm Cd}^{2+};\\ 103.3\%\end{array}$	No significant interference of 2.0 μ M Zn ²⁺ and 0.5 μ M Hg ²⁺ was observed in the simultaneous determination of 0.5 μ M Cd ²⁺ , and 2.0 μ M of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ , Pb ²⁺ , and Cd ²⁺ in tap water samples.	137
Cu(II), Cd(II), and Hg(II)	Poly(L-glutamic acid)/graphene oxide film modified GCE	0.1 M PBS (pH = 6.5)	DPASV	$\label{eq:cu2} \begin{tabular}{l} $^aCu^{2+}$:\\ 0.024 \ \mu M;\\ Cd^{2+}$:\\ 0.015 \ \mu M;\\ Hg^{2+}$:\\ 0.032 \ \mu M \end{tabular}$	0.25–5.5 μM for all analytes	At 2.0 μM of the analytes: 3.23% for Cu ²⁺ ; 6.85% for Cd ²⁺ ; 3.14% for Hg ²⁺	Cu ²⁺ : 100.2%; Cd ²⁺ : 100.4%; Hg ²⁺ : 99.8%	Slight interference of 10 μ M of K ⁺ , Ca ²⁺ , Zn ²⁺ , Fe ³⁺ , and Co ²⁺ was observed in the simultaneous determination of 2.0 μ M of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ , Hg ²⁺ , and Cd ²⁺ river water samples.	138
Cd(II)	Porous PPy, GO-functionalized with carboxyl composite film modified Au electrode	0.1 M PBS (pH = 4.5)	DPSV	$0.05 \ \mu g \ L^{-1}$	1–100 μg L ^{–1}	NR	63–116%	No significant interference of 1 mg L ⁻¹ of Zn^{2+} , Pb ²⁺ , Cu ²⁺ , Cl ⁻ , K ⁺ , CO ₃ ²⁻ , NO ₃ , SO ₄ ²⁻ , and Mg ²⁺ was observed in the determination of 100 µg L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Cd ²⁺ in tap, pond, and river water samples.	139
Pb(II) and Cd(II)	Single-walled carbon nanohorns Bi-film modified SPE	0.1 M ABS (pH = 4.5)	SWASV	$\begin{array}{c} {}^{a}Pb^{2+};\\ 0.4\ \mu g\ L^{-1};\\ Cd^{2+};\\ 0.2\ \mu g\ L^{-1} \end{array}$	1.0–60.0 μg L ⁻¹ for both analytes	At 30 μg L ⁻¹ of the analytes: 4.6% for Cd ²⁺ ; 3.6% for Pb ²⁺	Pb ²⁺ : 81.5–124.1%; Cd ²⁺ : 83.2–93.6%	Significant interference of $5-15 \text{ mg L}^{-1}$ of SDS, CTAB and Triton X-100 was observed in the simultaneous determination of the analytes. No significant interference of 4.5 and 150 mg L ⁻¹ of Ca ²⁺ , Ni ²⁺ , Na ⁺ , Zn ²⁺ , and Mg ²⁺ was	140

								observed in the simultaneous determination of 30 μ g L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in honey and milk water samples.	
Pb(II) and Cd(II)	rGO, MWCNTs, Au-NPs nanocomposite Bi-film modified SPE	0.1 M ABS (pH = 4.5)	SWASV	[*] Pb ²⁺ : 0.3 μg L ⁻¹ ; Cd ²⁺ : 0.7 μg L	1.0–80.0 μg L ⁻¹ for both analytes	NR	Pb ²⁺ : 97.95–105.08%; Cd ²⁺ : 91.98–105.36%	No significant interference of 10 times the concentration of K ⁺ , Cl ⁻ , Na ⁺ , CH ₃ COO ⁻ , Mg ²⁺ , Ca ²⁺ , Co ²⁺ , NO ₃ ⁻ , SO ₄ ²⁻ , and Ni ²⁺ was observed in the simultaneous determination of 10 µg L ⁻¹ of each analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in soil samples.	141
T1(I)	<i>In situ</i> Bi-film modified SPE	$\begin{array}{c} 0.053 \ \text{M} \\ \text{CH}_3\text{COONH} \\ _4, 0.047 \ \text{M} \\ \text{CH}_3\text{COOH} \\ \text{and} \\ 0.047 \ \text{M} \\ \text{NH}_4\text{Cl} \\ (\text{pH}=4.6) \end{array}$	SWASV	8.47 · 10 ⁻¹⁰ M	5 · 10 ⁻⁹ -1 · 10 ⁻⁶ M	At 1 · 10 ⁻⁷ M: 2.45%	NR	No significant interference of $5 \cdot 10^{-7}$ M Cu ²⁺ , Sb ³⁺ , Mo ⁶⁺ , V ⁵⁺ , and Sn ⁴⁺ , $1 \cdot 10^{-6}$ M Zn ²⁺ , Ni ²⁺ , and Se ⁴⁺ , $2 \cdot 10^{-7}$ M Mn ²⁺ and $5 \cdot 10^{-6}$ M Fe ³⁺ was observed in the determination of $1 \cdot 10^{-7}$ M Tl ⁺ . The significant interference of Pb ²⁺ and Cd ²⁺ can be avoided by adding $1 \cdot 10^{-5}$ M EDTA and $1 \cdot 10^{-5}$ M Bi ³⁺ . Significant interference of 0–50 mg L ⁻¹ CTAB, SDS and Triton X-100 surfactants was observed in the determination of Tl ⁺ . The modified electrode was successfully employed in the determination of Tl ⁺ in certified reference materials (surface and rainwater) samples.	142
Pb(II)	<i>In situ</i> Sb-film modified SPE	0.01 M HCl	SWASV	1.5 µg L ⁻¹	24.0–319.1 μg L ⁻¹	At 169.1 µg L ⁻¹ : 8.1%	97.0%	No significant interference of up to 100 times the concentration of Zn^{2+} , Fe^{2+} , Na^+ , As^{3+} , K^+ , Ca^{2+} , Mg^{2+} , and NO_3^- was observed in the determination of 200 µg L^{-1} of the analyte. Significant interference of 100 times the concentration of Cd^{2+} Bi^{3+} , Cu^{2+} , Sn^{2+} , and Hg^{2+} was observed in the determination of 200 µg L^{-1} of the analyte. The modified electrode was successfully employed in the determination of Pb^{2+} in river water samples.	143
Cu(II)	Bi-film modified GCE	3-[(2- mercapto- vinyl)- hydrazono]- 1,3- dihydro- indol-2-one (pH = 9-10)	SWASV	9.6 · 10 ⁻¹⁰ M	3.22 · 10 ⁻⁹ −2.0 · 10 ⁻⁷ M	At 1.0 · 10 ⁻⁷ M: 3.2%	99.0–111%	No significant interference of 1.0 mg mL ⁻¹ of Na ⁺ , Mn ²⁺ , Fe ³⁺ , Pb ²⁺ , and Mg ²⁺ was observed in the determination of $1.0 \cdot 10^{-7}$ ⁷ M of the analyte. The presence of 50– 100 times the concentration of Cd ²⁺ and Hg ²⁺ influenced the determination of the analyte. The modified electrode was successfully employed in the	144

								determination of Cu2+ in tap, ground, and	1
								mineral water samples.	
Pb(II),	In situ Bi-film modified	0.1 M ABS	SWASV	Pb ²⁺ :	$5.4-72.8 \ \mu g \ L^{-1}$	NR	Pb ²⁺ :		145
Cd(II),	GCE; $0.5 \text{ mgL}^{-1} \text{ Bi}^{-1}$	(pH = 4.5)		$0.7 \mu g L^{-1};$			76.7%;		
and Zn(II)				Cd^{2+} :			Cd2+:		
				$0./ \mu g L^{-1};$			116%; 7 ^{2±}		
				$2n^{-1}$:			Zn=1:		
Pb(II).	In situ Bi-film modified	0.1 M ABS	SWASV	Pb^{2+} :	5.4–72.8 µg L ⁻¹	NR	Pb ²⁺ :		145
Cd(II),	GCE; $1.0 \text{ mgL}^{-1} \text{ Bi}^{3+}$	(pH = 4.5)		$0.4 \ \mu g \ L^{-1}$;			90.8%;		
and Zn(II)		ч ,		Cd ²⁺ :			Cd ²⁺ :		
				0.3 µg L ⁻¹ ;			105.7%;		
				Zn^{2+} :			Zn^{2+} :		
				$1.1 \ \mu g \ L^{-1}$			108.3%		
Cu(II),	Oxygenous functionalized	0.1 M PBS	ASDPV	Cu ²⁺ :	Cu ²⁺ :	NR	Cu ²⁺ :	No significant interference of 50-2000) 146
Pb(II), and	carbon nitride nanosheets	(pH = 5.0)		$1.0 \cdot 10^{-13} \text{ M};$	$6.6 \cdot 10^{-12} - 8.5 \cdot 10^{-6} \text{ M};$		93.9–107.5%;	times the concentration of Cd^{2+} , Ni^{2+} , Fe^{2+}	,
Hg(II)	assembled porous films on			Pb^{2+} :	Pb^{2+} :		Pb ²⁺ :	Na^+ , K^+ , NO_3^- , SO_4^{2-} , Zn^{2+} , N	-
	MWCNT modified CFE			$1.8 \cdot 10^{-11} \text{ M};$	$8.1 \cdot 10^{-0} - 8.5 \cdot 10^{-0} M;$		97.6-102.7%;	ethylmaleimide, Bafilomycin, humic acid	,
				Hg ⁻¹ :	Hg^{-1}		Hg ⁻¹ :	uaranamil and 2 4 dinitrophonal way	,
				8.0 · 10 W	$2.2 \cdot 10 = 0.3 \cdot 10 M$		97.9-102.7%	observed in the simultaneous	
								determination of $5.1 \cdot 10^{-7}$ M of the	
								analytes The modified electrode was	
								successfully employed in the	
								determination of Cu^{2+} , Pb^{2+} , and Hg^{2+} ir	1
								immobile water samples and near the root	t
								surface of rice samples.	
Pb(II),	In-doped Bi hybrid	0.1 M ABS	SWASV	aZn^{2+} :	$0-120 \ \mu g \ L^{-1}$ for all	At 100 $\mu g \; L^{\text{1}}$ of	Zn^{2+} :	No significant interference of 200 times	s 147
Cd(II),	nanofilm modified GCE	(pH = 4.5)		$0.52 \ \mu g \ L^{-1};$	analytes	the analytes:	106–107%;	the concentration of Nd ³⁺ , Y ³⁺ , Ni ²⁺ , Ce ³⁺	,
and Zn(II)				Cd ²⁺ :		lower than 3.0%	Cd ²⁺ :	Fe^{3+} , Co^{2+} , Sb^{3+} , Cs^+ , Mg^{2+} , SO_4^{2-} , NO_3^{-1}	
				$0.15 \ \mu g \ L^{-1};$			98.7–102%;	was observed in the determination of Pb^{2}	+
				Pb ²⁺ :			Pb ²⁺ :	in the solution containing 100 μ g L ⁻¹ of	t
				0.67 μg L 1			99.8–103%	the analytes. Interference of 200 times the $(11)^{12+}$ $(12)^{12+}$ $(12)^{12+}$	e
								concentration of Nd ³⁺ , Ni ²⁺ and Co ²⁺ was	S
								observed for the determination of Zn^{-1} if	1
								analytes. Slight interference of 200 time	
								the concentration of Ni^{2+} and Co^{2+} was	
								observed for the determination of Cd^{2+} in	1
								the solution containing 100 μ g L ⁻¹ of the	
								analytes. The modified electrode was	s
								successfully employed in the	
								determination of Zn ²⁺ , Cd ²⁺ , and Pb ²⁺ ir	ı
								river water samples.	
Cd(II)	In situ Bi-modified GaN	0.1 M ABS	SWASV	2.72 nM	9.05-1358.21 nM	At 5 μg L ⁻¹ :	92.3-106.7%	No significant interference of 25 µgL ⁻¹ of	f ¹⁴⁸
	electrode	(pH = 4.5)				3.0%		Ca ²⁺ , Co ²⁺ , Cu ²⁺ , Ni ²⁺ , Mn ²⁺ , Zn ²⁺ , PO ₄ ³⁻	,
		containing						NO_3^- , and SO_4^{2-} was observed in the	•
		$600 \mu g L^{-1}$						determination of 20 μ gL ⁻¹ Cd ²⁺ . The	2
		B1.,.						modified electrode was successfully	/
				1				employed in the determination of Cd^2 in	1

								tan and lake water as well as in milk and	
								fetal bovine serum samples.	
Cd(II) and Pb(II)	<i>In situ</i> Bi-film modified pencil-lead graphite electrode	0.1 M ABS (pH = 4.5)	DPASV	$\begin{array}{c} Cd^{2+}:\\ 11.0\ \mu g\ L^{-1};\\ Pb^{2+}:\\ 11.5\ \mu g\ L^{-1} \end{array}$	48.3–233 μg L ⁻¹ for both analytes	At 150 μg L ⁻¹ of each analyte: 9.72% for Cd ²⁺ ; 7.87% for Pb ²⁺	Cd ²⁺ : 96.9–108%; Pb ²⁺ : 100–102%	The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in battery industry wastewater samples.	149
Cd(II)	Phenylsulfonic groups grafted MWCNT and Rhodamine B dye composite films modified GCE	$\begin{array}{c} 0.1 \text{ M ABS} \\ (\text{pH} = 4.5) \\ \text{containing } 12 \\ \mu \text{M Bi}^{3+} \end{array}$	SWASV	0.08 µM	0.1–1.2 µM	At 1 μM: 4.3%	NR	No significant interference of 5 times the concentration of Ni ²⁺ , Cu ²⁺ , Zu ²⁺ , Al ³⁺ , NO ₃ ⁻ , and SO ₄ ²⁻ was observed in the determination of 1 μ M of the analyte.	150
Ag(I)	Thiol-functionalized polysiloxane film electrodeposited Pb-NPs modified GCE	1 M HNO ₃ containing 20 nM Pb(NO ₃) ₂	SWASV	1.2 pM	0.0093–1.85 nM	At 0.46 nM: 3.3%	97.6–102.2%	No significant interference of $0.1-10$ times the concentration of Zn^{2+} , Fe^{3+} , Pt^{4+} , Sb^{3+} , Mn^{2+} , Bi^{3+} , Mg^{2+} , K^+ , Na^+ , Ca^{2+} , Cd^{2+} , and Tl^+ was observed in the determination of 0.46 nM of the analyte. No significant interference of 100 mg L ⁻¹ of non-ionic Triton X-100 and cationic CTAB, as well as of 20 mg L ⁻¹ anionic SDS surfactants was observed in the determination of 0.46 nM of the analyte. Significant interference of 1 and 10 times the concentration of Cu ²⁺ was observed in the determination of 0.46 nM of the analyte. This interference can be masked by adding EDTA. The modified electrode was successfully employed in the determination of Ag ⁺ in river water, skin tonic, throat spray, and shoes deodorant samples.	151
Cd(II) and Pb(II)	<i>In situ</i> Bi-film laser etched graphene-based carbon nanomaterials modified GCE	0.1 M ABS (pH = 5.0)	SWASV	^a Cd ²⁺ : 0.47 μg L ⁻¹ ; Pb ²⁺ : 0.41 μg L ⁻¹	Cd ²⁺ : 7–10 μ g L ⁻¹ and 10–120 μ g L ⁻¹ ; Pb ²⁺ : 5–10 μ g L ⁻¹ and 10–120 μ g L ⁻¹	At 50 µgL ⁻¹ of the analytes: 6.52% for Cd ²⁺ ; 7.75% for Pb ²⁺	Cd ²⁺ : 103.9–113.0%; Pb ²⁺ : 94.5–109.7%	No significant interference of 10 times the concentration of Zn^{2+} , Ni^{2+} , Co^{2+} , Mg^{2+} , Fe^{3+} , Mn^{2+} , Cr^{3+} , As^{3+} , and Al^{3+} was observed in the simultaneous determination of 30 µg L ⁻¹ of the analytes. Significant interference of 10 times the concentration of Cu^{2+} and Hg^{2+} was observed in the determination of 30 µg L ⁻¹ of the analytes. Significant interference of 300 times the concentration of EDTA-disodium salt, diethanolamine, citric acid, and aniline was observed in the determination of 30 µg L ⁻¹ of the analytes and 300 µg L ⁻¹ Bi ³⁺ . The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} lake water and industry wastewater samples	152
Cd(II), Pb(II)	Poly(1,2- diaminoanthraquinone)-film modified GCE	0.1 M ABS (pH = 5.3)	SWASV	$\begin{array}{c} Cd^{2+}:\\ 0.299\ \mu g\ L^{-1};\\ Pb^{2+}: \end{array}$	0–120 μg L ⁻¹ for all analytes	At 50 μ g L ⁻¹ of the analytes: 2.76% for Cd ²⁺ ;	NR	Significant interference of 10 times the concentration of Na^+ , K^+ , Ca^{2+} , Li^+ , Mg^{2+} , and Al^{3+} was observed in the	153

Hg(II),	$0.58 \ \mu g \ L^{-1};$	2.31% for Pb ²⁺ ;	determination of 100 μ g L ⁻¹ of the
and Cu(II)	Hg^{2+} :	9.69% for Cu ²⁺ ;	analytes. The modified electrode was
	$0.26 \ \mu g \ L^{-1};$	3.71% for Hg ²⁺	successfully employed in the
	Cu^{2+} :	_	determination of Cu ²⁺ , Pb ²⁺ , Hg ²⁺ , and
	$1.91 \text{ ug } \text{L}^{-1}$		Cd^{2+} in contaminated tap water samples.

^a – simultaneous determination of the analytes; NR – not reported by the authors

Table S4: Analytical performance parameters (as reported by the authors) of various types of electrodes for trace heavy metal analysis developed in the last five years (i.e. 2018–2022, including the research work published so far in 2023) using different metal- and covalent-organic frameworks as modifiers.

Analyte	Electrode type and modification	Supporting electrolyte	Technique used	LOD	Linear/Dynamic concentration range	RSD at certain concentration (%)	Recovery (%)	Observations	Ref.
Pb(II) and Hg(II)	Melamine-based COF modified GCE	0.1 M KNO3 and 0.01 M HCl (pH = 2.0)	SWASV	^a Pb ²⁺ : 0.00072 μM; Hg ²⁺ : 0.01211 μM	Рb ²⁺ : 0.01–0.3 µМ; Hg ²⁺ : 0.05–0.3 µМ	At 0.05 µM of each analyte: 2.55% for Pb ²⁺ ; 4.66% for Cd ²⁺	Pb ²⁺ : 94.4–105.3%; Hg ²⁺ : 93.3–105.0%	No significant interference of 1000 times the concentration of Na ⁺ and NO ₃ ⁻ , 500 times the concentration of K ⁺ , ClO ₄ ⁻ , and Fe ²⁺ , 200 times the concentration of Cl ⁻ , F ⁻ , Fe ³⁺ , and PO ₄ ³⁻ , 100 times the concentration of SO ₄ ²⁻ , Ca ²⁺ , Zn ²⁺ , Cd ²⁺ , Ni ²⁺ , Co ²⁺ , and Al ³⁺ , 10 times the concentration of Ag ⁺ and 5 times the concentration of O ₁ μ M of the analyte. No significant interference of 500 times the concentration of Na ⁺ , NO ₃ ⁻ , K ⁺ , ClO ₄ ⁻ , and Fe ²⁺ , 200 times the concentration of Cl ⁻ , F ⁻ , Fe ³⁺ , and PO ₄ ³⁻ , 100 times the concentration of Cl ⁻ , F ⁻ , Fe ³⁺ , and PO ₄ ³⁻ , 100 times the concentration of Cl ⁻ , F ⁻ , Fe ³⁺ , and PO ₄ ³⁻ , 100 times the concentration of SO ₄ ²⁻ , Ca ²⁺ , Zn ²⁺ , Cd ²⁺ , and Ni ²⁺ , 50 times the concentration of Co ²⁺ , and Al ³⁺ , 10 times the concentration of O ²⁺ and 5 times the concentration of O ²⁺ was observed in the determination of 0.1 μ M of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ and Hg ²⁺ in drinking water, black tea, rice,	154
Pb(II) and Cu(II)	Amino functionalized Zr-based MOF (NH ₂ -UiO- 66) integrated with Zn-based zeolitic imidazolate framework (ZIF-8), combined with carboxylated MWCNTs, modified GCE	0.1 M ABS (pH = 5.6)	DPASV	^a Pb ²⁺ : 1 nM; Cu ²⁺ : 10 nM	^a Pb ²⁺ : 0.003–70 μM; Cu ²⁺ : 0.03–50 μM	At 1 mM of each analyte: 3.1% for Pb ²⁺ ; 3.5% for Cu ²⁺	Pb ²⁺ : 95.0–103%; Cu ²⁺ : 94.2–106%	pepper, and salt samples. No significant interference of 10 times the concentration of K ⁺ , Na ⁺ , NH ₄ ⁺ , Al ³⁺ , Zn ²⁺ , Co ²⁺ , Mg ²⁺ , Ni ²⁺ , and Fe ³⁺ , was observed in the simultaneous determination of 1 mM mixture of the analytes. The addition of Cd ²⁺ influenced the determination of Cu ²⁺ . The modified electrode was successfully employed in the determination of Pb ²⁺ and Cu ²⁺ in tap water, soil, and Chinese cabbage samples.	155
Cd(II)	Star shaped ZIF-8 and CTAB nanomaterial modified GCE	0.1 M ABS (pH = 4.5)	SWASV	$0.48 \ \mu g \ L^{-1}$	0.5–30 $\mu g \ L^{-1}$ and 30–230 $\mu g \ L^{-1}$	At 50 μg L ⁻¹ : 1.31%	95.00–104.96%	No significant interference of 50 times the concentration of K ⁺ , Na ⁺ , Ca ²⁺ , Al ³⁺ , Zn ²⁺ , Co ²⁺ , Mg ²⁺ , Mn ²⁺ , and As ³⁺ was observed in the determination of 50 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Cd ²⁺ in tap, river, and wastewater samples.	156
Cd(II)	PANI-supported, Cr-based MOF modified PGE	ABS (pH = 5.0)	SWV	$0.20 \ \mu g \ L^{-1}$	0.5–32.5 µg L ⁻¹	At 5.0 μg L ⁻¹ : 1.2–1.5%	97–99%	No significant interference of Ag ⁺ , Co ²⁺ , Hg ²⁺ , Ni ²⁺ , Zn ²⁺ , Cr ³⁺ , and Mn ²⁺ , was observed in the determination of 5.0 μ g L ⁻¹ of the analyte. The addition of 10.0 μ g L ⁻¹ Pb ²⁺ and Cu ²⁺ influenced the determination of 5.0 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the	157

								determination of Cd ²⁺ in blood and plasma	
								complex as well as in tap and industrial	
								water samples	
Dh (II)	Di film DDy and (LHO 66	0.1 MADE	DDAGU	0.05 u a I -1	0.5 10 up I -1	ND	05 4 102 80/	Water samples.	158
P0(II)	DI-IIIII, PPy and (UIO-00-	(-11 - 50)	DPASV	0.05 µg L	0.5–10 µg L	INK	95.4-102.8%	No significant interference of 2.5 high of W^+ No $^+$ Co $^{2+}$ Mo $^{2+}$ Zo $^{2+}$ NO $^-$ SO $^{2-}$ and	
	NH ₂)-MOF modified GCE	(pH = 5.0),						K^{+} , Na^{+} , Ca^{-+} , Mg^{-+} , Zn^{-+} , NO_3 , $SO_4^{}$, and $Cl^{}$	
		containing						L^{-1} , was observed in the determination of 50	
		$300 \ \mu g \ L^{-1}$						$\mu g L^{-1}$ of the analyte. The modified electrode	
		B1 ⁵¹						was successfully employed in the	
								determination of Pb ²⁺ in tap and ground	
								water samples.	150
Pb(II)	Bi-film, nanocomposite of a	0.1 M KNO ₃	SWASV	0.95 nM	0.003–0.3 μM	NR	95.56–106.64%	No significant interference of 15 times the	159
	synthesized melamine-based	(pH = 2.0),						concentration of Cu ²⁺ and Hg ²⁺ , 20 times the	
	COF, and Fe ₃ O ₄ -NPs	containing						concentration of Ag ⁺ , 50 times the	
	modified GCE	26 µM Bi ³⁺						concentration of Al ³⁺ , 100 times the	
		-						concentration of Sn4+, Sb5+, SO42-, Ca2+,	
								Zn^{2+} , Cd^{2+} , Ni^{2+} , 500 times the concentration	
								of Sb^{3+} , Sn^{2+} , K^+ , Cl^- , F^- , NO_3^- , PO_4^{3-} , and	
								1000 times the concentration of Na ⁺ . Co ²⁺ .	
								Mn^{2+} , ClO_4^- , Fe^{2+} , was observed in the	
								determination of 80 nM of the analyte. The	
								modified electrode was successfully	
								employed in the determination of Ph^{2+}	
								drinking water red pepper powder black	
								tag graan tag rice maring salt black	
								near, green tea, nee, marine sait, black	
								pepper, ginger powder, sunnac powder, and	
	2D CO (ULO (C NUL)	0.1 MADE	DDV	a C 1 2+.	0.01.0.25 mM.fem	A + 2 0 - M - f +h -	C 12+.	NI significant interference of 5 times the	160
$Ca(\Pi),$	$3D-GO, (UIO-00-INH_2)-$	0.1 M ABS	DPV	-Ca-1	0.01–0.55 pM for	At 2.0 pM of the		No significant interference of 5 times the	
Hg(II),	MOF modified SPCE	(pH = 4.5)		10.90 fM;	all analytes	analytes: 4.28%	95.2-104.25%;	concentration of Ca ²⁺ , Ni ²⁺ , Zr ²⁺ , Zn ²⁺ , Al ²⁺ ,	
Cu(II),				PD-":		for Cd ²⁺ ;	PD-1:	K, and Min' was observed in the	
and				5.98 fM;		5.22% for Pb^{2+} ;	101.31-	simultaneous determination of Pb^{2+} , Cu^{2+} ,	
Pb(II)				Cu^{2+} :		1.58% for Cu^{2+} ;	105.64%;	Cd^{2+} , and Hg^{2+} . The modified electrode was	
				2.89 fM;		3.58% for Hg ²⁺	Cu ²⁺ :	successfully employed in the determination	
				Hg^{2+} :			97.63-107.23%;	of Pb ²⁺ , Cu ²⁺ , Cd ²⁺ , and Hg ²⁺ in rice, milk,	
				3.1 fM			Hg^{2+} :	and honey samples.	
							94.73-104.93%		
Hg(II),	2,5-diamino-1,	0.2 M ABS	SWASV	^a Cd ²⁺ :	Cd ²⁺ :	At 5.0 µM of the	Cd ²⁺ :	The modified electrode was successfully	161
Cu(II),	4-phenyldicarboxylic acid	and 0.1 M		2.91 nM;	0.0069-8.00 μM;	analytes: 4.0%	99.16%;	employed in the simultaneous determination	
Pb(II),	and 2,4, 6-	KCl		Pb ²⁺ :	Pb ²⁺ :	for Hg ²⁺ ; 8.0%	Pb ²⁺ :	of Pb ²⁺ , Cu ²⁺ , Cd ²⁺ , and Hg ²⁺ in river water	
and	triformylphloroglucinol	(pH = 5.4)		1.83 nM;	0.0056-8.00 µM;	for Cu ²⁺ , 2.4%	101.14%;	samples.	
Cd(II)	synthetized COF modified	v ,		Cu ²⁺ :	Cu ²⁺ :	for Pb ²⁺ ; 3.8%	Cu ²⁺ :	1	
, í	SPE			5.01 nM:	0.015-8.00 uM;	for Cd ²⁺	102.16%;		
	-			Hg ²⁺ :	Hg ²⁺ :		Hg ²⁺ :		
				2.80 nM	0.0085-8.00 uM		101.86%		
Ho(II)	2 5-diamino-1	0.2 MARS	SWASV	^a Cd ²⁺ .	Cd ²⁺ .	NR	NR	The modified electrode was successfully	161
$C_{11}(II)$	4-phenyldicarboxylic acid	(nH = 5.4)	511151	4 76 nM·	0.014_5.00 uM and	111	1111	employed in the simultaneous determination	
Ph(II)	and 2.4. 6	(p11 – 5.4)		-+. / 0 mvl, Pb ²⁺ ·	5 00_8 00M·			of Pb^{2+} Cu^{2+} Cd^{2+} and Ha^{2+} in river water	
and $0(11)$,	triformylphloroglucipol			10. 120 nM·	Dh ²⁺ .			camples	
	synthetized COE modified			+.29 mvl,	0.013 4.00 uM and			sampies.	
	GCE			Q 15 mM	$4.00 \times 10^{-4.00} \mu M and$				
	OCE			0.45 mvi, Llo ²⁺ .	$+.00-0.00 \mu \text{WI};$				
1				пд-::	Cu=::	1	1		

				2.22 mM	0.026.5.00 mM and				
				2.22 mvi	$5.00 \times 00 \text{ mM}$	L			
					$5.00-8.00 \mu M;$				
					ng .				
$\mathbf{H}_{-}(\mathbf{H})$	C	0.2 M ADC	CHIACH	a C 1 2+.	aC 12+.	A+ 10M	C 12+.	No significant interference of 10 times the	162
Hg(II),	S-containing	0.2 MABS	SWASV	26 mM	-Cd-1:	At 10 µM	Cd ⁻¹ :	No significant interference of 10 times the	
Cu(II),	callx[4]resorcinarene	(рп = 5.0)		20 IIIVI; Dh ²⁺ .	$0.1-1/.0 \mu WI;$	solution of the	98.70-102.44%;	concentration of Na, K, Ag, Zh, Ca, Ma^{2+} Ma^{2+} Ma^{2+} A^{13+} and Ca^{3+} was abaamind in	
$PD(\Pi),$	A more and MOE			PD :	PU :	1 25% for Ha^{2+}	PU :	the simultaneous determination of 10 uM of	
allu Cd(II)	modified CCE			Cu^{2+}	Cu^{2+}	1.25% for Hg^{2+} ;	59.60-103.70%, Cu^{2+}	and analyte. The modified electrode was	
Cu(II)				13 nM:	0.05, 12.0 mM	3.40% for Dh^{2+} :	08 80 102 02%	successfully employed in the determination	
				$H_{\alpha^{2+1}}$	$U.05-12.0 \mu WI,$ Ha^{2+}	2.02% for 10^{-1}	98.80-102.9270, Ца ²⁺ :	of $\mathbf{P}\mathbf{h}^{2+}$ $\mathbf{C}\mathbf{u}^{2+}$ $\mathbf{C}\mathbf{d}^{2+}$ and $\mathbf{H}\mathbf{a}^{2+}$ in tap mineral	
				11g . 18 nM	0.75_18.0 µM	4.2170 IOI Cu	00 30_10/ 30%	and lake water samples	
$H_{\alpha}(\Pi)$	258 triamino e hantazina	0.2 M ABS	SWASV	aCd2+.	Cd^{2+}	At 2.0 µM	Cd ²⁺	No significant interference of 10 times the	163
$C_{\rm D}({\rm II}),$	2,5,6-trianino-s-neptazine	(nH - 5.0)	SWASV	0.00474 uM·	0.0142 + 0.0 M	solution of	103 7 104 6%	concentration of K^+ Δa^+ Ea^{3+} Zn^{2+} Na^+	
Pb(II)	thiadiazole 4.7	(p11 – 5.0)		Pb^{2+}	Ph^{2+}	mixed analytes:	Ph ²⁺	Co ²⁺ Ni ²⁺ Co ²⁺ Mn ²⁺ Mn ²⁺ and Cr ²⁺ was	
and $0(\Pi)$,	divi)dibanzaldahyda			0.00123 uM·	0.0037 4.0 mM	5.0% for Ha^{2+}	06.1 101.1%	observed in the simultaneous determination	
Cd(II)	synthesized COF modified			Cu^{2+}	Cu^{2+}	1.6% for Cu ²⁺	Cu^{2+}	of 2.0 μ M of each analyte. The modified	
Cu(II)	GCF			0.00114 uM·	0.0034_4.0 µM·	1.0% for Pb^{2+}	99 4-100 6%·	electrode was successfully employed in the	
	GCE			Hσ ²⁺ .	Hσ ^{2+.}	3.6% for Cd ²⁺	Ησ ²⁺ ·	determination of Pb^{2+} Cu^{2+} Cd^{2+} and Hg^{2+}	
				0.00107 µM	$0.0032-4.0 \text{\mu}\text{M}$	5.070 IOI Cu	97 9–103 3%	in sewage and tap water samples	
Cd(II)	MIL -100(Fe)-decorated	0.1 M ABS	SWASV	^a Cd ²⁺	$2-180 \text{ µg L}^{-1}$ for	At 50 µg I ⁻¹ of	Cd ²⁺	No significant interference of 50 times the	164
and	mesoporous carbon powders	(pH = 4.5)	501150	$0.11 \text{ ug } \text{L}^{-1}$	both analytes	analytes:	96.7-102.5%:	concentration of K^+ , Na ⁺ , As ³⁺ , Mg ²⁺ , Ni ²⁺	
Pb(II)	on ZIF-8 framework	(p11)		Ph ²⁺	ootii uluij tos	1.76% for Cd ²⁺ :	Ph ²⁺ :	Al^{3+} , Ca^{2+} , Cu^{2+} , La^{3+} , and Cr^{6+} was observed	
10(11)	modified GCE			0.12 µg L ⁻¹		2.46% for Pb ²⁺	97.3_99.9%	in the simultaneous determination of 50 µg	
								L^{-1} of the analytes. The modified electrode	
								was successfully employed in the	
								determination of Pb^{2+} and Cd^{2+} in tap and	
								lake water samples.	
Cd(II)	MWCNTs and (UiO-66-	0.2 M ABS	DSPV	0.2 µg L ⁻¹	0.5–170 µg L ⁻¹	At 50 ug L ⁻¹ :	95.1-107.5%	No significant interference of 10 times the	165
()	NH ₂)-MOF modified GCE	(pH = 5.0)		10	18	4.6%		concentration of Ca ²⁺ , Al ³⁺ , Fe ³⁺ , Ni ²⁺ , Na ⁺ ,	
	2,	G						Co ²⁺ was observed in the determination of	
								50 μ g L ⁻¹ of the analyte. The presence of 10	
								times the concentration of Cu^{2+} influenced	
								the determination of 50 μ g L ⁻¹ of the analyte.	
								The modified electrode was successfully	
								employed in the determination of Cd ²⁺ in	
								meat samples.	
Cd(II)	Alternating multilayered	0.1 M ABS	SWASV	^a Cd ²⁺ :	Cd ²⁺ :	At 50 ppb of	Cd ²⁺ :	No significant interference of Zn ²⁺ , Mn ²⁺ ,	166
and	carboxylated MWCNTs and	(pH = 4.5)		0.090 ppb;	1-121 and	each analyte:	92-114%;	As ³⁺ , Al ³⁺ , Co ²⁺ , Mg ²⁺ , KCl, NaNO ₃ , and	
Pb(II)	(UiO-66-NH ₂)-MOF	· •		Pb^{2+} :	121–511 ppb;	6.79% for Cd ²⁺ ;	Pb ²⁺ :	Na ₂ SO ₄ , was observed in the simultaneous	
	modified GCE			0.071 ppb	Pb ²⁺ :	5.93% for Pb ²⁺	93-106%	determination of 100 μ gL ⁻¹ of each of the	
					1-121 and			analytes. The peak current of both analytes	
					121-271 ppb			increased in the presence of Hg ²⁺ . The	
								modified electrode was successfully	
								employed in the determination of Pb2+ and	
								Cd ²⁺ in air conditioning condensate,	
								seawater, and rainwater samples.	
Cd(II)	MWCNTs and Cu-based	0.1 M PBS	DPV	0.275 nM	0.2–10 µM	NR	100.4%	Interference of 10 times the concentration of	167
	MOF modified GCE	(pH = 3.5)						Cu^{2+} , Co^{2+} , Zn^{2+} , Ni^{2+} , Hg^{2+} , Fe^{3+} , and Pb^{2+} ,	
								was observed in the determination of 0.1	

1		1		1					
								mM of the analyte. The modified electrode	
								was successfully employed in the	
					~		~ - 2) ·	determination of Cd ²⁺ in tap water samples.	169
Hg(II),	$(UiO-66-NH_2)-MOF$ and	0.1 M PBS	DPV	^a Cd ²⁺ :	Cd ²⁺ :	At 5 μ M of each	Cd ²⁺ :	No significant interference of 10 times the	108
Cu(II),	semiconductor GaOOH	containing		0.016 µM;	0.35–1.60 μM;	analyte:	91.4–100.4%;	concentration of Mg^{2+} , Ca^{2+} , Ni^{2+} , Cr^{5+} , Cr^{6+} ,	
Pb(II),	composite modified GCE	0.1 M KCl		Pb^{2+} :	Pb^{2+} :	5.8% for Cd^{2+} ;	Pb ²⁺ :	Al ³⁺ , Fe ²⁺ , Fe ³⁺ , Mn ²⁺ , Zn ²⁺ , and Co ²⁺ , was	
and				0.028 µM;	0.55–2.50 µM;	4.1% for Pb^{2+} ;	96.3–105.4%;	observed in the simultaneous determination	
Cd(II)				Cu ²⁺ :	Cu ²⁺ :	4.9% for Cu^{2+} ;	Cu^{2+} :	of 5 μ gL ⁻¹ of the analytes. The modified	
				0.006 µM;	0.30–1.40 µM;	3.4% for Hg ²⁺	92.4–105.1%;	electrode was successfully employed in the	
				Hg^{2+} :	Hg ²⁺ :		Hg^{2+} :	determination of Cd ²⁺ , Pb ²⁺ , Cu ²⁺ , and Hg ²⁺	
				0.019 µM	0.10–0.45 µM		96.9-104.3%	in wastewater samples.	
Pb(II)	(Zn and Ni-ZIF-8)-MOF,	0.1 M ABS	DPV	^a Pb ²⁺ :	Pb ²⁺ :	At 5 ppm Pb ²⁺	Pb ²⁺ :	No significant interference of 50 times the	169
and	carbon black, Nafion	(pH = 5.5)		0.0150 ppm;	0.794–39.6 ppm;	and 2 ppm Cu2+:	91.20-101.32%;	concentration of Na ⁺ , K ⁺ , Mg ²⁺ , Fe ³⁺ , Co ²⁺ ,	
Cu(II)	modified GCE			Cu ²⁺ :	Cu ²⁺ :	3.10% for Pb ²⁺ ;	Cu ²⁺ :	Ni ²⁺ , Zn ²⁺ , Cd ²⁺ , Bi ³⁺ and Ca ²⁺ , was observed	
				0.0096 ppm	0.397-19.9 ppm	2.18% for Cu ²⁺	93.28-101.73%	in the determination of 5 ppm Pb ²⁺ and 2	
								ppm Cu2+. The modified electrode was	
								successfully employed in the determination	
								of Pb ²⁺ and Cu ²⁺ in lake water and honey	
								samples.	
Cu(II),	V(III)-based MOF modified	0.2 M ABS	DPV	Cu ²⁺ :	1–10 µM for all	NR	Pb ²⁺ :	No significant interference of 10 times the	170
Hg(II),	CPE	(pH = 3.6 -		87.80 nM;	analytes		97.7-103.6%;	concentration of Zn ²⁺ , Ba ²⁺ , Cd ²⁺ , Ni ²⁺ , Cr ³⁺ ,	
and		6.6)		Pb ²⁺ :			Cu ²⁺ :	Co ²⁺ , Mn ²⁺ , and Fe ³⁺ , was observed in the	
Pb(II)		-		29.01 nM;			101.7-104.2%;	determination of 10 µM mixture of the	
, í				Hg ²⁺ :			Hg ²⁺ :	analytes. The modified electrode was	
				67.67 nM			97.1-104.1%	successfully employed in the determination	
								of Pb ²⁺ , Cu ²⁺ , and Hg ²⁺ in river water	
								samples.	
Hg(II)	Clustered peonylike	Tris-HCl	SWV	0.52 pM	1 pM-100 nM	At 10 nM:	90.7-104.1%	No significant interference of 100 times the	171
	Cu-based MOF and	buffer		-	^	1.4%		concentration of Ag ⁺ , Ba ²⁺ , Co ²⁺ , Fe ³⁺ , K ⁺ ,	
	DNAzyme-driven DNA	(pH = 7.4)						Na ⁺ , Ni ²⁺ , Pb ²⁺ , and Zn ²⁺ , was observed in	
	modified Au electrode	a /						the determination of 10 nM of the analyte.	
								The modified electrode was successfully	
								employed in the determination of Hg ²⁺ in	
								milk powder samples.	
Hg(II)	Bimetallic (Fe and Co)-	0.1 M ABS	SWASV	7.82 nM	0.1–1.1 uM	At 0.7 uM:	97.8-103.3%	No significant interference of 0.7 uM Cd ²⁺	172
0()	based (ZIF-67)-MOF	(pH = 5.0)			p	2.11%		and $0.5 \mu M Pb^{2+}$ was observed in the	
	modified GCE	u,						determination of 0.7 uM of the analyte. The	
								addition of 0.5 μ M Cu ²⁺ influenced the	
								performance of the modified electrode in the	
								determination of $0.7 \mu\text{M}$ of the analyte. The	
								modified electrode was successfully	
								employed in the determination of Hg^{2+} in	
								river and lake water samples	
Hg(II)	Amino-functionalized (NH	0.2 M ABS	SWSV	^a Cd ²⁺	Cd ²⁺	At 2 µM of each	Cd ²⁺ :	No significant interference of 5 times the	173
$C_{\rm H}({\rm II})$	MII = 88(Fe) - MOF	(nH - 5.4)	51151	39.6 nM·	0.12-6.00 mM	analyte.	89 54-95 57%	concentration of Na ⁺ Ca^{2+} Zn^{2+} Co^{2+} Ni ²⁺	
Ph(II)	embedded with graphitic	(pii = 5.4)		Ph ²⁺ .	Ph ²⁺	7 17% for Cd^{2+}	Ph ²⁺	Ee^{3+} and Ag^+ and 50 times the concentration	
and	C_2N_4 nanosheets and acid-			7.6 nM·	0.02-6.00 uM·	11.4% for Ph ²⁺	83 67-104 74%	of K^+ and $M\sigma^{2+}$ was observed in the	
Cd(II)	functionalized CNT			Cu^{2+}	Cu ^{2+.}	4 39% for Cu^{2+}	Cu ²⁺	simultaneous determination of 2 µM of each	
	modified GCE			11.9 nM·	0.04–6.00 µM·	11.7% for $H\sigma^{2+}$	80 35-110 00%	analyte The modified electrode was	
				Ησ ^{2+.}	Ησ ^{2+.}	11.7 /0 101 11g	Ho ²⁺	successfully employed in the determination	
L					115 .	I	115.	pacessiumy employed in the determination	

				9.6 nM	0.03–6.00 μM		82.45-106.36%	of Cd^{2+} , Pb^{2+} , Cu^{2+} , and Hg^{2+} in sewage samples	
Cd(II), Pb(II), and Cu(II)	Ferrocene-functionalized Ni-based MOF modified GCE	0.1 M ABS (pH = 6)	DPASV	^a Cd ²⁺ : 7.1 nM; Pb ²⁺ : 0.2 nM; Cu ²⁺ : 6.3 nM	$\begin{array}{c} Cd^{2+} \text{ and } Cu^{2+}; \\ 0.01-2.0 \ \mu\text{M}; \ Pb^{2+}; \\ 0.001-0.1 \ \mu\text{M} \text{ and} \\ 0.1-2.0 \ \mu\text{M} \end{array}$	At 1.0 μM of each analyte: 7.4% for Cd ²⁺ ; 4.1% for Pb ²⁺ ; 6.3% for Cu ²⁺	Cd ²⁺ : 95–110%; Pb ²⁺ : 96–100%; Cu ²⁺ : 97–110%	No significant interference of 5 times the concentration of Mn^{2+} , Al^{3+} , K^+ , Ca^{2+} , Na^+ , and Zn^{2+} was observed in the simultaneous determination of 1.0 μ M of each analyte. The modified electrode was successfully employed in the determination of Cd^{2+} , Pb^{2+}	174
Hg(II)	NiCo ₂ O ₄ nanocages derived from (ZIF-67)-MOF modified GCE	0.1 M ABS (pH = 4.5)	DPASV	0.09 nM	0.1 nM–3.5 μM	At 1.0 μM: 3.71%	98.5-103.6%	and Cu ²⁺ in tap water samples. No significant interference of 100 times the concentration of K ⁺ , Ca ²⁺ , Na ⁺ , 10 times the concentration of Mg ²⁺ , Al ³⁺ , Zn ²⁺ , Fe ²⁺ and the same concentration of Pb ²⁺ , Cd ²⁺ , Cu ²⁺ , was observed in the determination of 1.0 μ M of the analyte. The addition of 10 times the concentration of Pb ²⁺ , Cd ²⁺ , Cu ²⁺ influenced the performance of the modified electrode in the determination of 1.0 μ M of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in lake water samples.	175
Hg(II)	Mercaptan functionalized Zr-based MOF attached to three-dimensional kenaf stem derived carbon	0.2 M ABS (pH = 6.0)	SWASV	0.05 μΜ	0.25–3.5 μΜ	At 2.0 μM: 4.2%	98.15–103.50%	No significant interference of Cd^{2+} , Pb^{2+} , Cu^{2+} , Zn^{2+} and Ni^{2+} , was observed in the determination of 2.0 μ M of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in tap, river, and sewage water samples.	176
Pb(II) and Cu(II)	Nafion, MWCNT and (ZIF- 67)-MOF modified GCE	0.1 M ABS (pH = 2.0)	SWSV	^a Pb ²⁺ : 10 nM; Cu ²⁺ : 3.8 nM	Pb ²⁺ : 1.38–0.60 μM and 0.60–5 μM; Cu ²⁺ : 1.26–0.20 μM and 0.20–5 μM	At 0.6 µM of the analytes: 3.6% for Pb ²⁺ ; 4.4% for Cu ²⁺	Pb ²⁺ : 87–126%; Cu ²⁺ : 94–106%	No significant interference of 50 times the concentration of K ⁺ , Na ⁺ , Mg ²⁺ , Zn ²⁺ , Hg ²⁺ , Fe ³⁺ , Co ²⁺ , Cd ²⁺ , and Mn ²⁺ was observed in the simultaneous determination of 0.6 μ M of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cu ²⁺ in domestic sewage and lake water samples.	177
Cd(II), Pb(II), and Cu(II)	Thermally rGO, ferrocenecarboxylic acid functionalized (UiO-66- NH ₂)-MOF modified GCE	0.1 M ABS (pH = 5.0)	DPASV	^a Cd ²⁺ : 8.5 nM; Pb ²⁺ : 0.6 nM; Cu ²⁺ : 0.8 nM	$\begin{array}{c} Cd^{2+}:\\ 0.01-2\ \mu M;\\ Pb^{2+}:\\ 0.001-0.1\ \mu M \ and\\ 0.1-2\ \mu M;\\ Cu^{2+}:\\ 0.001-0.1\ \mu M \ and\\ 0.1-2\ \mu M \end{array}$	At 1 μM of each analyte: 4.18% for Cd ²⁺ ; 5.92% for Pb ²⁺ ; 1.98% for Cu ²⁺	$\begin{array}{c} Cd^{2+};\\ 94.38-101.25\%;\\ Pb^{2+};\\ 95.63-104.88\%;\\ Cu^{2+};\\ 90.63-94.38\%\end{array}$	No significant interference of 5 times the concentration of K ⁺ , Na ⁺ , Ca ²⁺ , Zn ²⁺ , Ni ²⁺ , Al ³⁺ , Mn ⁷⁺ , and Zr ⁴⁺ was observed in the simultaneous determination of 1 μ M of Cd ²⁺ , Pb ²⁺ and Cu ²⁺ . The modified electrode was successfully employed in the determination of Cd ²⁺ , Pb ²⁺ and Cu ²⁺ in tap water samples.	178
Hg(II)	Cubic Cu-based MOF NPs modified GCE	0.1 M PBS (pH = 9.0)	DPV	0.0633 nM	0.1–50 nM	NR	101.0–122.5%	No significant interference of 100 times the concentration of Co^{2+} , Fe^{2+} , Pb^{2+} , and Zn^{2+} , was observed in the determination of 1 nM of the analyte. The modified electrode was successfully employed in the determination of Hg ²⁺ in tap water and canned tuna fish samples.	179

Cd(II),	Co-based zeolitic	0.1 M ABS	SWASV	Cd ²⁺ :	0.5–3 ppm for all	At 5 ppm of the	Cd ²⁺ :	Interference of the Cu2+ ions in the	180
Cu(II),	imidazolate framework	(pH = 5.0)		1.13 nM;	analytes	analytes:	98.62-102.50%;	determination of the Hg2+ ions, especially at	
Hg(II),	(ZIF-67) and expanded			Pb ²⁺ :		1.9% for Cd ²⁺ ;	Pb ²⁺ :	low concentrations was observed. The	
and	graphite modified GCE			1.11 nM;		3.3% for Pb ²⁺ ;	98.70-101.25%;	modified electrode was successfully	
Pb(II)				Cu^{2+} :		2.3% for Cu^{2+} ;	Cu^{2+} :	employed in the determination of Cd^{2+} , Pb^{2+} ,	
				2.23 nM;		3.6% for Hg ²⁺	98.70–101.38%;	Cu^{2+} , and Hg^{2+} in wastewater samples.	
				Hg^{2+} :			Hg^{2+} :		
				1.28 nM			98.67–101.30%		101
Cd(II),	1,4-benzenedithiol-2,5-	0.2 M ABS	DPSV	$^{\mathrm{a}}\mathrm{Cd}^{2+}$:	Cd ²⁺ :	At 2 µM mixed	Cd ²⁺ :	No significant interference of 5 times the	181
Cu(II),	diamino-hydrochloride and	(pH = 5.0),		12.3 nM;	0.0369–18.0 μM;	solution of the	93.7–105.3%;	concentration of K^+ , Ag^+ , Fe^{3+} , Zn^{2+} , Na^+ ,	
Hg(II),	1,3,5-triformylbenzene	N_2 -saturated		Pb ² ⁺ :	Pb ²⁺ :	analytes:	Pb ²⁺ :	Co^{2+} , Ni^{2+} , Ca^{2+} , Mn^{2+} , Mg^{2+} , and Cr^{2+} , was	
and	condensated COF attached			11.8 nM;	0.0356–19.0 μM;	2.6% for Cd^{2+} ;	8/.6-100.3%;	observed in the simultaneous determination	
Pb(II)	to 3D kenaf stem derived				Cu ²⁺ :	0.2% for Pb^{2+} ;	Cu ² ':	of 2 μ M mixed solution of the analytes. The	
	carbon			18.6 nM;	0.0536–19.0 μM;	0.9% for Cu^{2+} ;	102.6-106.6%;	modified electrode was successfully	
				Hg ² ":	Hg^{2+} :	6.3% for Hg^{2+}	Hg=":	employed in the determination of Cd^{2+} , Pb^{2+} ,	
				21.4 nivi	0.0503–18.0 µM		85.3-95.1%	Cu^{2+} , and Hg^{2+} in wastewater and soil	
		ADC	DDV	24.14	0.1.220 14	A . 20 M	06.0.100.60/	samples.	182
Hg(II)	Pt incorporated mordenite	ABS	DPV	3.4 nM	0.1–220 µM	At 20 μ M:	90.0-100.0%	No significant interference of 20 times the	
	zeonite modified GCE	(pri = 5.0)				2.29%		concentration of Fe , $\Sigma \Pi$, $C \Pi$, $C \sigma$, $N \Pi$, $C \eta^{2+} M \eta^{2+} D \eta^{2+} \Lambda^{13+}$ and $C \eta^{2+} \eta^{2+}$ was	
								Cu, Mill, PD, AI, and Cr, was	
								Observed in the determination of 2.0 μ W	
								ng . The mounted electrode was	
								successfully employed in the determination $f = Ha^{2+}$ in tan river and industrial	
								wastewater samples	
Cd(II)	Hexagonal	0.1 MABS	SWASV	Ph ²⁺	0.1–1.0 µM for	At 0.5 µM·	Cd ²⁺	No significant interference of $1 \mu M C d^{2+}$ and	183
and	lanthanide MOF (ZIII-27)	(nH - 5.0)	SWASY	1.0 nM·	both analytes	3.62%	94 47_103 2%·	Zn^{2+} was observed in the determination of	
Ph(II)	modified GCE	(p11 = 5.0)		Cd^{2+}	both analytes	5.0270	Ph ²⁺	$0.1 \pm 1.0 \text{ uM Pb}^{2+}$ The same concentration of	
1 0(11)				1.66 nM			97.3-101.8%	Cu^{2+} influenced the determination of Ph ²⁺	
				1100 1111			2010 1011070	The modified electrode was successfully	
								employed in the determination of Cd^{2+} and	
								Ph^{2+} in lake and drinking water samples	
Pb(II)	NH2-MIL-53(Al)-MOF and	0.1 M ABS	DPV	Ph ²⁺	^a 1–400 µg L ⁻¹ for	NR	Cu ²⁺ :	No significant interference of Cd^{2+} Hg^{2+}	184
and	PPv nanocomposite	(pH = 5.0)		0.315 µg L ⁻¹ ;	both analytes		99.2-100.7%:	Ca^{2+} . Ni ²⁺ and Zn ²⁺ was observed in the	
Cu(II)	modified Au electrode	G ,		Cu ²⁺ :	· · · · · · · · · · · · · · · · · · ·		Pb ²⁺ :	determination of 400 μ g L ⁻¹ of the analytes.	
				$0.244 \ \mu g \ L^{-1}$			96.8-101.2%	The modified electrode was successfully	
								employed in the determination of Cu ²⁺ and	
								Pb ²⁺ in tap water samples.	
Pb(II),	2D Ca-based MOF modified	0.1 M ABS	SWASV	^a Pb ²⁺ :	10–60 µg L ⁻¹	At 30 µg L ⁻¹ of	NR	The modified electrode was found to be	185
Cd(II),	GPE	(pH = 4.5)		$0.64 \ \mu g L^{-1};$		each analyte:		suitable for both sorption and	
Cu(II),		-		Cu ²⁺ :		lower than 4.2%		electrochemical determination of heavy	
and				1.4 µg L ⁻¹ ;				metal ions.	
Zn(II)				Zn^{2+} :					
				$1.1 \mu g L^{-1};$					
				Cd ²⁺ :					
				1.3 μgL ⁻¹					104
Cd(II)	Bi encapsulated into a	0.2 M ABS	DPASV	Cd ²⁺ :	$0.1-30 \ \mu g \ L^{-1}$ and	At 50 μ g L ⁻¹ of	97.0–103.2%	No significant interference of 1000 times the	180
and	mesoporous MIL-101(Cr)	(pH = 5.0)		$1 60 \text{ ng } L^{-1}$:	30–90 μg L ⁻¹ for	each analyte:		concentration of Mg ²⁺ , Ca ²⁺ , Zn ²⁺ , and Cr ³⁺	
		Q,		71.2		1 = 0 = -2			
Pb(II)	type MOF modified CCE	Y		Pb ²⁺ :	both analytes	1.7% for Cd^{2+} ;		was observed in the determination of 10 μ g	

								times the concentration of Cu^{2+} influenced the determination of Cd^{2+} and Pb^{2+} . The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in ground and lake water samples	
Cd(II)	Mn-based (ZJU-77)-MOF, Nafion modified GCE	0.2 M PBS (pH = 7.0)	SWASV	0.12 ррв	0–60 μg L ⁻¹	NR	97.0–102.0%	No significant interference of Br ⁻ , F ⁻ , I ⁻ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SCN ⁻ , SO ₄ ²⁻ , Fe ³⁺ , K ⁺ , Zn ²⁺ , Cu ²⁺ , Hg ²⁺ , Ca ²⁺ , Mg ²⁺ , and Ba ²⁺ was observed in the determination of Cd ²⁺ . The modified electrode was successfully employed in the determination of Cd ²⁺ in lake, drinking, and tap water samples.	187
Cd(II), Cu(II), Hg(II), and Pb(II)	Graphene aerogel and (UiO- 66-NH ₂)-MOF composites modified GCE	0.2 M ABS (pH = 5.0)	DPSV	^a Cd ²⁺ : 9 nM; Pb ²⁺ : 1 nM; Cu ²⁺ : 8 nM; Hg ²⁺ : 0.9 nM	Cd ²⁺ : $0.06-3.0 \mu$ M; Pb ²⁺ : $0.01-4.0 \mu$ M; Cu ²⁺ : $0.1-3.5 \mu$ M; Hg ²⁺ : $0.005-3.0 \mu$ M	At 1.5 μM: 3.2% for Cd ²⁺ ; 2.1% for Pb ²⁺ ; 3.1% for Cu ²⁺ ; 1.9% for Hg ²⁺	$\begin{array}{c} Cd^{2+};\\ 92-104.7\%;\\ Pb^{2+};\\ 90.7-101.3\%;\\ Cu^{2+};\\ 86.7-94.7\%;\\ Hg^{2+};\\ 99.3-103.3\%\end{array}$	No significant interference of 5 times the concentration of Zn^{2+} , Ni^{2+} , Cr^{3+} , K^+ , Ag^+ , Ca^{2+} , Na^+ , Fe^{3+} , Co^{2+} , Mg^{2+} , Mn^{2+} , and Bi^{3+} was observed in the simultaneous determination of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} , Pb^{2+} , Cu^{2+} , and Hg^{2+} in vegetable and soil samples.	188
Pb(II)	1,3,5-tris(4- aminophenyl)benzene and 2,5- dimethoxyterephaldehyde COF modified CPE	0.1 M ABS (pH = 4.5)	DPASV	1.9 nM	0.0050–2.0 μM	At 0.50 μM: 3.1%	99.3–103.0%	No significant interference of 5 times the concentration of Cu^{2+} , Hg^{2+} , 10 times the concentration of Cd^{2+} , 50 times the concentration of Ni^{2+} , Co^{2+} , Mn^{2+} , Fe^{2+} , Zn^{2+} , Cr^{3+} , Sn^{2+} , 200 times the concentration of Ag ⁺ , Mg^{2+}, Al^{3+}, and 1000 times the concentration of K ⁺ , Na ⁺ , Mg^{2+}, Ca^{2+}, NO_3^-, F ⁻ , Cl ⁻ , Br ⁻ , SCN ⁻ , SO4 ²⁻ , CO3 ²⁻ , PO4 ³⁻ , SiO3 ²⁻ was observed in the determination of 0.50 μ M of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in river, lake and tap water samples	189

^a – simultaneous determination of the analytes; NR – not reported by the authors

Table S5: Analytical performance parameters (as reported by the authors) of various types of electrodes for trace heavy metal analysis developed in the last five years (i.e. 2018–2022, including the research work published so far in 2023) using calixarene-based compounds, ionic liquids, and Schiff bases as modifiers.

					Linear/Dynamic	RSD at			
	Electrode type and	Supporting	Technique	LOD	concentration	certain	Recovery		D 4
Analyte	modification	electrolyte	used		range	concentration	(%)	Observations	Ref.
		2			0	(%)			
Pb(II)	(N¹-hydroxy-N¹,N²- diphenylbenzamidine)-Schiff base modified CPE	0.1 M ABS (pH = 5.0)	SWASV	0.0094 nM	0.100–2500 nM	At 100 nM: 4.3%	96.92–103.4%	No significant interference of 20 times the concentration of Cu^{2+} , 30 times the concentration of Cd^{2+} , 50 times the concentration of Ni^{2+} , Co^{2+} , Hg^{2+} , Fe^{2+} , and SO_4^{2-} , and 100 times the concentration of Na ⁺ , K ⁺ , Ca^{2+} , Mg^{2+} , NH_4^+ , Cl^- and NO_3^- was observed in the determination of 100 nM of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in wastewater, vegetable, fish, and cigarette complex	190
Pb(II) and Cu(II)	Thiolated calix[4]arene, Au-NPs modified SPCE	0.1 M KCl (pH = 8.0)	DPV	Pb ²⁺ : 0.7982 · 10 ⁻² ppm; Cu ²⁺ : 1.3358 · 10 ⁻² ppm	0.20–1.00 ppm for both analytes	At 1.00 ppm of the analytes: 3.08% for Pb ²⁺ ; 3.59% for Cu ²⁺	Pb ²⁺ : 94–108%; Cu ²⁺ : 94–103%	Samples. Significant interference of the same concentration of Zn^{2+} and Hg^{2+} was observed in the determination of 1.00 ppm of the analytes. Significant interference of the same concentration of Cd^{2+} , Ni^{2+} , was observed in the determination of Cu^{2+} in a 1.00 ppm solution of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} and Cu^{2+} in deionized and river water samples.	191
Pb(II) and Cd(II)	(1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl imide))-IL, carbon nanofibers and Bi particles nanocomposite modified CPE	$\begin{array}{l} 0.1 \ M \ ABS \\ (pH = 4.5) \\ containing \\ 300 \ \mu g \ L^{-1} \\ Bi^{3+} \end{array}$	SWV	^a Pb ²⁺ : 0.12 μg L ⁻¹ ; Cd ²⁺ : 0.25 μg L ⁻¹	2–120 μg L ⁻¹ for both analytes	At 40 μg L ⁻¹ of the analytes: 3.8% for Pb ²⁺ ; 3.6% for Cd ²⁺	Pb ²⁺ : 103.3%; Cd ²⁺ : 101.5%	No significant influence of 25 times the concentration of Fe ²⁺ , Al ³⁺ , Zn ²⁺ , Mg ²⁺ , SO ₄ ²⁻ , CO ₃ ²⁻ , Ca ²⁺ , K ⁺ , and Na ⁺ was observed in the determination of 40 μ g L ⁻¹ of the analytes. Significant interference of 25 times the concentration of Cu ²⁺ was observed in the determination of 40 μ g L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in well water samples.	192
Pb(II) and Cd(II)	L-cysteine-functionalized SWCNTs incorporating Nafion and (1-butyl-2,3- dimethylimidazolium bis(trifluoromethanesulfonyl) imide)-IL nanocomposite modified GCE	0.1 M ABS (pH = 5.0)	SWASV	^a Pb ²⁺ : 0.08 μg L ⁻¹ ; Cd ²⁺ : 0.05 μg L ⁻¹	0–50 μg L ⁻¹ for both analytes	At 12 μg L ⁻¹ of the analytes: 1.135% for Pb ²⁺ ; 0.709% for Cd ²⁺	Pb ²⁺ : 98.40–100.80%; Cd ²⁺ : 98.50–102.20%	No significant influence of 100 times the concentration of As^{3+} , Zn^{2+} , Cr^{2+} , Ca^{2+} , K^+ , and Na ⁺ was observed in the determination of 20 µg L ⁻¹ of the analytes. Significant interference of 100 times the concentration of Cu ²⁺ was observed in the determination of 20 µg L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ and Cd ²⁺ in extracts of soil samples.	193
Pb(II)	(N-butylpyridinium hexafluorophosphate)-IL, poly-L-cysteine composite	0.1 M ABS (pH = 4.5)	SWASV	0.17 μg L ⁻¹	$1{-}180 \ \mu g \ L^{-1}$	At 10 μg L ⁻¹ : 5.8%	Pb ²⁺ : 103.0–113.6%	No significant influence of 100 times the concentration of Zn^{2+} , Mg^{2+} , Cd^{2+} , As^{3+} , and Fe ³⁺ , and 50 times the concentration	194

	modified laser-engraved electrode							of Cl ⁻ , NO ₃ ⁻ , and SO ₄ ²⁻ was observed in the determination of 100 μ g L ⁻¹ of the analyte. Significant influence of 10 times the concentration of Cu ²⁺ and Hg ²⁺ was observed in the determination of 100 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap and lake water samples.	
Cd(II), Pb(II) and Hg(II)	Bis(imidazo[4,5-f][1, 10]phenanthroline) appended bis-triazolo calix[4] arene modified GCE	Britton- Robinson buffer (pH = 4.0)	SWASV	^a Pb ²⁺ : 0.0155 nM; Cd ²⁺ : 0.0371 nM; Hg ²⁺ : 0.0257 nM	l nM–2.5 µM for all analytes	At 2.5 μ M of each analyte: 0.28% for Pb ²⁺ ; 0.57% for Cd ²⁺ ; 0.28% for Hg ²⁺	Pb ²⁺ : 99.6%; Cd ²⁺ : 99.2% Hg ²⁺ : 99.6%	No significant interference of 3 times the concentration of Co^{2+} , Ni^{2+} , and Zn^{2+} , 2 times the concentration of Cr^{2+} and Al^{3+} was observed in the simultaneous determination of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ , and Hg ²⁺ in drinking water samples.	195
Pb(II) and Cd(II)	Calix[4]arene-functionalized Mn₃O₄-NPs modified GCE	ABS (pH = 6.0) containing 0.1 M KCl	DPASV	Pb ²⁺ : 7 ppb; Cd ²⁺ : 9 ppb	100–1000 ppb for both analytes	At 500 ppb: 3.3% for Pb ²⁺ ; 3.7% for Cd ²⁺	Pb ²⁺ : 99.69%; Cd ²⁺ : 98.60%	No significant interference of up to 1000 times the concentration of NH_4^+ , Ba^{2+} , Mg^{2+} , Ca^{2+} , K^+ , Mn^{2+} , Li^+ , Ag^+ , Cl^- , F^- , and SO_4^{2-} , 40 times the concentration of Co^{2+} , $C_2O_4^{2-}$ and CO_3^{2-} , 20 times the concentration of Hg^{2+} , Bi^{3+} , Sn^{2+} , and Fe^{3+} was observed in the determination of 500 ppb of each analyte. Significant interference of 2 times the concentration of Cu^{2+} was observed in the determination of Cu^{2+} was observed in the determination of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} and Cd^{2+} in wastewater samples.	196
Cu(II), Cd(II) and Pb(II)	Thiacalix[4]arene modified GCE	0.1 M ABS (pH = 5.0)	DPASV	$\begin{array}{c} Cu^{2+};\\ 3.0\ \mu g\ L^{-1};\\ Cd^{2+};\\ 4.0\ \mu g\ L^{-1};\\ Pb^{2+};\\ 2.5\ \mu g\ L^{-1} \end{array}$	$\begin{array}{c} {\rm Cu}^{2+};\\ 1.0{-}2.0\ {\rm mg}\ {\rm L}^{-1};\\ {\rm Cd}^{2+};\\ 0.1{-}1.0\ {\rm mg}\ {\rm L}^{-1};\\ {\rm Pb}^{2+};\\ 1.0{-}2.0\ {\rm mg}\ {\rm L}^{-1} \end{array}$	NR	NR	No significant interference of 500 times the concentration of K^+ , Na ⁺ , Ca ²⁺ , Mg ²⁺ , Al ³⁺ , Cl ⁻ , Br ⁻ , NO ₃ ⁻ , and SO ₄ ²⁻ was observed in the determination of 1.0 mg L ⁻ ¹ of the analytes. The modified electrode was successfully employed in the determination of Cu ²⁺ , Cd ²⁺ and Pb ²⁺ in river water samples.	197
Hg(II)	(N,N'-bis (5-bromo-2- hydroxybenzylidene)-2,2- dimethylpropane-1,3- diamine)-Schiff base modified CPE	Britton- Robinson buffer (pH = 2.0)	SWASV	0.042 μg L ⁻¹	0.4–120 μg L ⁻¹	At 10.0 µg L ⁻¹ : 3.3%	97.4–103.2%	No significant interference of 30 times the concentration of Cd^{2+} , 40 times the concentration of Ag^+ , 50 times the concentration of Cu^{2+} , 100 times the concentration of Zn^{2+} and Pb^{2+} , and 1000 times the concentration of Fe^{2+} , Na^+ , K^+ , Mg^{2+} , Ca^{2+} and Cr^{2+} was observed in the determination of 10 µg L^{-1} of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in	198

								tabacco, chewing gum, tap and river water and petrochemical samples.	
Pb(II) and Hg(II)	((E)-2((3-methylbenzilidene) amino) phenol)-Schiff base and MWCNTs modified CPE	ABS (pH = 3.0) and 0.1 M KCl	DPV	Hg ²⁺ : 28 nM; Pb ²⁺ : 41 nM	$\begin{array}{c} Hg^{2+};\\ 0.1-200\ \mu M;\\ Pb^{2+};\\ 0.1-250\ \mu M\end{array}$	At 100 μM of each analyte: 1% for Hg ²⁺ ; 2% for Pb ²⁺	98.43–102.43%	No significant influence of 10 times the concentration of Fe^{2+} , 100 times the concentration of Al^{3+} and 700 times the concentration of Ni^{2+} was observed in the determination of Hg^{2+} in a solution containing 100.0 µM of each analyte. No significant interference of 250 times the concentration of Al^{3+} , and 1000 times the concentration of Ni^{2+} , Cu^{2+} and Fe^{2+} was observed in the determination of Pb^{2+} in a solution containing 100.0 µM of each analyte. The modified electrode was successfully employed in the determination of Pb^{2+} and Hg^{2+} in algae samples.	199
Pb(II)	Calix[4]arene-tren modified GCE	0.1 M KCl (pH = 7.0)	DPASV	0.11 μΜ	0.48–2.31 μM	NR	NR	No significant interference of the same concentration of Cd^{2+} , Co^{2+} , Cu^{2+} , Fe^{2+} , Ni^{2+} , and Zn^{2+} was observed in the determination of 1 mM of the analyte. The modified electrode was successfully employed in the determination of Pb^{2+} in wastewater samples.	200
Cu(II)	p-tert-butylcalix[4]arene-bis- cyrhetrenylimine modified GCE	0.1 M Britton- Robinson buffer (pH = 4.0)	SWASV	0.03 μg L ⁻¹	10–180 µg L ^{–1}	At 40 μg L ⁻¹ : 3.79%	NR	No significant interference of 10 and 100 μ g L ⁻¹ of Zn ²⁺ , Fe ³⁺ , Ni ²⁺ , Al ³⁺ , Ca ²⁺ , Cr ³⁺ , Hg ²⁺ and Pb ²⁺ was observed in the determination of 40 μ g L ⁻¹ of the analyte. Significant interference of 10 and 100 μ g L ⁻¹ of Cd ²⁺ was observed in the determination of 40 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Cu ²⁺ in commercial oysters, clams, and mussel samples.	201
Cd(II)	Bi-film, Fe₃O₄, (n-octylpyridinium hexafluorophosphate)-IL composite modified SPE	$\begin{array}{c} 0.2 \text{ M PBS} \\ (pH = 5.0) \\ \text{containing} \\ 400 \ \mu\text{g } L^{-1} \\ Bi^{3+} \end{array}$	DPV	0.05 μg L ⁻¹	0.5–40 μg L ⁻¹	At 10 μg L ⁻¹ : 5.79%	91.77–107.83%	No significant interference of 50 times the concentration of Na ⁺ , Hg ²⁺ , Ca ²⁺ , Mg ²⁺ , Fe ³⁺ , Al ³⁺ , Ni ²⁺ , Cu ²⁺ , Pb ²⁺ , Zn ²⁺ , Cl ⁻ , and NO ₃ ⁻ was observed in the determination of 40 μ g L ⁻¹ Cd ²⁺ . The modified electrode was successfully employed in the determination of Cd ²⁺ in soil samples.	202
Pb(II)	Dicarboxyl-calix[4]arene, mercaptopropionic acid modified Au electrode	0.1 M KCl (pH = 7.0)	DPV	6.2 µg L ⁻¹	280–2500 μg L ⁻¹	At 1 μM: 8.33%	92%	Slight interference of the same concentration of Cu^{2+} , Ni^{2+} , Fe^{2+} , Hg^{2+} , Cd^{2+} and Mg^{2+} was observed in the determination of 1 μ M of the analyte. Significant interference of the same concentration of Zn^{2+} was observed in the determination of 1 μ M of the analyte. The	203

				modified electrode was successfully
				employed in the determination of Pb ²⁺ in
				river samples.

^a- simultaneous determination of the analytes; NR - not reported by the authors

Table S6: Analytical performance parameters (as reported by the authors) of various types of electrodes for trace heavy metal analysis developed in the last five years (i.e. 2018–2022, including the research work published so far in 2023) using different environmentally friendly compounds and natural products as modifiers.

Analyte	Electrode type and modification	Supporting electrolyte	Technique used	LOD	Linear/Dynamic concentration range	RSD at certain concentration (%)	Recovery (%)	Observations	Ref.
Pb(II) and Cd(II)	Biochar obtained from coffee husks modified CPE	0.1 M ABS (pH = 4.8)	DPAdsV	Cd ²⁺ : 1.7 μg L ⁻¹ ; Pb ²⁺ : 0.2 μg L ⁻¹	Cd ²⁺ : 2.5–10.0 μM; Pb ²⁺ : 0.5–2.0 μM	At 5.0 μM Cd ²⁺ and 1.0 μM Pb ²⁺ : 3.9% for Cd ²⁺ ; 4.4% for Pb ²⁺	Cd ²⁺ : 100.50–122.79%; Pb ²⁺ : 81.53–103.66%	The modified electrode was successfully employed in the simultaneous determination of Pb ²⁺ and Cd ²⁺ in drinking, ground, and river water samples.	204
Cd(II)	Mango seed kernel NPs modified GRCPE	Britton- Robinson buffer (pH = 3.9)	DPAASV	1.65 · 10 ⁻⁸ M	5.0 · 10 ⁻¹¹ -2.0 · 10 ⁻⁶ M	At 5.0 · 10 ⁻⁷ M: 2.1%	99.0–101.0%	No significant interference of Pb ²⁺ , Co ²⁺ and Fe ³⁺ was observed in the determination of $5.0 \cdot 10^{-7}$ M of the analyte. The modified electrode was successfully employed in the determination of Cd ²⁺ in chocolate and white rice samples.	205
Pb(II) and Cd(II)	Ag-NPs synthetized from <i>Persea Americana</i> leaves extract decorated silane grafted bentonite modified GCE	0.1 M ABS (pH = 4.5)	DPASV	Cd ²⁺ : 0.79 µg L ⁻¹ ; Pb ²⁺ : 0.88 µg L ⁻¹	5.0–60.0 µg L ⁻¹	At 50.0 μ g L ⁻¹ of the analytes: 3.7–4.4% for Cd ²⁺ ; 3.9–4.7% for Pb ²⁺	Cd ²⁺ : 93–108%; Pb ²⁺ : 99–113%	No significant interference of 10 times the concentration of Ag^+ , Fe^{2+} , Ni^{2+} , Zn^{2+} , Hg^{2+} , Cu^{2+} and Mn^{2+} was observed in the determination of 50.0 µg L ⁻¹ of the analytes. The modified electrode was successfully employed in the determination of Cd^{2+} and Pb^{2+} in spring water samples.	206
Pb(II)	Lignin-modified CPE	0.1 M NaCl (pH = 9)	SWASV	0.0225 nM	3–21 μM	NR	96%	The modified electrode was successfully employed in the determination of Pb ²⁺ in tap water samples.	207
Pb(II), Cd(II), Cu(II), and Hg(II)	Biochar obtained from walnut shells and poly-tyrosine modified CPE	0.1 M ABS (pH = 4.5– 5.5)	SWV	^a Cd ²⁺ : 0.0861 nM; Pb ²⁺ : 0.1754 nM; Cu ²⁺ : 0.2463 nM; Hg ²⁺ : 0.3834 nM	Pb ²⁺ and Cd ²⁺ : 1.0–75.0 and 100–1000 nM; Cu ²⁺ and Hg ²⁺ : 5.0– 75.0 and 100–1000 nM	At 0.1 mM of the analytes: 1.97% for Cd ²⁺ ; 1.72% for Pb ²⁺ ; 4.56% for Cu ²⁺ ; 4.45% for Hg ²⁺	96.4–107.9%	No significant interference of 100 times the concentration of Co^{2+} , Fe^{2+} , Mg^{2+} , Mn^{2+} , Ni^{2+} , Zn^{2+} and Ca^{2+} was observed in the determination of 0.1 mM of the analytes. The modified electrode was successfully employed in the determination of Pb ²⁺ , Cd ²⁺ , Cu ²⁺ , and Hg ²⁺ in river water and soil samples.	208
Hg(II)	<i>Cestrum nocturnum L.</i> leaves extract synthetized Ag-NPs modified GCE	0.1 M KCl	LSV	21 nM	100 nM–10 μM	At 200 nM: 0.98–4.86%	100.25-118.30%	The modified electrode was successfully employed in the determination of Hg ²⁺ in drinking, tap, pond, and river water samples.	209
Hg(II)	Hairpin DNA probe and quantum dot modified SPAuE	NR	DPV	0.11 pM	10 pM–1 μM	At 100 nM: 1.95%	95.55–101.55%	No significant interference of 10 times the concentration of Ca^{2+} , Co^{2+} , Cu^{2+} , Fe^{2+} , Mg^{2+} , Ni^{2+} , Zn^{2+} , Cd^{2+} , Pb^{2+} was observed in the determination of 10 nM of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in deionized water, tap water, ground water and urine samples.	210

Hg(II)	Ag-NPs synthetized from Syzygium aromaticum extract, PANI nanostructural array incorporated GCE	0.1 M PBS (pH = 5.7)	CV	0.382 nM	0.02–80 µM	At 0.01 mM: 0.79%	96.36–100.03%	No significant interference of 0.5 mM of Cu ²⁺ , Cd ²⁺ , Cr ²⁺ , 2-nitrophenol, 4-nitrophenol, and 2,6-dinitrophenol was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in tap, sea water and wastewater.	211
Hg(II)	Chitosan combined with S-doped rGO modified GCE	0.1 M KCl	DPASV	1.6 nM	0.125– 6 μM	At 1 μM: 4.2%	NR	No significant interference of 50 times the concentration of Fe^{3+} , Zn^{2+} , Mg^{2+} , Mn^{2+} , As^{3+} , Na^+ , Cd^{2+} and Co^{2+} was observed in the determination of 50 μ M of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in fish muscle samples.	212
Hg(II) and Cd(II)	Metal oxides NPs synthetized from orange peels extract and PANI modified SPCE	0.1 M HCl	SWV	Cd ²⁺ : 1.08 μM; Hg ²⁺ : 2.72 μM	Cd ²⁺ : 2.2–12.0 μM; Hg ²⁺ : 0.12–1.20 μM	At 6.55 μM: 6.50% for Cd ²⁺ ; At 2.94 μM: 4.44% for Hg ²⁺	NR	No significant interference of Co^{2+} , Mg^{2+} , Fe^{2+} , Ni^{2+} , and Cu^{2+} was observed in the determination of the analytes. A slight decrease of the current peak of Cd^{2+} was observed in the presence of Zn^{2+} .	213
Hg(II) and Cd(II)	Metal oxides NPs synthetized from lemon peels extract and PANI modified SPCE	0.1 M HCl	SWV	Cd ²⁺ : 3.04 μM; Hg ²⁺ : 5.08 μM	Cd ²⁺ : 0.17–1.50 μM; Hg ²⁺ : 2.95–11.80 μM	NR	NR		213
Hg(II)	Au-NPs, biopolymer-coated carbon modified SPE	0.1 M ABS (pH = 3.0)	SWASV	4.5 nM	10–100 nM	At 50 ppb: 5.1%	98–108%	No significant interference of 2 times the concentration of Zn^{2+} , Cd^{2+} , and Pb^{2+} was observed in the determination of 20 ppb of the analyte. Slight interference (an ~8.7% decrease in the peak current) was observed in the determination of 40 ppb of the analyte. The modified electrode was successfully employed in the determination of Hg^{2+} in wastewater matrix and landfill leachate samples.	214
Pb(II)	Cu-chitosan composite nanomaterial modified SPE	0.1 M ABS (pH = 4.5)	SWASV	0.72 ppb	2.5–60 ppb	At 15 ppb: 0.65%	94.8–98.1%	No significant interference of Zn^{2+} , Cd^{2+} , As^{3+} , Fe^{2+} , Na^+ , K^+ , Mg^{2+} , and Ca^{2+} was observed in the determination of the analyte. The modified electrode was successfully employed for Pb^{2+} determination in tap water, mining wastewater and soil leachate samples.	215
Pb(II), Cd(II), and Cu(II)	<i>Bigarreau Burlat</i> kernel shell modified CEP	0.2 M ABS (pH = 6.0)	SWV	Cd ²⁺ : 9.56 ppb; Pb ²⁺ : 8.48 ppb; Cu ²⁺ : 9.77 ppb	Cd ²⁺ : 9.5–80 and 100–1000 ppb; Pb ²⁺ : 8.5–80 and 100–1000 ppb;	At 80 ppb of the analytes: 2.23% for Cd ²⁺ ; 2.68% for Pb ²⁺ ; 3.01% for Cu ²⁺	Cd ²⁺ : 92.30–108.00%; Pb ²⁺ : 95.70–101.40%; Cu ²⁺ : 95.10–108.00%	No significant influence of 100 times the concentration of Ca^{2+} , Mg^{2+} , Mn^{2+} , and Co^{3+} , 30 times the concentration of Fe^{2+} , Zn^{2+} , and 20 times the concentration of Ni ²⁺ was observed in the determination of 0.1 μ M of the	216

					Cu ²⁺ :			analytes. The modified electrode was	
					10-80 and			successfully employed in the	
					100–1000 ppb			determination of Pb^{2+} . Cd^{2+} and Cu^{2+} in	
								tap, sea water and industrial wastewater	
								samples.	
Cd(II)	Imprinted chitosan,	0.1 M ABS	DPV	$1.62 \cdot 10^{-4} \mu M$	0.1–0.9 µM	NR	98.5-109.2%	No significant interference of 20 times	217
``	Au-NPs, graphene	(pH = 5.0)		•				the concentration of Cu^{2+} , Mn^{2+} , Fe^{2+} ,	
	modified GCE	ч ́						Pb ²⁺ , Ni ²⁺ , Zn ²⁺ , and Co ²⁺ was observed	
								in the determination of the analyte. The	
								modified electrode was successfully	
								employed in the determination of Cd ²⁺	
								in tap water, river water and pure milk	-
								samples.	
Pb(II)	Nafion-dispersed N-	0.1 M ABS	DPASV	$0.2~\mu g~L^{-1}$	$0.5 - 100 \ \mu g \ L^{-1}$	At 50 μg L ⁻¹ :	100.1-103.2%	No significant interference of 300 times	218
	doped-carbon framework	(pH = 4.5)				1.3%		the concentration of Fe^{2+} , 70 times of	
	synthetized from	containing						Ca^{2+} , 50 times of Ni ²⁺ , K ⁺ , Na ⁺ and	
	Benincasa hispida and	$1.4 \mu gm L^{-1}$						Hg ²⁺ ,10 times of Mg ²⁺ and Zn ²⁺ , 5 times	
	cattle milk modified GCE	B1 ³⁺						of Co^{2+} , Mn^{2+} and the same	
								concentration of Cd ²⁺ , Al ³⁺ and Fe ³⁺ was	
								observed in the determination of 50 μ g I ⁻¹ of the analyte. The presence of the	
								L of the analyte. The presence of the same concentration of Cu^{2+} was found	
								to interfere in the determination of Ph^{2+}	
								The modified electrode was	
								successfully employed in the	
								determination of Pb^{2+} in tap and lake	
								water samples.	
Cr(VI)	Chitosan coated magnetite	0.85 M HCl	SWACSV	$0.0061 \ \mu g \ L^{-1}$	$0.01-0.30 \ \mu g \ L^{-1}$ and	At 5 μg L ⁻¹ :	87-110%	The modified electrode was	219
	NPs modified CPE	(pH = 0.14)			$0.50 - 30.0 \ \mu g \ L^{-1}$	11.4%		successfully employed in the	
								determination of Cr6+ in drinking and	
								sea water samples.	
Pb(II) and	Biochar, nanodiamonds	0.1 M	SWASV	Cd ²⁺ :	Cd ²⁺ :	At 10.0 μM	Cd ²⁺ :	No significant interference of urea, uric	220
Cd(II)	and chitosan modified	H_2SO_4		$0.110 \mu M;$	$1.0-75.0 \mu M;$	Cd ²⁺ :	95–106%;	acid, caffeine, dipyrone, ascorbic acid,	
	GCE			Pb ²⁺ :	Pb ²⁺ :	3.4%	Pb ²⁺ :	diclotenac, and bisphenol was observed	
				0.056 μΜ	0.25–6.00 μM	At 1.0 μ M Pb ²⁺ :	96–104%	in the determination of the analyte. The	
						3.0%		modified electrode was successfully c_{2}	
								employed in the determination of Cd^{-1} and Pb^{2+} in river water samples	
Pb(II)	Ag-NPs obtained from	0.1 M ABS	SWASV	0.8 nM	0.25_1 uM and	At 5 µM·	100 20-108 02%	No significant interference of $0.25-10$	221
10(11)	Psidium guaiava leaves-	(pH = 5.0)	5 1115 1	0.0 1101	1-10 µM	1.8%	100.20 100.0270	μ M of Cd ²⁺ , Cu ²⁺ and Hg ²⁺ was	
	extract and Pt modified	(p11 010)			1 To pill	11070		observed in the determination of the	
	GPE							analyte. The modified electrode was	
								successfully employed in the	
								determination of Pb ²⁺ in tap, river, and	l
								sewage water samples.	
Pb(II) and	Spent coffee grounds	0.01 M	DPASV	Cd ²⁺ :	Cd ²⁺ :	NR	NR		222
Cd(II	modified CPE	HClO ₄		89 μM;	$30-269 \ \mu M;$				
				Pb ² ':	Pb ² ':				
1				90 µM	50-189 μM	1			

Pb(II),	Tapioca-derived	0.1 M PBS	DPV	Cd ²⁺ :	0.01-0.27 ppm	At 0.2 ppm of	Cd ²⁺ :	No significant interference of 50-500	223
Cd(II),	fluorescent carbon dots	(pH = 2)		0.0028 ppm;		the analytes:	90.47-101.88%;	times the concentration of Mg ²⁺ , K ⁺ ,	
and Cu(II)	and Au-NPs modified	· ·		Pb ²⁺ :		3.19% for Cd ²⁺ ;	Pb ²⁺ :	Na ⁺ , NO ₃ ⁻ and SO ₄ ²⁻ was observed in	
	SPCE			0.0042 ppm;		6.59% for Pb ²⁺ ;	122.00-137.93%;	the determination of 0.2 ppm Cd ²⁺ , and	
				Cu^{2+} :		3.99% for Cu ²⁺	Cu ²⁺ :	0.1 ppm of Pb ²⁺ and Cu ²⁺ . The modified	
				0.0140 ppm			72.73-84.61%	electrode was successfully employed in	
								the simultaneous determination of Cd ²⁺ ,	
								Pb^{2+} , and Cu^{2+} in tap water samples.	
Cd(II),	Na ₂ CO ₃ -activated	0.5 M HCl	DPV	Cd ²⁺ :	Cd ²⁺ :	At $2 \cdot 10^{-8}$ M	96.4–98.5%	No significant interference of 1 µM of	224
Pb(II), and	Hordeum vulgare L. Dust			$2.83 \cdot 10^{-8} \text{ M};$	200–1200 nM;	$Pb^{2+}, 5 \cdot 10^{-7} M$		Mg^{2+} , Ca^{2+} , Na^+ , K^+ , Cl^- , NO_3^- , SO_4^{2-}	
Hg(II)	modified CPE			Pb ²⁺ :	Pb ²⁺ :	Hg ²⁺ , and		and CO_3^{2-} , 0.8 µM of In ³⁺ , Cu ²⁺ , Zn ²⁺ ,	
				$4.3 \cdot 10^{-10} \mathrm{M};$	2.5–20.6 nM;	$8 \cdot 10^{-8} \text{ M Cd}^{2+}$:		Fe^{2+} , Ni^{2+} , Mn^{2+} , Co^{2+} and Tl^+ was	
				Hg^{2+} :	Hg^{2+} :	2.89% for Pb ²⁺ ;		observed in the determination of $2 \cdot 10^{-8}$	
				$3.3 \cdot 10^{-9} \text{ M}$	70–101 nM	3.34% for Hg ²⁺ ;		M Pb ²⁺ , $5 \cdot 10^{-7}$ M Hg ²⁺ , and $8 \cdot 10^{-8}$ M	
						3.85% for Cd ²⁺		Cd^{2+} . The modified electrode was	
								successfully employed for simultaneous	
								determination of Cd^{2+} , Pb^{2+} , and Hg^{2+} in	
C1(II) 1		0.1 M ADC	CINACIA	C 1 ²⁺	1 200 I-1 C 1 4	A+ CO I -1 C	C 1 ² +	river and tap water samples.	225
Cd(II) and $Dl(II)$	Fe_3O_4 , MWCN1, laser	0.1 M ABS	SWASV		$1-200 \ \mu g L^{-1}$ for both	At 60 µg L · of		No mutual interference of Cd ²⁺ and Pb ²⁺	225
Pb(II)	scribed graphene	(pH = 5),		0.10 µg L ';	analytes	each analyte: 2.770 for Dh ²⁺	105.96%;	was observed. No significant	
	composites	containing		PD ⁻ :		5.77% IOF PD ⁻⁷ ;	PD-1:	interference of 50 times the $1 = 10^{-2}$ po 3^{-1}	
	modified CCE	500 μg L D:3+		0.07 µg L		0.97% 101 PD	99.71%	Concentration of Na, CI, SO ₄ , PO ₄ [*] , Eo ²⁺ Eo ³⁺ Z ²⁺ and Ao ³⁺ was absorved	
	modified GCE	DI						Fe , Fe , ZII and As was observed in the determination of 60 μ g L ⁻¹ of the	
								in the determination of 00 µg L of the	
								Ha^{2+} and Cu^{2+} was observed in the	
								determination of the analytes. The	
								modified electrode was successfully	
								employed in the determination of Cd^{2+}	
								and Pb^{2+} in tap water.	
Hg(II).	Zeolitic imidazolate	0.1 M ABS	DPASV	Hg ²⁺ :	Hg ²⁺ :	At 0.05 mM of	Hg ²⁺ :	Slight interference of 50 times the	226
Cu(II),	framework ZIF-8 and	(pH = 3.0)		0.029 µM;	1.0-80.0 µM;	the analytes:	94-114%;	concentration of Zn ²⁺ , Ni ²⁺ , Co ²⁺ , Fe ²⁺ ,	
Pb(II) and	chitosan modified GCE	ч ,		Cu ²⁺ :	Cu^{2+} , Pb^{2+} and Cd^{2+} :	6.2% for Hg ²⁺ ;	Cu ²⁺ :	Ca ²⁺ , Mg ²⁺ , Na ⁺ , K ⁺ , Cl ⁻ , NO ₃ ⁻ , and	
Cd(II)				0.11 μM;	1.0-100.0 µM	3.2% for Cu ²⁺ ;	98.5-107.0%;	SO4 ²⁻ was observed in the determination	
. /				Pb ²⁺ :		4.9% for Pb ²⁺ ;	Pb ²⁺ :	of the analytes. The modified electrode	
				0.062 µM;		5.8% for Cd ²⁺	91.0-107.5%;	was successfully employed in the	
				Cd ²⁺ :			Cd ²⁺ :	determination of Hg ²⁺ , Cu ²⁺ , Pb ²⁺ , and	
				0.14 µM			98.5-110%	Cd ²⁺ in lake water samples.	
Pb(II) and	rGo, CMC, fondaparinux	0.1 M ABS	SWASV	Cd ²⁺ :	2–20 nM	At 4 nM mixture	NR	No significant interference of the same	227
Cd(II)	modified GCE	(pH = 4.5)		0.28 nM;		of the analytes:		concentration of Zn ²⁺ , Hg ²⁺ and Cu ²⁺	
				Pb ²⁺ :		2.77% for Cd ²⁺ ;		was observed in the determination of	
				0.17 nM		2.86% for Pb ²⁺		the analytes. The modified electrode	
								was successfully employed in the	
								determination of Cd ²⁺ and Pb ²⁺ in	
								ground and sewage water samples.	220
Pb(II) and	Eichhornia crassipes	0.1 M HCl	SWASV	Cd^{2+} :	10–5000 μg L ⁻¹	At 4000 μg L ⁻¹	Cd ²⁺ :	No significant interference of 200 times	228
Cd(II	powder modified CPE	(pH = 5.0)		4.9 μ g L ⁻¹ ;		of the analytes: $2 correction c$	96.0-101.8%;	the concentration of K^{+} , Na^{+} , Ca^{2+} ,	
				Pb ²⁺ :		2.6% for Cd^{2+} ;	Pb ² ':	Mg^{2+} , $N1^{2+}$, Ag^{+} , $A1^{2+}$, Mn^{2+} , Cr^{3+} , Ba^{2+} , NUL + 20, times the constant of	
				2.1 µg L ⁻¹		2.4% IOr PD ²¹	98.75-104.00%	$1NH_4$, 50 times the concentration of Γ_3^{++} , Γ_2^{++} and T_2^{++} and 100 cm s ⁺⁺	
1	1	1	1	1	1	1		re , re^{-} and $2n^{-}$, and 100 times the	

								concentration of Cl ⁻ , NO ₃ ⁻ , SO ₄ ²⁻ , PO ₄ ³⁻ , was observed in the determination of 4000 μ g L ⁻¹ of each analyte. Significant interference of 100 times the concentration of Cu ²⁺ was observed in the determination of the analytes. The modified electrode was successfully employed in the simultaneous determination of Cd ²⁺ and Pb ²⁺ in dam water samples.	
Pb(II)	Cellulose-hydroxyapatite carbon electrode composite	0.1 M HCl (pH = 2)	SWASV	0.11 μg L ⁻¹	10–50 µg L ^{−1}	At 40 μg L ⁻¹ : 3.11%	92.50-100.00%	No significant interference of 500 times the concentration of K ⁺ , Na ⁺ , Ca ²⁺ , Mg ²⁺ , Ni ²⁺ , Cd ²⁺ , Co ²⁺ , Cu ²⁺ , Fe ²⁺ , Hg ²⁺ , Mn ²⁺ , Zn ²⁺ , and SDS (anionic surfactant), Triton X-100 (neutral surfactant) and CTAB (cationic surfactant), was observed in the determination of 40 μ g L ⁻¹ of the analyte. The modified electrode was successfully employed in the determination of Pb ²⁺ in tap water, blood serum, and palm oil mill effluent samples.	229
Pb(II) and Cu(II)	Blast furnace slag modified GCE	0.1 M ABS (pH = 5.0)	DPV	Pb ²⁺ : 0.084 μM; Cu ²⁺ : 0.44 μM	10–80 μM for both analytes	NR	NR	Significant interference of 2 times the concentration of Cd^{2+} , Zn^{2+} , and Hg^{2+} was observed in the determination of 1 mM of the analytes.	230
Pb(II) and Cd(II)	<i>Ex-situ</i> Bi film mesoporous silica NPs and chitosan modified GCE	0.1 M HCl and 0.1 M KCl (pH = 2.2)	DPASV	Pb ²⁺ : 0.3 μg L ⁻¹ ; Cd ²⁺ : 0.1 μg L ⁻¹	0–40 μgL ⁻¹ for both analytes	At 20 μgL ⁻¹ of the analytes: 2.26% for Pb ²⁺ ; 1.71% for Cd ²⁺	Pb ²⁺ : 93.3–101.9 %; Cd ²⁺ : 99.3–103.7 %	No significant interference of 10 times the concentration of Ca^{2+} , Mg^{2+} , Zn^{2+} , Fe^{3+} , Ni^{2+} , and Hg^{2+} was observed in the determination of 20 µg L^{-1} of the analytes. Significant interference of 10 times the concentration of Cu^{2+} was observed in the determination of 20 µg L^{-1} of the analytes. The modified electrode was successfully employed in the determination of Pb^{2+} and Cd^{2+} in water lily stems samples.	231
Cu(II)	Amino-functionalized graphene and chitosan composite modified GCE	0.1 M ABS (pH = 4.6)	DVP	0.064 µM	0.4–40 µM	At 32 μM: 2.37%	NR	No significant interference of 13 times the concentration of Ca^{2+} , Cd^{2+} , Fe^{3+} , Mg^{2+} , Ni^{2+} , Zn^{2+} , Na^+ , K^+ , Pb^{2+} , Cr^{3+} , Cr^{6+} , and Co^{2+} was observed in the determination of the analyte.	232
Cr(VI)	Ion imprinted chitosan-graphene nanocomposite modified Au electrode	0.1 M PBS (pH = 7)	DVP	$6.4 \cdot 10^{-10} \text{ M}$	1.0 · 10 ⁻⁹ -1.0 · 10 ⁻⁵ M	NR	96.5–104.0%	No significant interference of Zn^{2+} , Co^{2+} , Cu^{2+} , Ni^{2+} , Mn^{2+} , MnO^{4-} , $C_2O_4^{2-}$, $S_2O_6^{2-}$, and MoO_4^{2-} was observed in the determination of the analyte. The modified electrode was successfully employed in the determination of Cr^{6+} in tap and river water samples.	233

Cd(II)	rGo_CMC_and	0.1 M ABS	SWASV	0.05 nM	2–20 nM	At 2 nM:	NR	No significant interference of the same	234
cu(ii)	glutathione modified GCE	(pH = 4.5)	5	0100 1111	2 20 1101	2.6%		concentration of Zn^{2+} H σ^{2+} Ph ²⁺ and	
	graduinone mounted GCE	(pm = 1.5)				2.070		Cu^{2+} was observed in the determination	
								of 10 nM of the analyte. No significant	
								interference of 0 5–1 μ M of NO ₂ ⁻ SO ₂ ²⁻	
								SO_{2}^{2-} Cl ⁻ Na ⁺ Al ³⁺ Mg ²⁺ K ⁺ Fe ²⁺	
								and Ca^{2+} was observed in the	
								determination of 2 nM of the analyte	
								No significant interference of the	
								cationic surfactant CTAB was	
								observed while the anionic surfactant	
								SDS significantly decreased the neak	
								current of the analyte. The modified	
								electrode was successfully employed in	
								the determination of Cd^{2+} in egg	
								albumin and milk samples	
Pb(II) and	Nafion	0.1 M ABS	DPASV	Cd ²⁺	0.05–5.0 µM	At 0.5 µM	93 5-105 3%	No significant interference of 10 times	235
Cd(II)	Ca-lignosulphonate	(pH = 4.0)	21110	0.003 µM·	0100 010 µ111	mixture of the	2010 1001070	the concentration of Al^{3+} Zn^{2+} Fe^{3+}	
00(11)	functionalized porous	(p11)		Ph ²⁺		analytes:		Co^{2+} Ni ²⁺ Ag ⁺ and Mn ²⁺ was observed	
	graphene nanocomposite			0.010 µM		3.85% for Pb ²⁺ :		in the determination of 5.0 µM of the	
	modified GCE					3.32% for Cd ²⁺		analytes. Significant interference of	
								Hg^{2+} and Cu^{2+} was observed in the	
								determination of the analytes. The	
								modified electrode was successfully	
								employed in the determination of Cd ²⁺	
								and Pb^{2+} in tap and lake water samples.	
Pb(II) and	Graphene oxide,	0.1 M ABS	SWASV	Cd ²⁺ :	5–50 nM	At 5 nM of each	NR	No significant interference of 0.5-1.0	236
Cd(II)	κ-carrageenan and	(pH = 4.5)		0.58 nM;		analyte:		μ M of NO ₃ ⁻ , SO ₃ ²⁻ , SO ₄ ²⁻ and Cl ⁻ was	
	L-cysteine nanocomposite	· ·		Pb ²⁺ :		3.2% for Cd ²⁺ ;		observed in the determination of 5 nM	
	modified GCE			1.58 nM		2.7% for Pb ²⁺		of the analytes. No significant	
								interference of the cationic surfactant	
								CTAB was observed, while the anionic	
								surfactant SDS significantly decreased	
								the peak current of Cd ²⁺ . The modified	
								electrode was successfully employed in	
								the determination of Cd2+ and Pb2+ in tap	
								and ground water, and raw milk	
								samples.	
Pb(II) and	Ag-NPs obtained at pH =	0.1 M ABS	DPASV	^a Cd ²⁺ :	Cd ²⁺ :	NR	NR		237
Cd(II)	4 from grape stalk waste	(pH = 4.5)		2.8 μ g L ⁻¹ ;	9.5–39.7 μg L ⁻¹ ;				
	extract modified SPCNFE			Pb ²⁺ :	Pb ²⁺ :				
				2.7 μg L ⁻¹	8.9–100.4 μg L ⁻¹				007
Pb(II) and	Ag-NPs obtained at $pH =$	0.1 M ABS	DPASV	^a Cd ²⁺ :	Cd^{2+} :	NR	NR		237
Cd(II)	6 from grape stalk waste	(pH = 4.5)		8.1 μ g L ⁻¹ ;	$26.9-39.7 \ \mu g \ L^{-1};$				
	extract modified SPCNFE			Pb ²⁺ :	Pb ²⁺ :				
		0.1.14.4.5.5	DDAGU	3.7 $\mu g L^{-1}$	$12.3-100.4 \ \mu g \ L^{-1}$		G 12+		238
Pb(II) and	Functionalized carbon	U.I M ABS	DPASV	Cd ² ⁺ :	NK	NK	Cd ² ⁺ :	No mutual interference of Cd^{2+} and Pb^{2+}	200
	function of the second filamentous	(pH = 4.5)		$0.1 \mu \text{NI};$			99.2-106.5%;	was observed. The modified electrode	
	iuligi (<i>Trichoaerma</i>			PD-::			PD-::	was successfully employed in the	
1	1		1	0.01 μΜ			93.3-103.0%		1

asperellum) modified				determination of Cd ²⁺ and Pb ²⁺ in rea	1
GCE				water samples.	

^a- simultaneous determination of the analytes; NR - not reported by the authors

ABBREVIATIONS

ABS - acetate buffer solution ASDPV - anodic stripping differential pulse voltammetry CCE – carbon cloth electrode CFE – carbon fiber microelectrode CMC - carboxymethyl cellulose COF – covalent-organic framework CPE – carbon paste electrode CPSPE - carbon paste screen-printed electrode DPASV – differential pulse anodic stripping voltammetry DPAASV – differential pulse adsorptive anodic stripping voltammetry DPV – differential pulse voltammetry GCE – glassy carbon electrode GCPE – graphite carbon paste electrode GO – graphene oxide GPE – graphite paste electrode GRCPE – graphite reinforcement carbon paste electrode GSPE – graphite screen-printed electrode HEPES – 2-[4-(2-hydroxyethyl)-1-piperazinyl]-ethanesulfonic acid IIP – ion imprinted polymer LOD – limit of detection LSASV - linear sweep anodic stripping voltammetry LSV – linear sweep voltammetry MOF – metal-organic framework MILs – Materials of Institute Lavoisier MWCNTs – multiwalled carbon nanotubes NPs – nanoparticles PANI – polyaniline PBS – phosphate buffer solution PDA – polydopamine PEDOT – poly(3,4-ethylenedioxythiophene) PGE – pencil graphite electrode PIGE – paraffin-impregnated electrode PPy – polypyrrole rGO – reduced graphene oxide SPAuE – screen-printed gold electrode SPCE – screen-printed carbon electrode SPCNFE - screen-printed carbon nanofibers electrode SPE – screen-printed electrode

SPGE – screen-printed graphene electrode SPPtE – screen-printed platinum electrode

SSE – stainless steel electrode

 $SqW\text{-}AdSV-square\text{-}wave \ adsorptive \ stripping \ voltammetry$

SWACSV – square wave adsorptive cathodic stripping voltammetry

SWASV – square wave anodic stripping voltammetry

SWCNTs – single walled carbon nanotubes SWV – square wave voltammetry UiO – Universitetet i Oslo

ZIFs – zeolitic imidazolate frameworks

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