Supplementary Information (SI) for New Journal of Chemistry.

Table.S1. Nonlinear equations of kinetic, classic isotherm, and advanced isotherm models

Kinetic models		
Model	Equation	Parameters
Pseudo-first-order	$Q_t = Q_e\,(1 - e^{-k_1.t})$	Q_t (mg/g) is the adsorbed ions at time (t), and K_1 is the rate constant of the first-order adsorption (1/min)
Pseudo-second-order	$Q_t = \frac{Q_e^2 k_2 t}{1 + Q_e k_2 t}$	Qe is the quantity of adsorbed ions after equilibration (mg/g), and K_2 is the model rate constant (g/mg min).
Classic Isotherm models		
Model	Equation	Parameters
Langmuir	$Q_e = \frac{Q_{max}\, bC_e}{(1 + bC_e)}$	C_e is the rest ions concentrations (mg/L), Q_{max} is the theoritical maximum adsorption capacity (mg/g), and *b* is the Langmuir constant (L/mg)
Freundlich	$Q_e = K_f C_e^{1/n}$	K_F (mg/g) is the constant of Freundlich model related to the adsorption capacity and n is the constant of Freundlich model related to the adsorption intensities
Dubinin–Radushkevich	$Q_e = Q_m e^{-\beta\varepsilon^2}$	β (mol²/KJ²) is the D-R constant, ε (KJ²/mol²) is the polanyil potential, and Q_m is the adsorption capacity (mg/g)
Advanced isotherm models		
Model	Equation	Parameters
Monolayer model with one energy site (Model 1)	$Q = nN_o = \frac{nN_M}{1 + (\frac{C1/2}{C})^n} = \frac{Q_o}{1 + (\frac{C1/2}{C})^n}$	Q is the adsorbed quantities in mg/g n is the number of adsorbed ion per site Nm is the density of the effective receptor sites (mg/g)
Monolayer model with two energy sites (Model 2)	$Q = \frac{n_1 N_{1M}}{1 + (\frac{C_1}{C})^{n_1}} + \frac{n_2 N_{2M}}{1 + (\frac{C_2}{C})^{n_2}}$	Q_o is the adsorption capacity at the saturation state in mg/g C1/2 is the concentration of the ions at half saturation stage in mg/L
Double layer model with one energy site (Model 3)	$Q = Q_o \frac{(\frac{C}{C1/2})^n + 2(\frac{C}{C1/2})^{2n}}{1 + (\frac{C}{C1/2})^n + (\frac{C}{C1/2})^{2n}}$	C1 and C2 are the concentrations of the ions at the half saturation stage for the first active sites and the second active sites, respectively n1 and n2 are the adsorbed ions per site for the first active sites and the second active sites, respectively
Double layer model with two energy sites (Model 3)	$Q = Q_o \frac{(\frac{C}{C1})^n + 2(\frac{C}{C2})^{2n}}{1 + (\frac{C}{C1})^n + (\frac{C}{C2})^{2n}}$	

Table.S2. Comparison study between the developed Mth/EXG as adsorbent and other adsorbents in literature

Adsorbent	q_{max} (mg/g)	References
SFR		
Ppy NF/Zn-Fe LDH	63.4	Mohamed et al., (2018)
Glass-MCM-48	62.5	Abukhadra et al., (2019)
MCM-41	68.8	Kaur et al., (2015)
MgO-FLG-FE	201.1	Reddy et al., (2018)
CuO-NP	189.5	Vidovix et al., (2021)
N/porous graphite	20.66	Shaban et al., (2017)
Sepiolite	233.81	Barhdadi et al., (2024)
Ferruginous kaolinite	59.3	Debnath et al., (2017)
HM24	**211.4**	**This study**
PO_4^{3-}		
Lanthanum hydroxides	107.5	Xie et al., (2014)
La doping magnetic graphene	116.28	Nodeh et al., (2017)
Biochar	133	Yao et al., (2011)
Red mud-chitosan microspheres	23.54	Tandekar et al., (2021)
$Mg(OH)_2/ZrO_2$	87.2	Lin et al., (2019)
Zirconia/graphite oxide	149.3	Zong et al., (2013)
ZrO_2 nanoparticles	99	Su et al., (2013)
La_{100}SBA-15	45.6	Yang et al., (2011)
Hydrous zirconium oxide	51.8	Lin et al., (2017)
Calcined Mg-Al-LDHs	40.78	Das et al., (2006)
Kaolintic clay	38.46	Hamdi and Srasra, 2012
HM24	**148**	**This study**