Suplementary

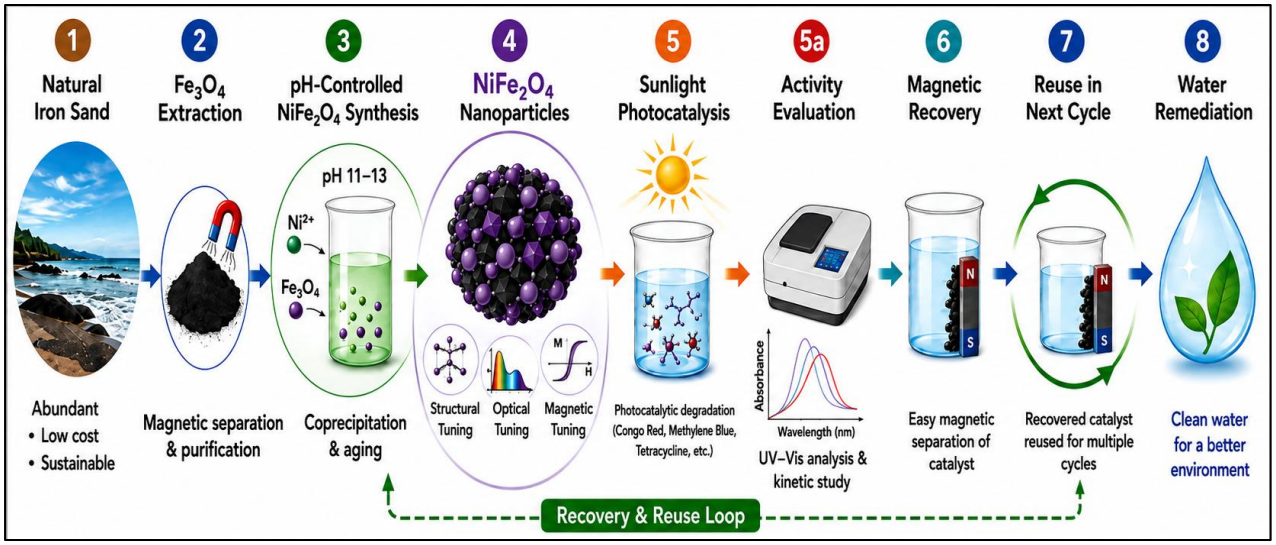

Figure S1 From natural iron sand to recyclable $NiFe_2O_4$ photocatalyst

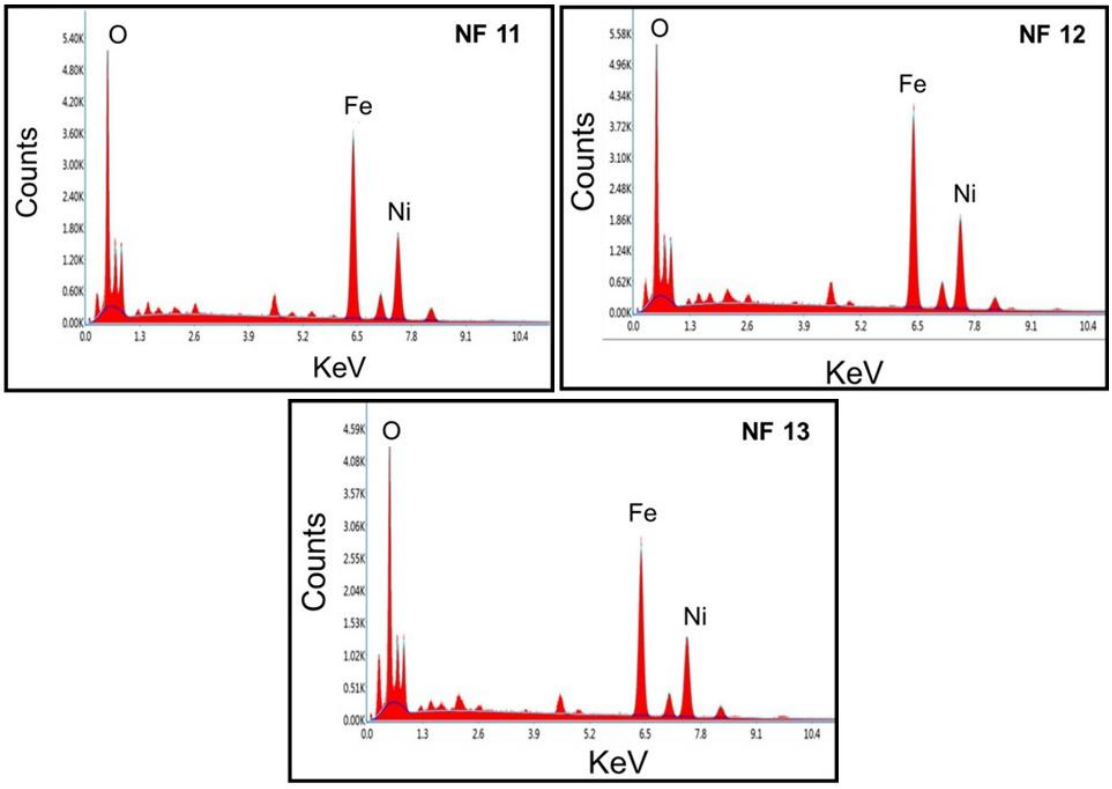

Figure S2 EDX spectrum of NF11, NF12, and NF13

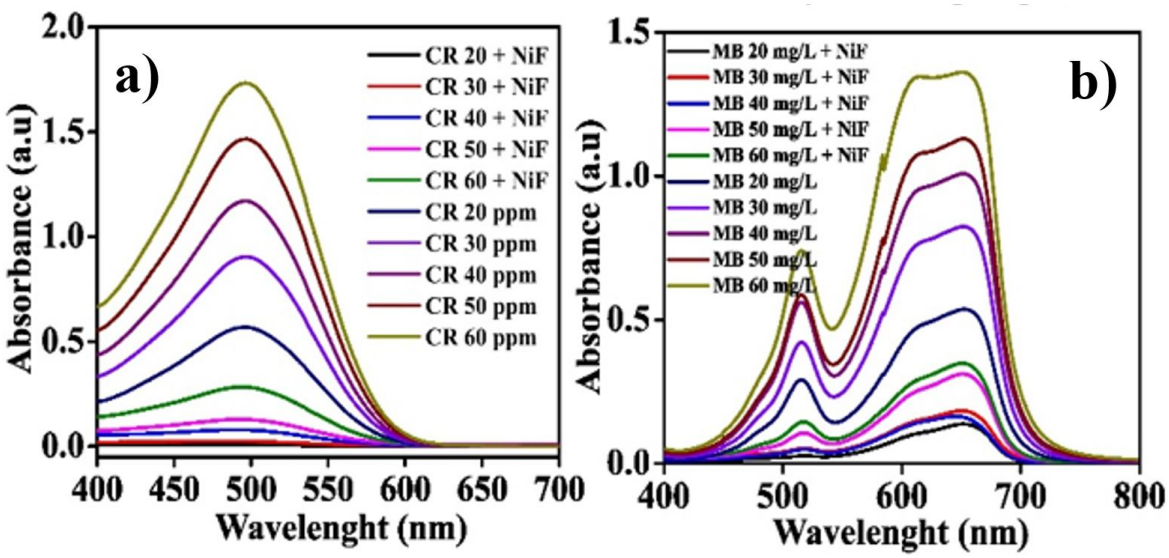

Figure S3 UV-vis Spectrum CR and MB before and after degradation process using NiF13 as catalyst

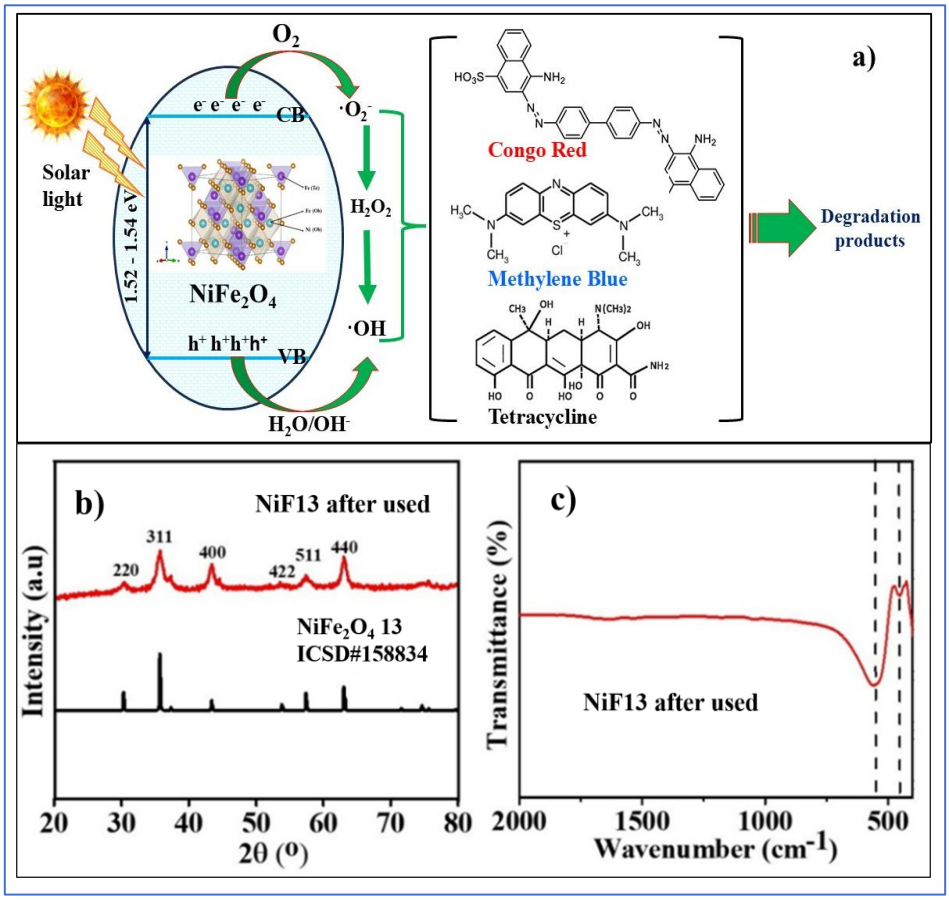

Figure S4 XRD proposed mechanism of the photocatalytic degradation of Congo Red, Methylene Blue, and Tetracycline molecules (a) patterns, and FTIR spectrum of the NiF13 catalyst after used in the photocatalytic reaction (b) and c)

Table S1 Comparative analysis of photocatalytic activity using $NiFe_2O_4$

Materials	Precursor	Fe source	pollutant	concentration	catalyst dose	volume	light source	irradiation time	k	Degradation %	cycles	Ref.
$NiFe_2O_4$	$Ni(NO_3)_2.4H_2O$, $Fe(NO_3)_2·9H_2O$	$Fe(NO_3)_2·9H_2O$	Methylene Blue, Rhodamine B, and Congo Red	10 ppm	0.05 g	100 mL	solar light	11.00 a.m. to 3.00 p.m	0.0149, 0.0135, and 0.0090 min^{-1}	90.2 % 80.2% 90.1 %	3	(Biswas et al., 2024)
$NiFe_2O_4$	$Ni(NO_3)_2.4H_2O$, $Fe(NO_3)_3.9H_2O$	$Fe(NO_3)_3.9H_2O$	Direct yellow 27 and batik waste dyes	30 mg/L	0.02 mg	20 mL	solar light	2 h	-	95% and 84%	-	(Rahmayeni et al., 2019)
$NiFe_2O_4$	$Ni(NO_3)_2.4H_2O$, $Fe(NO_3)_2·9H_2O$	$Fe(NO_3)_2·9H_2O$	Deep Blue and Tetracycline	-	0.5 g/L	100 mL	400 W Hg lamp	30 min	0.2275 min^{-1} for Deep Blue and 0.1178 min^{-1} for Tetracycline	>93%	5	(Aggarwal et al., 2025)
$NiFe_2O_4$	NiO and Fe_3O_4 $Ni(NO_3)_2.4H_2O$, $Fe(NO_3)_2·9H_2O$	$Fe(NO_3)_2·9H_2O$	Oxytetracycline	10 mgL^{-1}	0.25 g L^{-1}	-	25 W Philips Xenon lamp	3 h	0.0346 min^{-1}	87.1% 82.8% 77.4% 72.8%	4	(Vargas-Bustamante et al., 2025)
$NiFe_2O_4$	($FeCl_3·6H_2O$), ($NiCl_2·6H_2O$)	($FeCl_3·6H_2O$)	Methyl orange	10 mg/L	200 mg	100 mL	Sunlight	10.30 a.m. to 3.30 p.m	-	72.66%	-	(Hirthna et al., 2018)

$NiFe_2O_4$	$NiCl_2{\cdot}6H_2O$ and $FeCl_3{\cdot}6H_2O$	$FeCl_3{\cdot}6H_2O$	Ciprofloxacin, erythromycin, and ampicillin	5.00 mg/L	0.1 g	100 mL	150 W, Xe solar simulator	180 min	ERY (0.017 min^{-1}) < AMP (0.024 min−1) < CIP (0.032 min^{-1})	>80 %	15	(Mohammed et al., 2024b)
$NiFe_2O_4$	$NiCl_2.6H_2O$ $FeCl_3.6H_2O$	$FeCl_3.6H_2O$	Methylene Blue and D. Yellow	20 ppm	60 mg	100 mL	UV light from 400-W Hg lamp	Every 15 min	-	89.4% 43%	-	(Amulya et al., 2020)
$NiFe_2O_4$	$Ni(NO_3)_2{\cdot}6H_2O$ and iron sand	iron sand	Congo Red, Methylene Blue, Tetracycline, CR + MB	50 mg/L	20 mg	20 mL	sunlight	120 min	0.029 min^{-1} for Congo Red and 0.014 for Methylene Blue	98% 84% 86% 95%	4	This work

Table S2 Correlation between synthesis pH, crystallite size, band gap energy, and photocatalytic degradation performance toward Congo Red (CR), Methylene Blue (MB), tetracycline (TC), and the CR–MB mixed dye solution.

pH	crystallite size	Band gap	Ms	BET	% Degradation CR	% Degradation MB	%Degradation TC	%Degradation Cr + MB
11	5,78 nm	1,54 eV	7,55	—	—	—		
12	5,16 nm	1,54 eV	6,97	—	—	—		

pH	crystallite size	Band gap	Ms	BET	% Degradation CR	% Degradation MB	%Degradation TC	%Degradation Cr + MB
13	4,63 nm	1,52 eV	4,40	95,7 m^2/g	98%	84%		