Supplementary information

A Magnetic Carbon Sorbent for Radioactive Material of Fukushima Nuclear Accident

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Legend:

MCNC: mesoporous carbon-γ-Fe_2O_3 nanoparticle composite

Cs: cesium

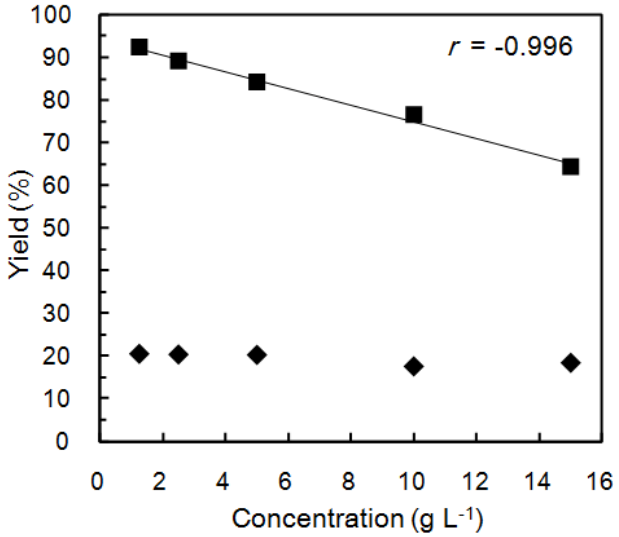

Figure S1 | Concentration dependence on the yield of precursor (square) and the final yield (diamond) of MCNC.

Table S1 | Mössbauer effect parameters of MCNC (concentration of iron(III) nitrate enneahydrate solution: 5.0 g L^{-1}).

Temperature	Component	δ a)	Δ a)	H a)	%Fe
293 K	[1]	+0.44	−0.16	465	41
	[2]	+0.36	0.02	0	59
78 K	[1]	+0.46	−0.04	507	52
	[2]	+0.47	+0.04	451	36
	[3]	+0.40	0.07	0	12

a) δ: isomer shift (mm s^{-1}), Δ: quadrupole shift (mm s^{-1}), H: magnetic field (kOe).

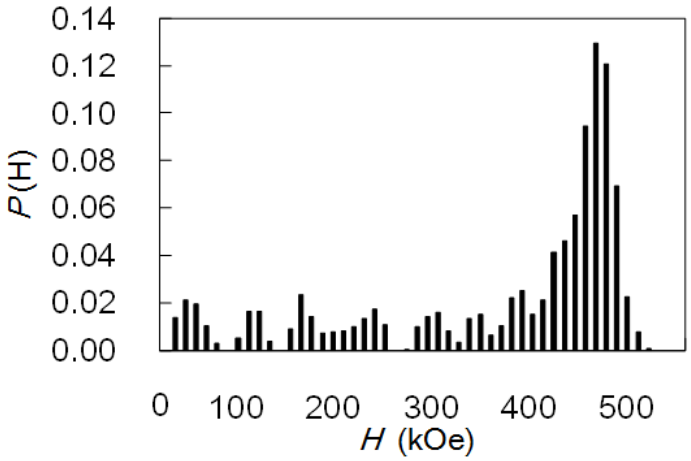

Figure S2 | The magnetic field distribution analysis for MCNC at 78 K, assuming that the tails of the peaks were entirely attributable to magnetic field distribution (concentration of iron(III) nitrate enneahydrate solution: 5.0 g L^{-1}).

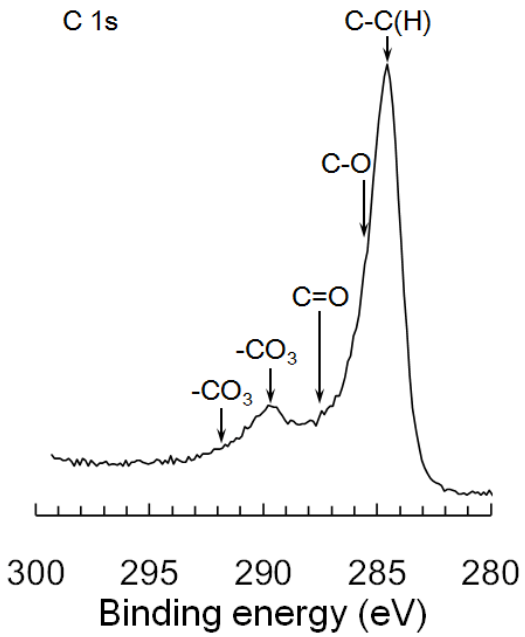

Figure S3 | XPS spectra of C 1s.

Table S2 | Magnetic remanence (M_r), saturation magnetization (M_s), and coercivity (H_c) of MCNC samples synthesized using different iron nitrate concentrations.

Samples (with iron nitrate concentration)	M_r (emu g^{-1})	M_s (emu g^{-1})	H_c (Oe)	M_r / M_s
1.25 g L^{-1}	0.80	5.56	57	0.143
2.50 g L^{-1}	0.90	10.48	53	0.086
5.00 g L^{-1}	1.29	11.89	111	0.109
10.0 g L^{-1}	2.30	28.33	73	0.081
15.0 g L^{-1}	3.56	37.51	74	0.095

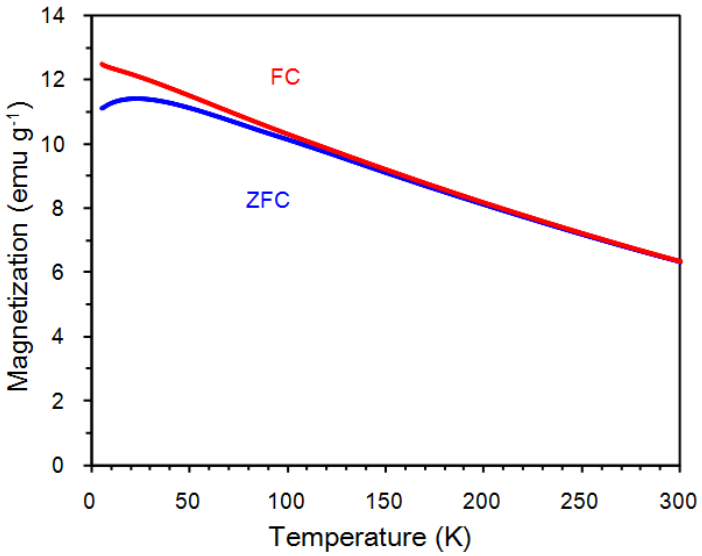

Figure S4 | Zero field cooled (ZFC) and field cooled (FC) magnetization for MCNC (concentration of iron(III) nitrate enneahydrate solution: 5.0 g L^{-1}).

Table S3 | Brauner-Emmett-Teller (BET) surface areas, total pore volumes and average pore sizes of MCNC samples synthesized using different iron nitrate concentrations.

Samples (with iron nitrate concentration)	BET specific surface area ($m^2\ g^{-1}$)	Total pore volume ($cm^3\ g^{-1}$)	Average pore size (nm)
1.25 g L^{-1}	36.4	0.108	11.80
2.50 g L^{-1}	68.3	0.100	5.83
5.00 g L^{-1}	100.6	0.125	4.98
10.0 g L^{-1}	152.1	0.159	4.19
15.0 g L^{-1}	143.7	0.157	4.36

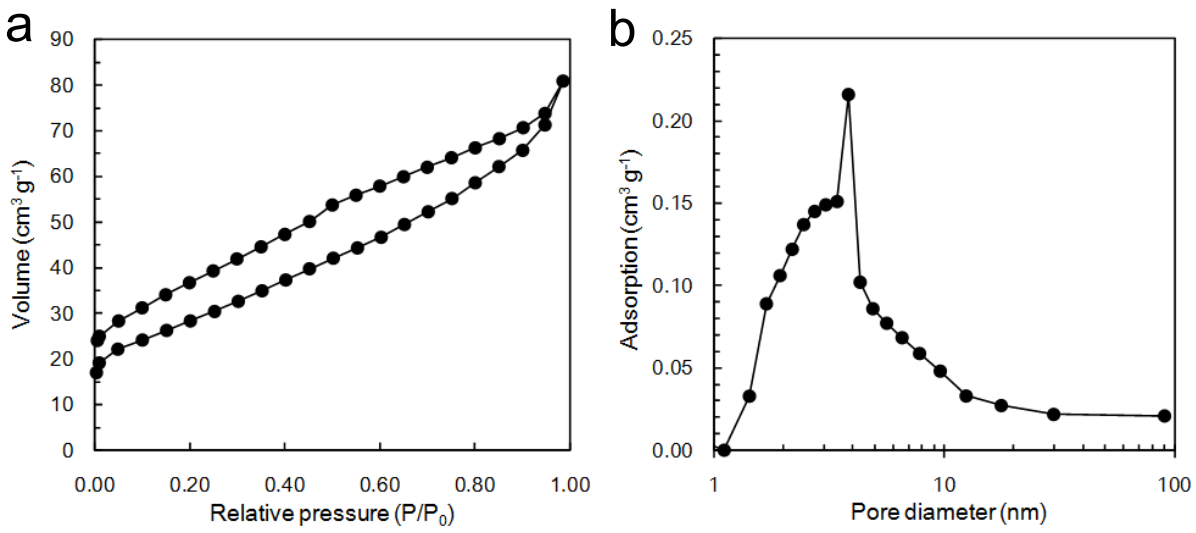

Figure S5 | Pore size distribution of MCNC (concentration of iron(III) nitrate enneahydrate solution: 5.0 g L^{-1}). (a) Nitrogen adsorption-desorption isotherms. (b) Pore size distribution obtained from desorption isotherms as calculated by the BJH (Barret-Joyner-Halenda) method.

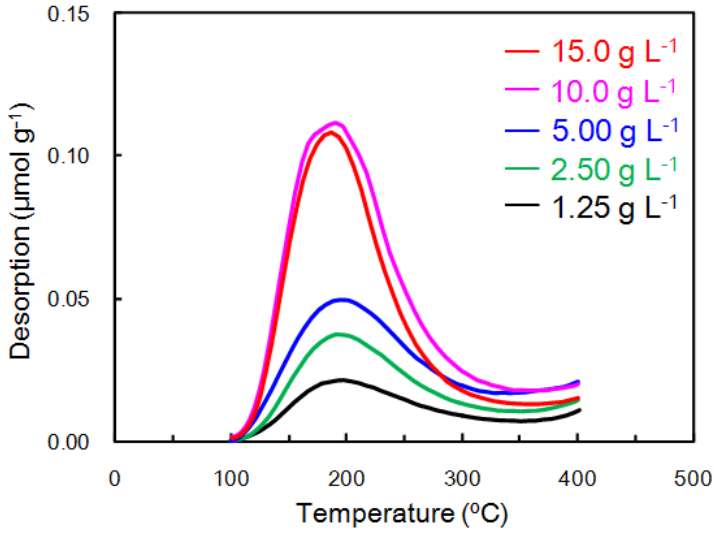

Figure S6 | NH_3-TPD spectra of MCNC.

Table S4 | Total desorptions and peak temperatures of MCNC based on NH_3-TPD measurements.

Samples (with iron nitrate concentration)	Desorption (μmol g^{-1})	Peak temperature (°C)
1.25 g L^{-1}	19.5	196
2.50 g L^{-1}	31.5	190
5.00 g L^{-1}	45.5	194
10.0 g L^{-1}	82.8	189
15.0 g L^{-1}	72.0	185

Table S5 | Compositions of MCNC.

Sample[a] (with iron nitrate concentration)	C (1s)	N (1s)	O (1s)	Na (1s)	Fe ($2p_{3/2}$)
5.0 g L^{-1}	63.5	1.1	22.1	11.7	1.7

a) Elemental compositions by XPS analysis, in atomic percent.

Sample[b] (with iron nitrate concentration)	C	H	N
1.25 g L^{-1}	69.41	2.75	0.88
2.50 g L^{-1}	63.08	2.45	0.87
5.00 g L^{-1}	58.24	1.65	1.00
10.0 g L^{-1}	39.94	1.52	0.64
15.0 g L^{-1}	28.52	1.10	0.54

b) Compositions determined by elemental analyzer, in weight percent.

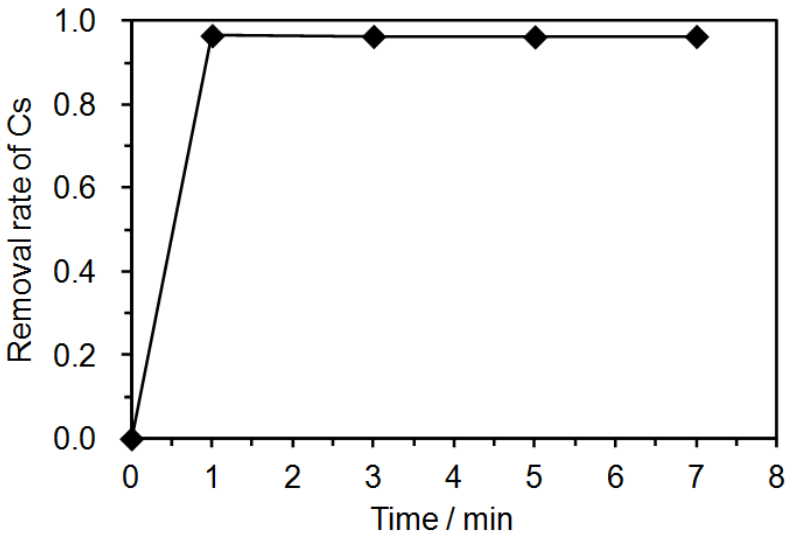

Figure S7 | Kinetics of the removal of Cs. Carbon, 1 g; agitating speed, 150 rpm; CsCl solution, 10mL (0.0075 mM); particle size, under 150 μm.

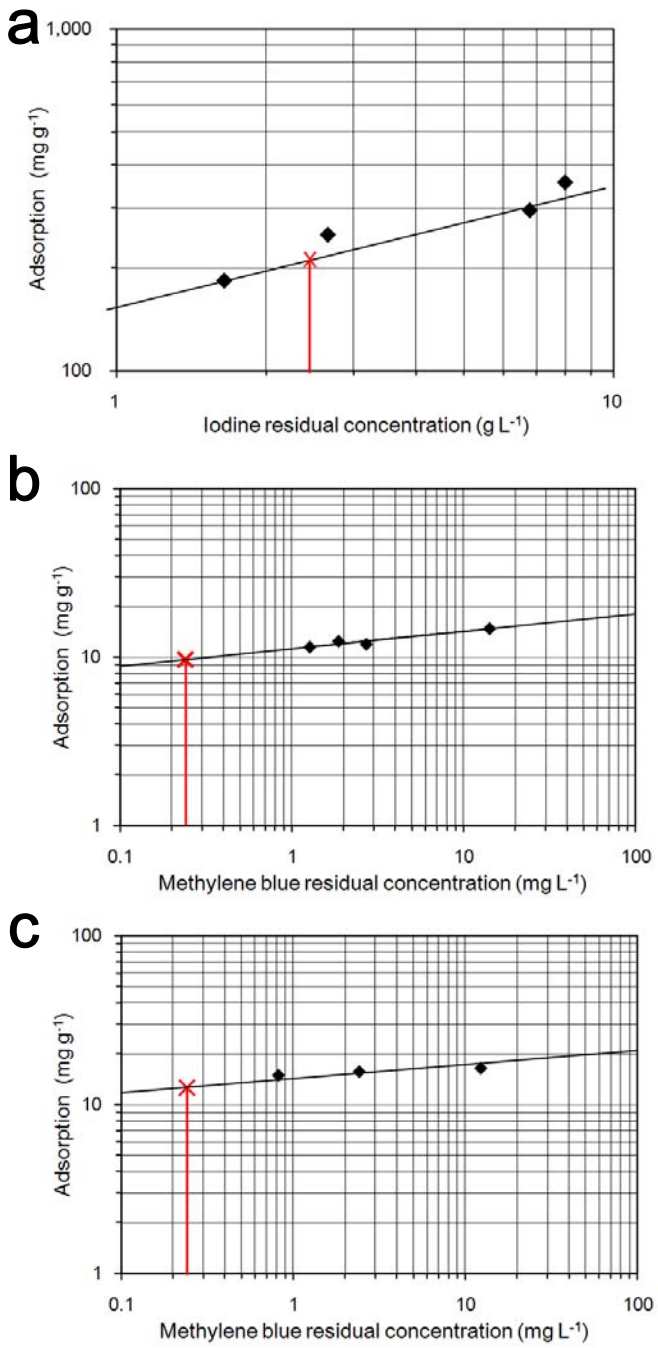

Figure S8 | Iodine (a) and methylene blue (b and c) adsorption performance of MCNC. Particle size is (a) under 150 μm, (b) 100-150 μm and (c) under 100 μm. (b) and (c) : red indicates extrapolation for unmeasurable levels.

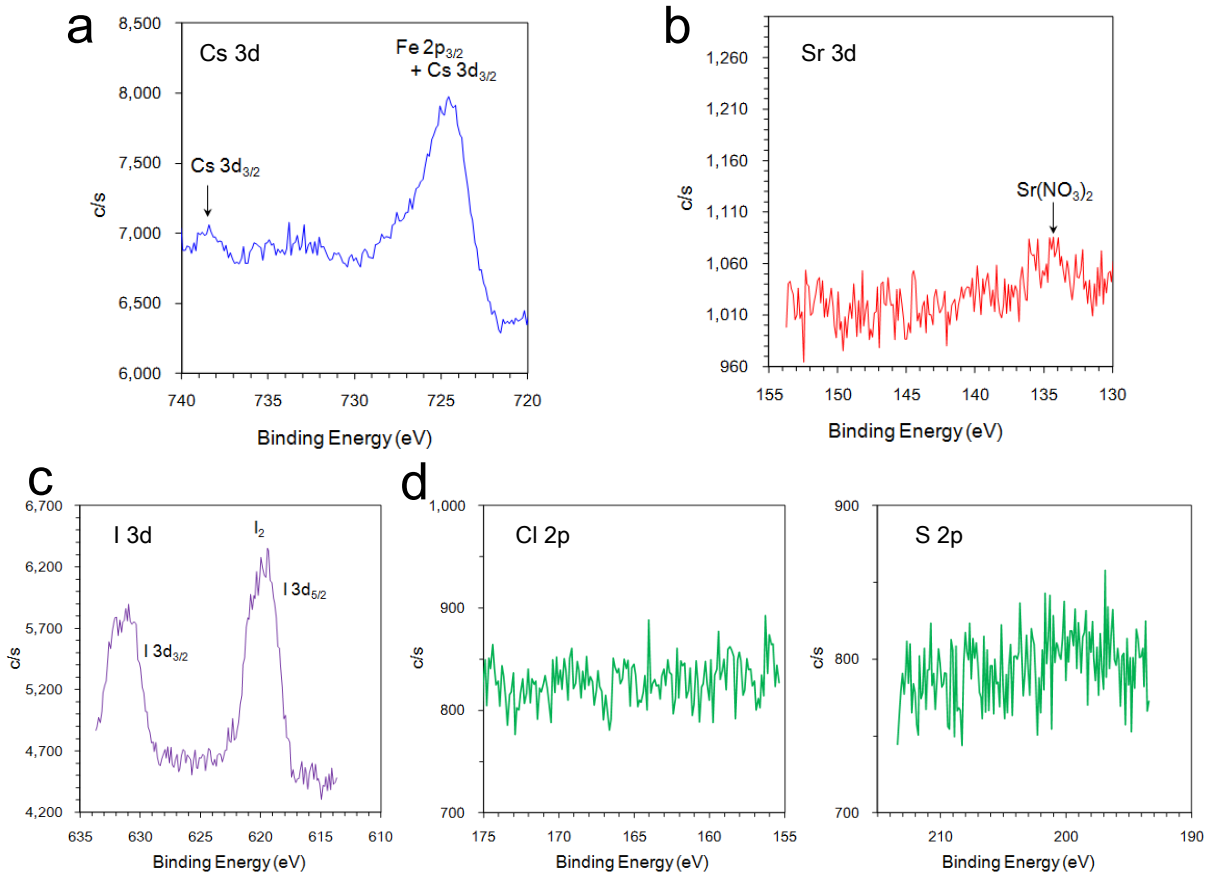

Figure S9 | XPS spectra. (a) Cs 3d, (b) Sr 3d, (c) I 3d, (d) Cl 2p and S 2p.

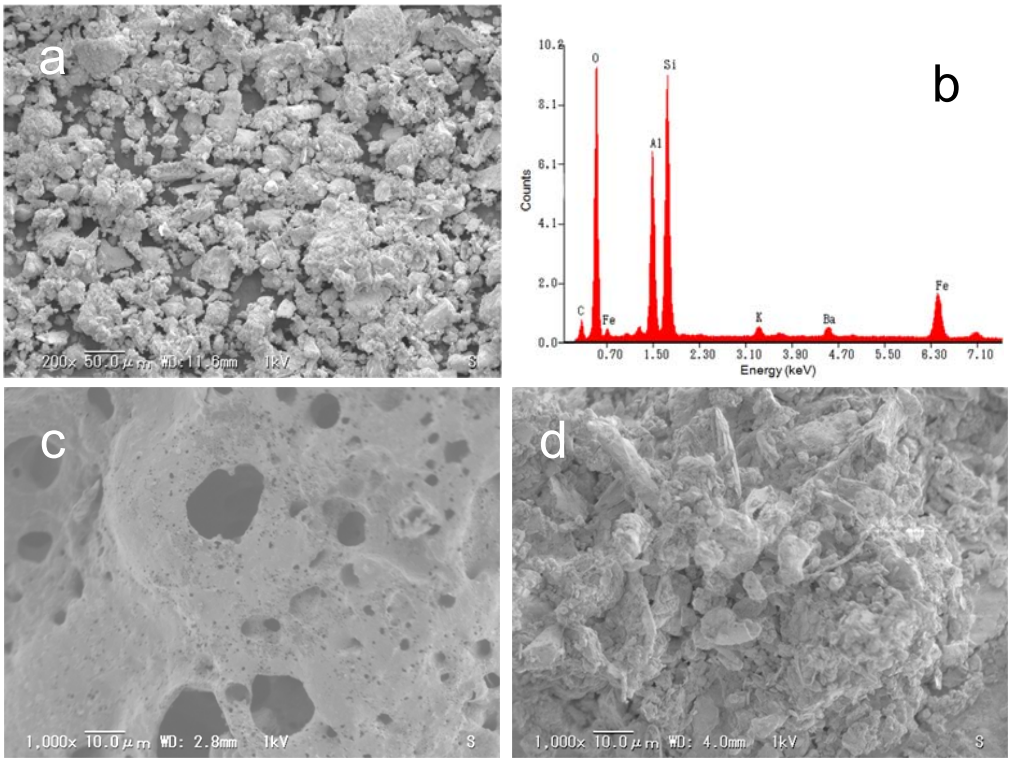

Figure S10 | SEM images of sorbent and soil. (a) Soil, (b) result of EDX analysis, (c) sorbent, and (d) magnetically separated sorbent bonded to clay particles.