Electronic Supplementary Material (ESI) for Environmental Science: Water Research & Technology.

Reutilizations of drinking water treatment residuals (DWTR):

A review focused on the adsorption of contaminants in wastewater and soil

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Table S1. Chemical composition of Drinking Water Treatment Residues (DWTR) expressed in (%) as oxides and used analytical techniques.

Source	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	Analytical technique	pH	Comments	Reference
El-Fustat, Egypt	36.51	22.21	5.65	2.66	1.34	0.49	1.35	-	XRF	-	Albite appears at 500^{o}C	Abo-El-Enein et al., 2017
Ghasiabad, India	52.78	14.38	5.20	4.39	3.08	3.62	0.97	0.61	ED-XRF	6.82	Most particles > 0.1 mm	Ahmad et al., 2016a,b
Taq, Iraq	36.29	27.92	5.33	3.77	1.12	1.81	1.31	-	Not given	-	For cement slabs	Ahmed et al., 2022
17 plants, UK (Al, Fe)	-	0.93-28.69	0.11-42.62	0.09-3.48	0.03-1.53	-	-	-	ICP-AES	4.1-7.1	Estimated from elemental values	Al-Tahmazi and Babatunde, 2016
Various locations						-	-	-	Various techniques		Compiled from several studies and estimated from elemental values	Babatunde and Zhao, 2007
1. Alum	33.4±26.2	56.1±25.1	14.6±17.2	4.1±2.4	1.5±1.3					7.0±1.4		
2. Ferric	nd	18.9±9.1	37.2±22.2	11.6±13.3	2.6					8.0±1.6		
3. Lime	nd	0.9±1.5	4.7±8.3	46.3±29.5	3.7±1.7					8.9±1.8		
Kildare, Ireland	-	8.06	0.48	0.11	0.04	-	-	-	ICP-MS	5.9	For P removal in wetlands	Babatunde et al., 2009
Turkey	16.02	2.62	48.23	8.10	1.15	0.31	0.30	0.53	XRF	7.92	For soil improvement	Bağriaçik and Güner, 2020
Beijing, China	-	18.52	19.06	3.01	0.31	-	-	-	ICP-AES	6.84	Estimated from elemental values	Bai et al., 2014a
Istanbul, Turkey	9.41	51.01	0.70	1.31	0.22	0.20	0.07	0.05	XRF	7.0	Geotechnical study	Balkaya, 2015
Perth, Australia	-							-	ICP-OES		Estimated from elemental values	Bal Krishna et al., 2016
A		0.05	45.76	1.27	0.12	0.01	0.04			7.3		
B		27.22	0.37	0.45	0.06	0.01	0.22			6.9		
C		21.17	1.29	0.50	0.38	0.01	0.10			6.8		
D		19.85	0.99	0.48	0.04	0.01	0.07			7.4		
El-Jidida, Morocco	29.6	19.7	9.6	6.3	1.7	3.6	-	1.2	ICP-OES	-	Tested to recover Al	Ballou et al., 2022
Fort Collins, USA	-				-		-	-	ICP-AES		Estimated from elemental values	Bayley et al., 2008
1991		11.91	2.79	0.48		0.50				6.8		
2002		11.15	0.02	1.75		0.21				7.1		
Rabat, Morocco	27.12	62.66	1.16	1.25	0.37	0.83	0.24	0.16	XRF	-	In ceramic bricks	Benlalla et al., 2015
Columbia	60.91	19.72	11.59	1.48	1.47	2.42	-	0.96	XRF	-	In mortars	Bohórquez González et al., 2020
1. Arcadia (Al)	-	26.46	0.64	0.53	0.16	0.09	-	-	ICP-AES	6.2	For P removal in surface water. Estimated from elemental values.	Boyer et al., 2011
2. Tampa (Fe)		0.47	21.45	3.64	0.14	0.03				6.9		
USA												
Malaysia	43.29	32.19	5.52	0.17	0.33	2.08	0.13	-	XRF	6.6	For cement incorporation	Breesem et al., 2016
1. Abbanoa (Al)	-	24.93	2.48	1.54	0.34	0.46	0.02	-	EDS	6.45	Estimated from elemental values.	Castaldi et al., 2014; 2015; Silvetti et al., 2015
2. Sassari (Fe), Italy		3.65	35.10	0.01	0.01	0.01	-			7.88		
Marrakech, Morocco	45.05	25.93	7.84	3.79	3.80	3.81	1.73	0.86	XRF	-	For olive oil mill wastewater	Chahid et al., 2015

China	52.18	19.90	6.29	1.68	1.38	2.90	0.97	-	ICP-OES	-	For cement production	Chen et al., 2010
Sudbury, Canada	3.97	37.79	0.54	0.42	0.04	-	0.01	-	ICP-OES	5.1	For anionic metals and metalloids	Chen et al., 2018
Fong Yuan, Taiwan, China	53.36	15.28	21.01	1.20	-	5.41	-	1.38	XRF	6.76	In lightweight bricks	Chiang et al., 2009
Flanders, Belgium	10.7	1.9	87.2	9.5	0.4	0.4	-	0.1	XRF	8.1	Estimated from elemental values	Chiang et al., 2012
Rock Hall, USA	-	11.72	29.17	0.13	0.01	0.01	1.63	-	AAS	8.0	Estimated from elemental values	Codling et al., 2000; Codling and Isensee, 2005
Barcelona, Spain	53.7	15.8	5.0	14.4	3.6	3.2	0.4	0.7	XRF	-	For ceramic tiles production	Cremades et al., 2018
Wadi, India	42.31	21.21	21.65	7.44	2.06	-	0.19	-	XRF	7.74	To recover Al	Dahasahastra et al., 2022
Bouregreg, Morocco	33.08	48.94	4.46	4.67	0.7	2.53	0.0	0.36	WD-XRF	-	For cement production	Dahhou et al., 2018
Oklahoma, USA 21 samples	-	18.20	3.53	3.47	-	0.56	-	-	ICP	7.24	Estimated from average values	Dayton et al., 2003
Southern region, Brazil	52.2	26.7	12.4	0.5	1.5	4.2	-	-	SEM-EDS XRF	-	As a supplement for cement	de Godoy et al, 2019; 2020
Southern region, Brazil	40.5	28.5	9.5	0.3	0.4	0.4	0.1	1.0	XRF	5.13	Source of fine mortar aggregates	de Oliveira-Andrade et al., 2018
Sharkia, Egypt	54.1	28.84	9.92	3.1	0.64	0.75	0.30	1.28	Not given	-	For composite cement	El-Didamony et al., 2014
El-bohera, Egypt	22.38	11.79	2.41	1.43	1.51	0.47	0.69	0.65	SEM-EDS	6.5	As nanoparticles. Estimated from elemental values	El-Kammah et al, 2022a; b; c
El-bohera, Egypt	46.6	11.9	71.0	9.7	-	-	-	-	SEM-EDS	6.7	Estimated from elemental values	Elkhatib et al., 2015;
Various locations Alum Ferric Lime	20.0 nd 0.8	21.2 1.6 0.5	3.2 10.9 0.3	2.7 15.0 45.1	0.5 1.6 2.1	1.7 0.3 0.0	-	-	Various techniques	7.0 7.3 10.2	For land application	Elliott and Dempsey, 1991
Bradenton, USA Al Fe Ca	-	16.84 1.60 0.11	0.52 46.90 0.06	2.13 2.30 49.32	0.02 0.12 1.55	-	-	-	ICP-AES	5.25 6.25 8.93	To test P leaching from treated soils	Elliott et al., 2002
Mexico City, Mexico	33.2	31.98	4.94	0.64	0.63	0.43	0.41	-	XRF	5.94	To produce zeolites	Espejel-Ayala et al., 2013
Kluizen, Belgium	11.10	73.90	-	1.90	-	-	-	-	XRF	-	For granulation at high temperature	Everaert et al., 2013
Caracas, Venezuela Activated 600°C	36.24 41.54	29.46 33.60	10.05 11.09	0.98 0.42	1.23 1.51	3.31 3.67	0.83 0.98	1.23 1.36	XRF	-	As a composite for cement	Frías et al., 2014
Mumbai, India	-	12.21	13.30	3.82	2.89	2.41	-	-	ICP	6.4	Modeling dye	Gadekar and

									SEM-EDS		removal	Ahammed, 2019
Beijing, China	-	7.58	12.74	0.99	1.06	-	-	-	ICP-AES	-	Estimated from elemental values	Gao et al., 2013
Sao Paulo, Brazil	34.92	34.11	7.19	-	0.61	1.76	-	0.79	XRF	-	For geopolymer application	Geraldo et al., 2017
Mumbai, India	26.46	25.60	12.84	2.71	2.04	0.60	0.17	-	ICP-AES	7.29	Estimated from elemental values	Ghorpade and Ahammed, 2018
Dartmouth Waterloo Brandon, Canada Tampa Bay, USA	-	27.93 35.34 1.65 1.27	1.65 1.38 0.14 31.27	0.36 3.68 45.82 6.66	0.06 0.61 6.94 0.39	-	-	-	FAAS		For P adsorption. Estimated from elemental values	Gibbons et al., 2009
Dartmouth Waterloo Brandon, Canada New York Tampa Bay, USA	-	23.85 18.33 1.81 6.27 1.27	1.19 0.99 0.16 38.30 39.65	0.18 1.48 39.48 4.51 5.98	0.02 0.37 6.76 1.86 0.37	-	-	-	ICP-AES	-	For P and As adsorption. Estimated from elemental values	Gibbons and Gagnon, 2010; 2011
SãoPaulo, Brazil	44.80	30.23	12.17	0.37	0.83	2.01	0.19	1.30	XRF	-	For mortars repair	Hemkemeier et al., 2023
Yu Qing Que He Xue Shan Sun He, China	-	21.22 12.13 12.68 17.26	4.45 2.53 2.50 6.05	7.15 13.71 14.62 1.90	2.26 1.96 1.31 1.98	1.42 1.13 1.10 1.55	-	-	SEM-EDS	-	For P adsorption. Estimated from elemental values	Hou et al., 2018
Brisbane, Australia	5.33	21.00	2.63	0.01	0.02	0.05	0.06	-	ICP-AES	6.4	Estimated from elemental values	Hua et al., 2015
Taipei, Taiwan, China	43.42	10.48	5.51	0.06	-	0.92	0.52	-	ICP-AES	6.59	For brick making	Huang et al., 2001
Taiwan, China	52.75	20.15	6.75	0.3	-	3.69	0.87	-	ICP-AES EDS	6.59	In bricks and artificial aggregate	Huang et al., 2005
Various plants, Taiwan, China	54.8-65.6	19.6-23.0	4.91-11.30	0.72-4.26	1.06-4.15	0.79-2.08	0.08-1.99	-	ED-XRF	-	For lightweight aggregate	Huang and Wang, 2013
Englewood, USA (Al)	-	12.11	2.51	5.87	0.64	0.37	0.06	-	ICP-AES	7.6	Estimated from elemental values	Ippolito and Barbarick, 2006
Fort Collins, USA	42.16	14.12	2.54	2.20	0.75	-	-	-	ICP-AES	6.9	Estimated from elemental values	Ippolito et al., 2009
3 locations, Taiwan, China	37.62 32.19 52.79	40.79 22.67 14.99	19.50 19.36 19.67	-	-	-	-	-	ICP-AES	6.1 6.8 6.5	Washed to remove impurities	Irawan et al., 2011
Go-san, South Korea	16.41 (105°C) 21.43 (300°C) 21.47 (500°C)	42.48 60.07 47.12	0.77 1.29 1.14	-	0.37 0.50 0.65	-	-	-	SEM-EDS	-	Estimated from elemental values	Jeon et al., 2018
Beijing, China	21.25	23.10	42.00	9.36	0.58	0.38	0.28	0.23	ICP-AES	-	Added to blast furnace slag to form geopolymer	Ji and Pei, 2020

Australia (1) Xi'an China (2) (3) (4)	26.59 28.16 28.83 26.94	29.35 27.76 28.60 29.54	4.93 6.98 5.79 4.31	1.73 4.01 1.39 3.98	0.64 1.02 0.99 0.98	1.08 1.44 1.62 0.87	0.44 0.37 0.58 0.17	-	XRF	-	For cement-based materials	Jia et al., 2021
Seoul, South Korea	29.3	30.7	4.8	1.0	-	1.2	-	-	XRF	-	Calcined at high temperature	Jung et al., 2016a
Seoul, South Korea	42.0	39.3	8.3	1.4	-	1.9	-	-	XRF	-	Al recovery and reuse	Jung et al., 2016b; c
Go-san, South Korea	16.4	38.5	2.9	-	0.37	-	-	-	XRF SEM-EDS	-	Pelletization with bentonite	Jo et al., 2021a
Putrajaya, Malaysia	48.82	40.42	5.30	0.22	0.44	2.08	0.08	-	XRF	7.70	In self-compacting concrete	Kaish et al., 2018
Putrajaya, Malaysia	41.98	33.09	5.05	0.43	0.31	1.83	0.06	0.58	XRF	-	As a replacement for fine aggregate	Kaish et al., 2021
Go-san, South Korea	35.6	51.1	4.02	0.96	0.52	1.22	0.24	0.32	XRF	-	Binder and gelling solution	Kang et al., 2019a
Lithuania	10.90	1.34	68.65	8.23	0.61	-	-	-	EDS	7.81	For ceramic products	Kizinievič et al., 2013
Beijing, China	19.89	35.24	34.88	4.95	0.28	0.29	-	0.22	XRF	-	Use for granulated materials	Li et al., 2020
Australia	17.1	30.1	3.1	4.1	0.6	0.5	0.2	-	XRF	-	In mortar	Li et al., 2021
Waanshan, China	57.64	20.41	9.21	3.24	2.63	3.76	-	-	EDS	-	Estimated from elemental values	Lian et al., 2020
Taipei, Taiwan, China	53.6	20.9	6.6	0.3	1.9	-	-	-	Not given	6.7	For pavement materials	Lin et al., 2006
Sungai Dua Penang, Malaysia	40.33	31.84	6.43	0.09	0.48	1.32	0.04	0.46	XRF	-	Substitute of green clay in ceramics	Ling et al., 2017
Happy Valley, Australia	26.43	28.27	6.66	5.36	1.11	1.23	-	-	XRF	-	For concrete paving blocks	Liu et al., 2020a; b
Adelaide, Australia	31.11	47.68	4.94	4.32	0.96	0.97	0.19	-	XRF	-	In cement blocks	Liu et al., 2021a; b; 2022a
Bradenton, USA (Al) (Fe)	-	17.46 1.85	35.89 1.85	-	-	-	-	-	ICP-AES	5.4 6.3		Makris et al., 2004
Bradenton, USA (Al) (Fe)	-	16-5-20.8 0.25	0.66- 1.74 24.31	-	-	-	-	-	ICP-AES	5.6-6.1 6.0	Estimated from elemental values	Makris et al., 2006a; b
Rio de Janeiro, Brazil	24.68	30.39	11.59	0.16	0.17	0.35	-	0.90	XRF	-	In red ceramic	Monteiro et al., 2008
Surat, India	0.82	21.26	6.91	2.87	1.81	-	-	-	ICP-AES	6.4	Estimated from elemental values	Nair and Ahammed, 2015
Meet Khames, Egypt	-	41.2	1.1	1.2	0.73	-	-	-	ICP	-	For P removal	Nawar et al., 2015
Bangkok, Thailand	58.99	24.64	6.63	0.69	1.14	1.54	4.08	0.88	XRF	-	In geopolymer	Nimwinya et al., 2016

Araki Meotoisi Tatara, Japan	40.0 59.8 54.2	49.9 29.7 31.2	5.6 6.0 7.4	1.4 1.1 1.6	-	-	-	-	XRF	6.2 6.3 6.4	A possible use for defluoridation	Oh and Chikushi, 2010
Morgan, Australia	-	13.66	11.76	2.38	-	-	0.10	-	Not given	7.3	Estimated from elemental values	Oliver et al., 2011
Selangor, Malaysia	42.38	35.03	4.94	0.13	0.29	1.87	0.10	-	XRF	7.2	In concrete	Owaid et al., 2014; Ching et al., 2021; Ng et al., 2022
South Australia	26.43	28.27	7.66	5.36	1.11	1.23	-	-	Not given	-	In mortar	Pham et al., 2021
Malaysia	43.5	28.6	7.8			2.1			XRF	6.03	In bricks	Rahman et al., 2019
Cairo, Egypt	43.12	15.97	5.26	5.56	0.85	0.26	0.52	-	Not given	-	For brick manufacturing	Ramadan et al., 2008
Aswan, Egypt (2 sources	54.72 55.92	12.1 11.1	10.32 13.43	-	-	-	-	-	SEM-EDS	-	For methylene blue adsorption	Rashed et al., 2016
Barcelona, Spain	29.63	17.57	5.18	11.85	2.15	2.85	6.09	0.56	XRF	-	Cement industry	Rodriguez et al., 2010; 2011
Rio Grande do Sul, Brazil	66.93	17.86	11.01	0.74	-	1.35		1.10	SEM-EDS	-	Cement industry	Ruviaro et al., 2021
Bangkok, Thailand	48.0	25.0	7.0	1.2	0.9	1.8	-	-	XRF	-	For As adsorption and stabilization	Sarntanayoot et al., 2019
York, United Kingdom	10.28	44.24	2.51	2.50	0.34	0.43	0.15	0.16	XRF	-	For cement-based materials	Shamaki et al., 2021
Yogyakarta, Indonesia	0.02	13.23	4.29	0.70	0.33	-	-	-	ICP-AES	-	Estimated from elemental values	Siswoyo et al., 2019
Visakhapatnam, India	1.6	47.2	7.18	-	-	-	-	20.65	Not given	-	For fluoride removal	Sujana et al., 1998
Minia, Egypt	44.21	16.47	4.12	4.62	0.74	0.31	0.61	-	XRF	-	Calcined at 900°C	Tantawy, 2015
Minia, Egypt	59.70	10.52	4.38	6.01	2.20	1.16	1.53	-	XRF	-	For brick manufacturing	Tantawy and Mohamed, 2017
Brisbane, Australia	3.56	25.77	1.10	0.41	0.21	0.04	-	0.27	XRF	7.2	Added to soils	Tay et al., 2017
Pulau Indah, Malaysia	36.38	19.74	2.34	2.83	0.24	0.43	0.14	0.18	XRF	-	For roofing tiles	Teoh et al., 2022
Midmar Midvaal Amatola Rand Faure 1 Faure 2 South Africa	54.57 53.07 52.59 24.36 29.93 37.96	22.60 22.36 29.06 9.89 8.70 17.78	11.95 14.24 10.31 4.85 53.80 32.13	4.20 4.45 1.55 53.19 3.15 3.35	1.92 1.83 1.82 5.25 0.72 1.54	1.47 1.89 2.98 0.82 0.93 1.86	0.15 0.33 0.43 0.61 - 0.49	0.86 0.74 0.86 0.31 0.78 0.62	XRF	7.78 7.66 6.94 8.66 6.19 7.23	For land application	Titshall and Hughes, 2005
Chuncheon, South Korea	19.10	47.20	2.10	0.42	0.18	0.46	0.14	-	XRF	6.69	Tested as such and calcined	Van Truong and Kim, 2021
Bradenton, USA (Al)	-	21.94	0.61	0.78	1.03	-	-	-	ICP-AES	6.62	Estimated from elemental values	Wagner et al., 2008
Bangkaen, Thailand	54.00	29.30	9.84	1.01	0.92	2.58	-	-	XRF	-	In geopolymers	Waijarean et al., 2014

Beijing, China	-	16.14	16.59	2.84	0.25	-	-	-	ICP-AES	6.96	Estimated from elemental values	Wang et al., 2014
Hong Kong, China	40.60	41.31	8.56	1.55	0.86	2.15	0.18	-	XRF	-	For controlled low-strength materials	Wang et al., 2018d
Belo Oriente, Brazil	37.5	30.1	12.3	0.2	0.4	0.9	0.2	1.0	XRF	-	Structural ceramics	Wolff et al., 2015
Beijing, China	6.09	3.22	5.74	6.09	0.98	0.60	0.39	-	ICP-AES	7.16	For cement	Xu et al., 2014
Dublin, Ireland	-	46.05	1.21	1.16	0.75	-	-	-	ICP-AES	-	P removal from wastewater	Yang et al., 2006a
Suzhou, China	54.80	14.86	3.46	-	-		2.18	-	XRF	6.1	For ammonium removal	Yang et al., 2015
Xi'an, China	35.58	32.26	6.25	1.59	1.36	1.59	1.00	0.42	XRF	-	For cement	Yang et al., 2023
Taipei, Taiwan, China	49.2	26.3	6.6	0.8	1.0	3.2	0.6	-	ICP-AES	-	For cement raw materials	Yen et al., 2011
Putrajaya, Malaysia	60.28	52.20	13.56	-	-	7.18	-	-	EDS	-	Estimated from elemental values	Yusuff et al., 2017; 2018
Mexico	33.23	31.98	4.94	0.64	0.63	0.43	0.41	0.48	XRF	-	For ceramic production	Zamora et al., 2008
Beijing, China	-	18.52	19.02	2.94	0.30	-	-	-	ICP-AES	6.80	Pesticide removal	Zhao et al., 2013; 2015
Ballymore, Ireland	33.4	29.3	10.5	2.7	0.89	-	-	-	Not given	6.9	For clay brick. Estimated from elemental values	Zhao et al., 2016
Brisbane, Australia	5.33	20.98	2.63	0.02	0.02	0.06	0.06	-	ICP-AES	6.8	Estimated from elemental values	Zhou and Haynes, 2011a
Beijing, China	16.5	16.6	50.9	7.06	0.83	0.25	0..28	-	XRF	-	NOM removal	Zhou et al., 2018
Harbin, China	40.61	27.36	6.99	2.62	1.89	1.28	1.05	-	XRF	-	For ceramsite	Zou et al., 2009

Abbreviation: AAS: Atomic Absorption Spectrometry; ED-XRF: Energy Dispersive X-Ray Fluorescence; FAAS: Flame Atomic Absorption Spectrometry; ICP-AES: Inductively Coupled Plasma – Atomic Emission Spectroscopy; ICP-OES: Inductively Coupled Plasma – Optical Emission Spectroscopy; NOM: Natural Organic Matter; SEM-EDS: Scanning Electron Microscopy – Energy Dispersive Spectroscopy; WD-XRF: Wavelength Dispersive XRF

Table S2. Conditions of adsorption of trace metals, metalloids, and some anions by DWTR and main observations.

Origin/ (Based Al, Fe, or Ca)	Treatment/ Modification	Metals Metalloids Anions	Medium tested	Tested contact time	Tested pH	Main observations and comments	Reference
El-Fustat, Egypt (Al)	Dried, crushed and fired at 100 to 700 ^{o}C	Cd(II) Ni(II) Pb(II)	Synthetic solutions	0 - 25 h	3.0 - 8.0	Batch experiments showing better removal at higher pH and lower doses of metals. Best removal after 25 h with DWTR fired at 500^{o}C. General removal in the order Pb(II) > Cd(II) > Ni(II).	Abo-El-Enein et al., 2017
Johore, Malaysia (Al)	Oven-dried, ground, and sieved >2 mm	Cu(II)	Synthetic solutions	0 - 720 min	Not controlled	Batch studies showing DWTR tested with other sorbents such as mussel shells and bentonite. More effective removal by mixtures with mussel shells with an adsorption capacity of 9.0-11.8 mg/g. Described by Langmuir isotherm.	Awab and Paramalinggam, 2011
1. Bradenton (Al) 2. Hillsboro (Fe), USA	Dried, milled & sorted in size fractions	As(III) As(V)	Synthetic solutions	24 - 168 h with or, w/o competing ions	3.0 - 9.0	Batch studies showing better removal of both species by Al-DWTR due to larger specific surface area, better by smaller particles of both DWTR and, better in the absence of competing ions. Maximum adsorption at pH 7 up to 40.3 and 50.0 mg/g for As(III) and As(V), respectively.	Caporale et al., 2013
1. Abbanoa (Al) 2. Sassari (Fe), Italy	Dried, ground, and sieved to <0.02 mm	As(V)	Synthetic solutions	0 - 1500 min	4.0, 7.0, 9.0	Batch studies showing better removal by Fe-DWTR than with Al-DWTR. Maximum adsorption at pH 4 and decreasing toward pH 9. Capacity estimated to 120 and 68 mg/g for As(III) and As(V), respectively. FTIR spectra proposing the formation of inner-sphere complexes. Also testing for P adsorption as reported in Table S3.	Castaldi et al., 2014
1. Abbanoa (Al) 2. Sassari (Fe), Italy	Dried, ground and sieved to <0.02 mm	Cu(II) Pb(II)	Synthetic solutions	0 - 1500 min	4.5	Batch studies showing better removal of both metals by Fe-DWTR at pH 4.5 and being slightly higher for Pb(II). Estimated adsorption capacity of 21.8 and 5.7 mg/g for Pb(II) and Cu(II), respectively. Influence of organic matter in the formation of inner-sphere complexes as revealed by FTIR spectroscopy.	Castaldi et al., 2015
Sudbury, Canada (Al)	Dried and homogenized	As(V) Cr(VI) Mo(VI) Se(IV)	Synthetic solutions and mine tailing waters	0 - 450 min	3.0 - 8.0	Batch studies showing complete As(V) removal at any pH and much faster in real mine waters. Better Se(VI) removal at pH < 5. Moderate removal of Cr(VI and Mo(VI) in synthetic solutions but significantly faster in real mine waters. Estimated adsorption capacity going from 26 to 52 mg/g for As(V) in synthetic solutions to real mine waters, respectively with similar results for Se(VI). Adsorption of As on DWTR shown by XPS spectroscopy.	Chen et al., 2018
Flanders, Belgium (Fe)	Dried	As(V), Cd(II) Co(II), Ni(II) Pb(II), Zn(II)	Synthetic solutions, surface waters, and sediments	0 - 48 h	5.5	Batch studies showing much better adsorption of metals in synthetic solutions in comparison to goethite. Improvement of adsorption of DWTR amended with natural zeolite. Efficient removal of metals and metalloids from surface waters and sediment porewaters with 20 mg/g added DWTR. Langmuir model to estimate maximum adsorption capacity of 40, 120, 21, and 39 for As(V), Pb(II), Cd(II), and Zn(II), respectively.	Chiang et al., 2012
Jinan, South Korea	Acid and water-washed and dried	Cd(II)	Synthetic solutions	0 - 320 min	5.0	Batch studies comparing sewage sludge to landfill sludge and DWTR and showing better Cd(II) adsorption (max at 42.7 mg/g) by sewage sludge.	Choi and Yun, 2006
Hong Kong, China (Al)	Dried	Pb(II)	Synthetic wastewater	Not given	9.5 - 12.0	Batch studies showing low Pb(II) removal at pH 9.7 and optimal at pH 11.6 with precipitation of $Pb(OH)_2$ in combining DWTR with fresh alum.	Chu, 1999
Bradenton, USA (Al)	Air dried	Hg(II)	Synthetic solutions	Up to 4 years	Not given	High concentration of Hg(II) adsorbed by a flooding technique on Al-DWTS over long periods. Techniques such as SEM and XPS and sequential extraction showing strong incorporation in DWTS in a residual fraction and a maximum capacity of 24 mg/g.	Deliz Quiñones et al., 2016
Beijing, China	Dried, crushed,	Cd(II)	Synthetic	0 - 1400 min	2.0 - 7.0	Batch studies showing the adsorption of the three metals on the pelletized	Du et al., 2020

(Al, Fe)	sieved, mixed with clay 1:2 in mass, and baked at 600°C	Cu(II) Zn(II)	solutions			sorbent being pH-dependent with a maximum at pH 4.0, 5.0, and 5.0 for Cd(II), Cu(II) and Zn(II), with a capacity of 1.5, 2.8 and 1.2 mg/g, respectively. Cu being favored in competitive adsorption. Electrostatic interaction and surface complexation.	
Elbohera, Egypt (Al)	Air dried, sieved <51 µm and ball milled to <100 nm as nanoparticles	Cu(II)	Synthetic solutions	0 - 120 min	3 - 11	Batch studies showing maximum adsorption on nano-DWTR at pH > 6.0 after 120 min with 71.9 mg/g capacity or ~3.7 times higher than with bulk particles of DWTR. Described by the Langmuir isotherms and pseudo-first-order kinetics. Possibility of reusing over 5 cycles. Also tested for the removal of indigo carmine dye and Thiamethoxam pesticide as reported in Table S4.	El-Kammah et al., 2022a
Mumbai, India (Al)	Oven-dried, crushed, and sieved <150 µm	Cu(II), Co(II), Cr(VI), Hg(II), Pb(II), Zn(II)	Synthetic solutions and wastewater	0 - 480 min	2.5 - 8.5	Batch and column tests showing an increase in the removal of cationic metals with increasing pH and the opposite for Cr(VI). The influence of competition in mixtures being higher at low DWTR dosages. Column test with diluted electroplating wastewater showing removal of Cu(II) at pH 6.0. Capacities of 1.7 and 3.5 mg/g for Cu(II) and Cr(VI), respectively.	Ghorpade and Ahammed, 2018
From Canada, 1. Dartmouth (Al) 2. Waterloo (Al) 3. Brandon (Ca) From USA, 4. Tampa Bay (Fe) 5. New York (Fe)	Dried at 105°C	As	Synthetic solutions & ground-water (GW) from Halifax, Canada	12 d	5.0 - 8.0 8.1 (GW)	Batch adsorption experiments showing the best removal of As by iron-based (2.23 mg/g) and lime DWTR at pH 5 and 6 as explained by more small pores in iron-based measured by porosimetry. A porous surface in iron-based DWTR revealed by SEM in comparison to a smooth surface for Al-DWTR. The 2011 paper also covering P removal as presented in Table 2.	Gibbons and Gagnon, 2010; 2011
Bradenton, USA (Al)	Air-dried and sieved to <2 mm	Hg(II)	Synthetic solutions	0 - 180 h	3.0 - 8.0	Batch studies showing a maximum sorption capacity of 79 mg Hg/g Al-DWTR. Effective immobilization in the studied pH range. Sorption kinetic data as the best fit to a pseudo-first-order model. Potential for soil remediation.	Hovsepyan and Bonzongo, 2009
Brisbane Australia (Al)	Dried, ground, and sieved <200 µm	Mo(VI), V(V), As(V), Ga(III)	Synthetic solutions	0 - 300 min	3.0 - 10.0	Batch studies showing maximum adsorption of Mo(VI) at pH<6.0, V(V) at pH<8.0, As(V) at pH<9.0, and Ga(III) at 4.0<pH<8.0, better than other compared waste sorbents.	Hua et al., 2015
Fort Collins, USA (Al)	Air-dried and sieved to <2 mm	Se(IV) Se(VI)	Synthetic solutions	0 - 28 h	5.0 - 9.0	Batch studies showing no pH effect on adsorption in the tested range (~1.6 mg/g). Se(VI) adsorbed as an outer-sphere and Se(IV) as an inner-sphere complex. Adsorbed Se(IV) being reduced to Se(0) under anoxic conditions.	Ippolito et al., 2009
3 different plants Taiwan, China (Al, Fe)	Washed, oven-dried, and sieved to <150 µm	Boron	Synthetic solutions	0 - 3000 min	4.0 - 11.0	Batch studies showing optimal pH adsorption at 8.2-8.5 with 0.19 to 0.98 mg/g capacities. Best adsorption by DWTR containing more Al through a combination of electrostatic and van der Waals interactions. Proposing a pseudo-second order model.	Irawan et al., 2011
Go-san, South Korea (Al)	Oven-dried, calcined at 300 and 500°C, pulverized	As(V)	Synthetic solutions	0 - 24 h	2.0 - 12.0	Calcination at 300°C improving the adsorption of As(V) (up to 50 mg/g) with enhanced specific surface area in batch studies, not at 500°C because of an increased crystallinity of the adsorbent. Adsorption being optimal below pH 6.	Jeon et al., 2018
Beijing, China (Al, Fe)	Dried	Co(II)	Synthetic solutions	0 - 100 h	3.0 - 8.0	Batch studies showing adsorption equilibrium reaching after 30 h. The maximum adsorption capacity of 17.31 mg/g at pH 6 in a spontaneous endothermic process. FTIR indicating a covalent bond with Fe(Al)-O groups.	Jiao et al., 2017
Go-san, South Korea (Al)	Alone and mixed with bentonite at 0.5 and 1.0% wt.	As(V)	Synthetic solutions and other anions	10 - 1900 min	7.0	Batch and column studies showing a decreased adsorption capacity with the addition of bentonite but improving compressive strength. Maximum adsorption of 22.2 mg/g pelletized adsorbent. Negligible of competing anions except for PO_4^{3-}.	Jo et al., 2021a
Seoul, South Korea (Al)	Air dried and sieved to <850 µm, calcined at 250-	Fluoride	Synthetic and wastewater solutions	0 - 300 min	2.0 - 11.0	Batch and fixed-bed studies showing best results obtained at pH 6-7 with pre-calcined DWTR at 450°C. Maximum capacity of 39.6 mg/g. Possibility of regeneration of the adsorbent. Almost no influence from co-existing anions	Jung et al., 2016a

	650^{o}C, and reacted with Ca-alginate					such as nitrate, chloride, and sulfate.	
Go-san, South Korea (Al)	Oven-dried, sieved at <0.15 mm, calcined at 300^{o}C, reacted with Na-alginate and polyvinyl alcohol	As(V)	Synthetic solutions	0 - 1000 min	-	Batch and column studies showing enhanced adsorption on calcined adsorbents (up to 12 mg/g) due to increased surface area of the bead by 100 fold. Adsorption kinetics being 3-21 times faster than an uncalcined bead.	Kang et al., 2019a
Go-san, South Korea (Al)	Sludge mixed with molasses, oven dried, calcined at 300-400^{o}C	As(V)	Synthetic solutions	0 - 8 h	3.0 - 10.0	Batch studies showing enhanced adsorption after calcination up to 35 mg/g. Pellets thermally treated under air and CO_2 showing 2 times faster adsorption than simply dried and in an N_2 medium.	Kang et al., 2019b
Go-san, South Korea (Al)	Composites made of DWTR & g-C_3N_4 pyrolyzed at 550^{o}C for 4 h and sieved at <150 µm	As(III) As(V)	Synthetic solutions	0 - 4500 min	2.0 - 10.0	Batch studies showing maximum adsorption of As(V) at pH 2.0 under dark and light (up to 60 mg/g composite DWTR: g-C_3N_4 at 1:0.2 ratio, and that of As(III) at pH 7.0 in light. Composite material oxidizing As(III) by photocatalytic action *via* outer-sphere complexation and adsorbing As(V) efficiently changing to inner-sphere complexation and chemisorption.	Kim et al., 2020
Maanshan, China (Fe, Al)	Heated at 600^{o}C and acidified by different [HCl]	Mo(VI)	Synthetic solutions	0 - 900 min	1.0 - 10.0	Batch studies showing the optimal condition of adsorption after thermal activation for 4 h followed by activation of 4.0 M HCl with a solid-to-liquid ratio of 1:1 at low pH (2-4). Maximum capacity at 39.5 mg/g. Reduction of average pore size after heating but increase of surface areas. Possibility of regeneration.	Lian et al., 2019; 2020
1. Colorado 2. Texas, USA (Fe)	Wet and oven-dried	B(III), Cu(II) Cr(VI), Pb(II), Se(VI)	Synthetic solutions and reverse osmosis concentrate	0 - 24 h	5.5, 7.8	Continuous-flow column studies showing high removal of Cu(II) at 1.8 mg/g and Pb(II) at 22 µg/g both at pH 7.8 through inner-sphere complexes. Low removal of non-ionic B(III) at 125 µg/g, and Se(VI) at 17 µg/g, both at pH 5.5. Decreased removal of Se(VI) Cr(VI) at higher pH due to electrostatic repulsions and competition with other anions. No significant effect of water temperature, solid moisture content, or loading rate.	Lin et al., 2014
1. Bradenton (Al) 2. Tampa (Fe) USA	Air dried and sieved <2 mm	As(III) As (V)	Synthetic solutions	0 - 48 h	~ 6 no control	Batch studies showing both Al- and Fe-DWTRs showing high affinities for As(V) and As(III), with Freundlich-type adsorption. The Al-DWTR being less effective in removing As(III) and the Fe-WTR showing a greater affinity for As(III). Estimated capacity at 15 mg/g for both species.	Makris et al., 2006a
Bradenton, USA (Al)	Air-dried and sieved <1 mm	Perchlorate ion	Synthetic solutions	0 - 24 h	Not given	Fast removal of perchlorate (65%) after 2 h and increasing to 76% after 24 h. Possible degradation to chloride over a longer time of 96 h.	Makris et al., 2006b
Bradenton, USA (Al)	Air dried and sieved <2 mm	As(III) As (V)	Synthetic solutions	0 - 48 h	6.5	Batch studies showing high sorption capacity for As(III) and As(V) by Al-DWTR (up to 8.0 mg/g). XAS showing As adsorbed to Al-hydroxide surfaces through strong, inner-sphere surface complexes with Al hydroxides.	Makris et al., 2009
14 plants, UK (Al, Fe)	Air-dried, ground, and sieved < 2mm	Cd, Cr, Pb	Synthetic solutions	0 - 100 h	2.0 - 9.0	Batch studies showing maximum uptake of metals by most DWTR at pH 4 and fitting Freundlich, Langmuir, and Temkin models. Adsorption capacities being generally below 100 µg/g for the three metals. FTIR study showing possible mechanisms of adsorption.	Mohammed et al., 2016
1. Bradenton (Al) 2. Tampa (Fe), USA	Air dried and sieved <2 mm	As (V)	Synthetic solutions	0 - 48 h	3.0 - 9.0	Batch studies showing good removal of As(V) by both DWTR. At 200 g/L solid: solution ratio, maximum adsorption by Fe-DWTR was limited to pH 3-7 and 3-9 by Al-DWTR. Competing effect of phosphate but not sulfate.	Nagar et al, 2010
Delran, USA (Al)	Air dried, sieved <2 mm and mixed with sand to improve hydraulic	Cu(II), Pb(II) Zn(II) TPH	Synthetic solutions	0 - 24 min 0 - 4 month	5.8 - 6.7 Not controlled	Laboratory column and field studies showing higher removal of the three metals and total petroleum hydrocarbons (TPH) from synthetic stormwater when the proportion of DWTR was increased. Increased efficiency at higher pH values.	Na Nagara et al., 2021

	performance						
Bridgewater, (Al) USA	Air dried, sieved <1 mm, milled, and granulated with K-alginate and Ca^{2+}	Cd(II), Cr(VI), Ni(II)	Synthetic solutions	0 - 36 h	5.2 - 7.9	Batch studies showing the removal of metals Cr(VI) > Cd(II)> Ni(II) through pseudo-second-order kinetic Langmuir and Freundlich models. Estimated capacities of 2.95, 2.12, and 1.23 mg/g for Cd(II), Cr(VI), and Ni(II), respectively. Removal is affected by the presence of divalent cations and anions having a strong effect on Cd(II) removal as followed by SEM and FTIR.	Na Nagara et al., 2022
Kelantan, Malaysia (Fe)	Oven-dried, ground, and sieved <0.5 mm	Cu(II) Zn(II)	Synthetic solutions	0 - 1400 min	1.0 - 6.0	Batch studies showing removal by groundwater DWTR. Best removal for both metals at pH 2.5 with 2000 mg/L solid and higher dosage for precipitation.	Ngatenah et al., 2010
Wroclaw, Poland, (Fe)	Washed, air dried, sieved <1 mm	As(III) As(V)	Synthetic solutions	0 - 24 h	3.0 - 13.0	Batch studies showing high adsorption and oxidation of As(III) on FeOOH/MnO_2 DWTR in a two-step chemisorption process with oxidation and inner-sphere complexation. Maximum capacities at 132 and 77 mg/g for As(III) and As(V), respectively. Better adsorption at pH<10. Confirmed by XPS.	Ociński et al., 2016
3 locations, Japan (Al)	Air dried and sieved <425 µm	Fluoride	Synthetic solutions	0 - 720 min	2.0 - 9.0	Batch studies showing maximum adsorption in pH 5.1-6.0 at a maximum of ~19 mg/g, with a rapid increase in initial minutes and a smooth increase afterward. No effect from other ions such as sulfate, nitrate, and chloride.	Oh and Chikushi, 2010
Changhua Taiwan, China (Fe)	Air-dried groundwater treatment sludge	Ni(II)	Synthetic solutions	0 - 120 min	4.5 - 7.5	Batch studies showing no pH effect in the tested range. Increased adsorption with increased initial concentration to a maximum of 11.6 mg/g. Pseudo-second-order process is described by the Freundlich model.	Ong et al., 2017
1. Bradenton (Al) 2. Tampa (Fe), USA	Air dried, ground, and sieved <500 µm. Used to spike 2 Florida soils	As(V)	Synthetic solutions and various soil-solutions	0.17 - 48 h	~6.0, Not imposed but measured	Incubation studies showing efficient and rapid removal of As by both DWTRs with an optimum soil-solution ratio of 1:5. All DWTR loads (2.5 to 10%) highly increasing adsorbed As(V) by both soils with capacities close to 5.0 and 3.2 mg/g for Al- and Fe-DWTR. Desorption of 50% As in high phosphate level.	Sarkar et al., 2007
Bangkok, Thailand (Al)	Oven-dried, crushed, and sieved <500 µm and doped with Fe nanoparticles	As(III) As(V)	Synthetic solutions and wastewater	0 - 120 min	2.0 - 12.0	Batch studies showing optimum removal of both As species at pH 3.0 with 10% wt. Fe added to DWTR. Maximum capacities of 24.2 and 35.5 mg/g for As(III) and As(V) respectively. As in wastewater stabilized after adsorption in cement.	Sarntanayoot et al., 2019
Guwahati, India (Fe, Al)	Air-dried, ground, and pulverized	Fluoride	Synthetic solutions and ground-water	0 - 180 min	5.0 - 9.0	Batch studies showing excellent fluoride removal in synthetic and groundwater at pH 5-8 within 2 h. Isotherm data best fitting to Langmuir and Freundlich models and a maximum capacity of 0.298 mg/g. SEM, FTIR, and XRD showing F^- attachment to metal hydroxyl and oxide groups.	Shakya et al., 2019
1. Abbanoa (Al) 2. Bidighinzu (Fe), Italy	Dried, ground, and sieved to <0.02 mm	Cd(II) Zn(II)	Synthetic solutions	0 - 24 h	4.5, 5.5, 7.0	Batch studies showing better adsorption of both metals by Fe-DWTR and better at pH 7.0 linked to higher content of Fe - Mn oxides and specific surface area (maximum at ~10 and ~22 mg/g for Zn(II) and Cd(II), respectively) compared to Al-DWTR (max at ~ 6 and 10 mg/g for Zn(II) and Cd(II), respectively). Could be linked to inner-sphere complex formation and co-precipitation reactions.	Silvetti et al., 2015
Sapporo, Japan (Al)	Washed, oven dried, crushed, and sieved <1 mm	Cd(II)	Synthetic solutions	0 - 1440 min	2.0 - 9.0	Batch studies showing favorable adsorption at pH 6 to 8 with maximum capacities at 5.3 and 9.2 mg/g. Humic acid and iron oxide being key components of adsorption. Described by the Langmuir model.	Siswoyo et al., 2014
Yogyakarta, Indonesia (Al)	Washed, dried, crushed and sieved <50 mesh	Cd(II)		0-24 h	2.0 - 8.0	Batch studies showing efficient Cd removal by raw, acid-modified, and encapsulated DWTR with a maximum capacity of 25, 40, and 30 mg/g, respectively at pH 7-8. Described by the Langmuir and Freundlich models.	Siswoyo et al., 2019
Bridgewater, USA (Al)	Air dried, sieved <2mm, and ground. Glued and coated on wood mulches	Cu(II) Pb(II) Zn(II)	Synthetic stormwater	0 - 120 min	7.0	Batch and column tests showing effective removal of the three metals within 120 min with maximum capacities of 9.74, 61.07, and 8.14 µg/g, respectively. Adsorption being a 2nd order reaction for each pollutant. Also tested for phosphorus as shown in Table 2.	Soleimanifar et al., 2016

São Carlos, Brazil (Al)	Oven dried and milled compared to soil	Pb(II) Cd(II)	Synthetic solutions and soils	0 - 72 h	5.0	Batch studies showing the adsorption of both metals to DWTR much better than to soil (maximum capacities of 15.67 and 1.04 mg/g for Pb(II) and Cd(II), respectively. In 1:1 DWTR : soil mixture, the bioaccessibility assay showing a reduction of 28.8 and 34.5% for Pb(II) and Cd(II), respectively.	Souza et al., 2019
Visakhapatnam, India (Al)	Oven-dried, crushed, calcined at 400^{o}C for 3h, and sieved <100 µm	Fluoride	Synthetic solutions	0 - 240 min	3.5 - 8.8	Batch studies showing optimal removal of fluoride ions at pH 6 being rapid in the first 5 min and reaching equilibrium at 240 min. Adsorption following first-order kinetics and described by the Langmuir model and the maximum capacity estimated at 5.394 mg/g.	Sujana et al., 1998
Brisbane, Australia (Al)	Oven-dried, ground, and sieved <1 mm as a soil amendment	As, Cd	Synthetic solutions and soils	7 weeks of growth	Acidic soils 5.2 and 5.9	Sandy loam soils amended with 2–4 wt% DWTR significantly reducing Cd and As availability and uptake by vegetable *B. pekinensis* and not limiting P uptake by plants as reported in Table 2.	Tay et al., 2017
Sivas, Turkey (Fe)	Washed, oven dried, pulverized, and sieved <1 mm	Ni(II)	Synthetic solutions	0 - 24 h	3.0 - 7.0	Batch tests showing optimized removal of Ni(II) at pH 6-7 with capacity at 6.97 mg/g. Conditions of adsorption and types of interaction studied by SEM, FTIR, and AFM. Langmuir and Freundlich as better models to describe the process.	Yildiz and Sevinç, 2018
Harbin, China (Fe)	Dried, ground, sieved to <100 mesh, and mixed with chitosan to produce granulated particles	As(V)	Synthetic solutions	0 - 48 h	3.0 - 11.0	Batch and column studies showing better removal at pH<6.5 and higher granules dosage with maximum capacity at 14.95 mg/g. Little effect of Ca^{2+} and Mg^{2+} but a competing effect of some anions at higher concentrations. A better description of the process by the Langmuir model. Possibility of regeneration and reuse of the sorbent.	Zeng et al., 2020
Brisbane, Australia (Al)	Dried	Cr(III) Cr(VI) Pb(II)	Synthetic solutions	0 - 360 min	2.0 - 9.0	Batch studies showing better adsorption of cations at pH>6 and pH=3 for Cr(VI). Described by Freundlich and Langmuir models and correlated to a pseudo-second-order kinetic model for Cr(III) and Pb(II). Maximum capacities at 62.2, 19.2, and 10.9 mg/g for Pb(II), Cr(III), and Cr(VI), respectively. Possible regeneration of surface using 0.1M HNO_3.	Zhou and Haynes, 2010b; 2011a
Brisbane, Australia (Al)	Dried, ground, and sieved <125 µm	Cd(II), Cr(III), Cu(II), Pb(II), Zn(II)	Synthetic solutions	2 h	4.0, 6.0, 8.0	Comparison of 7 solid wastes including DWTR in batch studies. The magnitude of sorption at pH 6.0 followed the general order: Cr(III) ≥ Pb(II) ≥ Cu(II) > Zn(II) = Cd(II). Maximum adsorption capacities of ~100 and 12 mg/g for Pb(II) and Cd(II), respectively. Possible regeneration of DWTR by acid treatment.	Zhou and Haynes, 2011b

Abbreviations: AFM: Atomic Force Microscopy; FTIR: Fourier Transform Infra Red Spectroscopy; SEM: Scanning Electron Microscopy; XAS: X-ray Absorption Spectroscopy; XPS: X-ray Photoelectron Spectroscopy; XRD: X-ray Diffraction Spectroscopy.

Table S3. Conditions of DWTR utilization for the removal or control of phosphorus and phosphorus compounds from various environments.

Origin/ Based Al, Fe, or Ca	Treatment/ Modification	Treated systems	Tested contact time	Tested pH	Main observations and comments	Reference
Holland, USA (Al)	Dried before application	Added to soils to remove excess P	0 - 7.5 y	Soil at pH 6.4 & 6.8	The concentration of water-soluble P reduced by ≥ 60% over 7.5 y and DWTR-immobilized P remaining stable over the same period.	Agyin-Birikorang et al., 2007
17 plants, UK (Al, Fe)	Air-dried, ground, and sieved <2 mm	Synthetic solutions of different [P]	48 h	4.0, 7.0, 9.0	Batch studies showing Al-based DWTR tending to have higher P retention due to higher specific surface areas than Fe-DWTR. P retention up to 26.95 mg/g Al-DWTR. Data being generally well fitting to the Freundlich model. Surface complexation, ligand exchange, and precipitation.	Al-Tahmazi and Babatunde, 2016
Kildare, Ireland, (Al)	Dried, ground, and used particles of 1.18 mm avg.	Condensed phosphate with $(NaPO_3)_{12-13}\cdot Na_2O$ as model	48 h (batch) 140 d (continuous flow)	4.0 - 9.0	Increased P removal with increasing DWTR dosage in batch and column trials. The maximum adsorption capacity of condensed phosphate of 4.52 mg/g at pH 4.0. In continuous flow, P removal efficiency decreasing when P loading increasing. The process is described by the Langmuir model.	Babatunde et al., 2008
Kildare, Ireland (Al)	Air-dried, ground, and sieved <2 mm	Synthetic solutions of different [P]	0 – 120 h	4.0, 7.0, 9.0	Specific surface area ranging from 28.0 to 41.4 m^2/g. Significant P removal achieved in batch and long-term column experiments at pH 5.9-6.0 with a maximum capacity of 31.9 mg/g.	Babatunde et al., 2009
KIldare, Ireland, (Al)	Air-dried, ground, and sieved 0.5 -1.18 mm	Laboratory constructed wetland	1 - 91 d	7.81 (Initial)	Under specific conditions (loading rate of 1.27 m^3/m^2 d & organic loading rate of 279.4–774.7 g-BOD$_5$/m^2 d and 361.1–1028.7 g-COD/m^2 d), the wetland system achieving high removal efficiencies for BOD$_5$ (90.6%), COD (71.8%), reactive P (80%), and soluble reactive P (89%).	Babatunde et al., 2010
Beijing, China (Al, Fe)	Air-dried, ground, and sieved <2 mm	Urban wastewater with various loading of DWTR and P conc.	0 - 300 min	7.80	In a continuously stirred tank reactor, 94% of P being removed from urban wastewater at an initial [P] of 10 mg/L for 2 h in a DWTR dosage of 10 g/L. Low leaching of trace metals.	Bai et al., 2014a
Beijing, China (Al, Fe)	Dewatered DWTR	Lab-scale constructed wetlands in continuous & tidal flow for secondary effluent.	0 - 260 d	7.0 - 8.5	Both continuous flow operation and tidal flow operation systems efficiently removing nutrients TN (76%), TP (98%), and chemical oxygen demand and suspended solids in constructed wetlands to treat secondary effluents. Low leaching of Fe and Al.	Bai et al., 2014b
Perth, Australia (Al, Fe)	Oven-dried, crushed, and sieved <600 µm	Synthetic and second-effluent wastewater	0 - 24 h	4.0 - 9.0	Batch studies showing better and faster P removal by DWTR with higher Al content. One DWTR showing a maximum adsorption capacity of 41.67 mg/g. Pseudo-second-order kinetic well fitted for all sludge samples.	Bal Krishna et al., 2016
Fort Collins, USA (Al)	Mixed with swine wastewater as a source of P.	Tested in a greenhouse to grow spring wheat in comparison to fertilizer	128 d	Soil at pH 8.1 - 8.4	The capacity of the mixture to supply P depending on soil type and being comparable to P-fertilizer in low clay soils. The mixture not affecting soil organic P uptake but increasing phosphatase activity in soils. Al-DWTR as an efficient P fertilizer.	Banet et al., 2020
Arcadia (Al) Tampa (Fe) USA	Dried, crushed, and sieved 420-595 µm	River and organic lake waters	0 - 60 min	Water at pH 7.0 - 7.8	Comparison of several low-cost adsorbents in jar and column tests. The Al-based DWTR being the best-performing material for P removal.	Boyer et al., 2011
Ireland (Al, Fe)	Oven-dried, crushed, and sieved <0.5 mm	Synthetic wastewater	0 - 24 h & long term	8.1 (initial pH)	Data of different parameters used to model long-term phosphorus removal.	Callery et al., 2016
Akron, USA (Al)	Used as such	Synthetic solutions and surface water	0 - 720 h 28 d (long-term)	~7.0	Batch and column experiments showing more efficient P adsorption on DWTR than activated carbon. Theoretical phosphate uptake of 9.0 mg/g Al-DWTR. P adsorption decreasing with increasing pH.	Carleton and Cutright, 2020
1. Abbanoa (Al)	Dried, ground, and	Synthetic	0 - 1500 min	4.0, 7.0, 9.0	Batch studies showing better removal by Fe-DWTR compared to Al-	Castaldi et al., 2014

2. Sassari (Fe), Italy	sieved to <0.02 mm	solutions			DWTR. Proposing inner-sphere complexes by FT-IR. Max at pH 4.0 and decreasing toward pH 9.0. Also testing As(V) and reported in Table S2.	
Trinidad (Al, Fe, Ca)	Oven-dried, crushed, and sieved <2.36 mm	Synthetic solutions	0 - 24 h	2.0 - 10.0	Batch studies showing good adsorption by Al-DWTR at pH 4.0 and best at pH 8.0 for Fe- and Ca-DWTR. The diffusion chemisorption model producing the best description of the process.	Chittoo and Sutherland, 2014
Rock Hall, USA (Al, Fe)	Dried, ground, and sieved to <250 µm	Soils amended with poultry litter and litter	2 - 7 weeks	Soils at pH 4.6 to 5.6	Incubation studies showing increased rates of application of DWTR increasing the litter and soil pH and reducing water-soluble P. Similar results with Fe-rich residues. The 2002 study showing that reducing water-soluble P not severely impacting soil fertility. The 2005 study showing the addition of DWTR to poultry litter effectively reducing P in runoff.	Codling et al., 2000; Codling and Isensee, 2005
21 samples, Oklahoma, USA (Al, Fe)	Dried, ground, and sieved to <2 mm	Sorption tested and runoff from poultry litter	12 min for adsorption	5.3 - 8.2	Variable P sorption capacity depending on the source of DWTR. Reduction of P runoff from 14 to 85% correlated to P level and extractable Al.	Dayton et al., 2003
El-bohera, Egypt (Al)	Air-dried, ground, sieved <51 µm and ball milled to <100 nm as nanoparticles	Synthetic solutions	24 h	3.0 - 11.0	Nanoparticles being more efficient (30-fold) for P sorption at 50 mg/g than bulk DWTR and showing low release from P-saturated solids. Maximum adsorption at pH 3.0 and competing effect of arsenate ions. Described by the Freundlich model.	Elkhatib et al., 2015
Bradenton, USA (Al, Fe, Ca)	Dried	Used to test P solubility and leaching in P-amended soils	0 - 24 h 4 months		Batch and greenhouse tests showing the ability to reduce soluble P as : Al-DWTR > Ca-DWTR > Fe-DWTR. In the greenhouse and absence of DWTR, an important % of P-source in bio-solids leached over 4 months.	Elliott et al, 2002
Kluizen, Belgium (Al)	Oven-dried, milled to 1-4 mm, and calcined in granules at 100-600^{o}C	Synthetic solutions and pilot-plant setup	0 - 24h	4.0 - 9.0	Batch studies showing superior adsorption capacity by the granules calcined at 550^{o}C at initial pH of 4.0. Pilot-scale column test showing the 550 material removing P from a P-rich surface water stream at a flow rate of 200 L/h, at >86% throughout the experiment.	Everaert et al., 2021
Oklahoma, USA (Al)	Not mentioned	Added to poultry litter-containing soils	24 h	Initial pH 7.3	Higher addition of DWTR reducing dissolved P in the runoff by 42% attributed to Al and soluble NH_4-N by 64%. Land application not increasing dissolved solids or Al in surface runoff.	Gallimore et al., 1999
Beijing, China (Fe, Al)	Air-dried, ground, and sieved to <80 mesh	Synthetic solutions	0 - 48 h	5.0, 7.0, 9.0	Batch tests showing strong adsorption ability for 3 forms of P being maximum at pH 5.0 and decreasing with pH increase. Described by a pseudo-second-order model and Langmuir isotherm.	Gao et al., 2013
Athens, Greece (Al)	Dried	Synthetic and real wastewater	0 - 90 min	6.0	Batch studies showing pure Al, Fe, and Ca salts being more efficient P adsorbents than DWTR in synthetic and real wastewater both at pH 5-6. Phosphate removal being associated with the release of OH ions in the solution.	Georganas and Grigoropoulou, 2005; Georganas et al., 2006
4 locations, Canada (Al, Fe, Ca)	Oven-dried, crushed, and sieved in 3 sizes	Synthetic solutions and municipal wastewater	0 - 12 d	6.2 6.8	Batch tests showing ferric DWTR presenting the highest adsorptive capacity followed by the Ca-based DWTR. Ca- and Al-based DWTR showing higher adsorption rates in synthetic solutions. Langmuir isotherms.	Gibbons et al., 2009
From Canada, 1. Dartmouth (Al) 2. Waterloo (Al) 3. Brandon (Ca) From USA, 4. Tampa Bay (Fe) 5. New York (Fe)	Oven-dried, crushed, and sieved in 3 sizes	Synthetic solutions and spiked municipal wastewater effluent	12 d	6.2 6.8	Batch tests showing ferric DWTR showing the highest adsorptive capacity followed by the Ca-based DWTR as explained by porosity measurements. Langmuir isotherm. The study also including As(V) adsorption as reported in Table 1.	Gibbons and Gagnon, 2011

1. Yu Qing (Al) 2. Que He (Al, Ca) 3. Xue Shan (Ca) 4. Sun He (Al), China	Dried	Synthetic solutions	0 - 48 h	Not mentioned	Batch studies showing good P adsorption (up to 6.06 mg/g DWTR), with all samples with the largest capacity of the samples containing more Al. Sequential extraction showing most P forms in inorganic fractions. Better described by pseudo-second order equations.	Hou et al., 2018
Gold Coast, Australia (Al)	Dried, ground, and sieved <2 mm	Synthetic solutions and wastewater effluents	10 h & 48h, continuous flow	6.5 - 7.1 (variation)	Rapid P removal (~ 55%) in the first 20 min. in a small-scale continuous flow experiment. Concomitant release of ammonia and nitrate.	Huang and Chiswell, 2000
Englewood, USA (Al)	Air-dried and sieved to 1.0 - 0.3 mm	Synthetic solutions and river water	0 - 211 d	7.2 - 8.2 (variation)	Batch tests showing a decrease of P content with pH increase during shaking being attributed to the formation of calcium phosphate and not to the release of P in solution. Maximum capacity at 12.5 mg/g.	Ippolito et al., 2003
Go-san, South Korea (Al)	Mixed with charcoal and bentonite in a pellet	Synthetic solutions of NH_4^+, phosphate, and antibiotics	0 - 1560 min	7.5	Batch and column studies showing pellet adsorbent removing 47 and 71% of ammonium and phosphate, respectively. Also efficient to remove sulfathiazole and sulfamethoxazole from solutions as reported in Table 3.	Jo et al., 2021b
Seoul, South Korea (Al)	Air dried and sieved to <850 µm. Calcined at 200-800ºC	Synthetic solutions	0 - 60 h	2.0 – 10.0	Batch tests showing best adsorption results (29.42 mg/g) with DWTR-calcined at 310ºC and pH 4.0. Negligible influence of competing anions in the P adsorption process. Described by the Freundlich model.	Jung et al., 2016b
Derbyshire, UK (Fe)	Used as such or acidified-recovered	Municipal wastewater	0 - 120 min 0 - 24 h	1.0 - 4.5	Batch studies showing improvement of P removal and kinetics when using acidified and ultra-filtered recovered coagulants.	Keeley et al., 2016
Chungju, South Korea (Al)	Dried, ground, and sieved <2 mm	Synthetic solutions	32 min 12 h	3.0 - 12.0	Batch and column experiments showing the highest P removal at pH 3.0 (max. of 25 mg/g), more efficient removal of inorganic P vs organic forms.	Kim et al., 2003
Florida, USA (Ca, Fe)	Tested to be added to wetlands	Agricultural and municipal wastewater	52 weeks	6.7 - 7.4 (wastewater)	Constructed wetland tests showing soluble and total P reduced by 95% in secondary municipal wastewater. Soluble and total P reduced by 18 and 53% in anaerobically dairy wastewater.	Leader et al., 2005
Singapore (Al)	Air-dried, crushed, and sieved to different sizes	Synthetic solutions	0 - 24 h	4.0, 7.0, 9.0	Batch and column studies showing maximum adsorption at pH 4.0 and 40ºC. Best adsorption with smallest sizes and decreasing with increasing size. Maximum capacity of 15.57 mg/g.	Lee et al., 2015
Beijing, China (Fe, Al)	Ai dried, crushed, sieved <125 µm and granulated with Na-alginate and $FeCl_3$	Synthetic solutions	0 - 72 h	3.0 - 11.0	Batch studies showing granulation of DWTR stabilizing the initial metal content and offering strong P adsorption attributed to the formation of Fe- and Al-phosphate. Possibility of recycling. Described by Langmuir and Freundlich models.	Li et al., 2018
Beijing, China (Fe, Al)	Ai dried, crushed, sieved <125 µm and granulated with polyvinyl alcohol	Synthetic solutions	0 - 72 h	3.0 - 11.0	Batch studies showing granulation of DWTR stabilizing the initial metal content and offering strong P adsorption (23.34 mg/g) attributed to the presence of micro- and mesoporous structures induced during a freeze-thaw preparation process. Possibility of recycling. Described by Langmuir and Freundlich models.	Li et al., 2020
El-bohera, Egypt (Al)	Air-dried and sieved <1 mm	Added to 3 types of soils	60 d	7.7 - 8.1 (soil pH)	Incubation and greenhouse tests showing that adding DWTR at 30 g/kg in soils as increasing dry matter yield and plant P concentrations in the plant (shoots and roots).	Mahdy et al., 2007
4 locations (Al) 3 locations (Fe), USA	Air dried and sieved <2 mm	Synthetic solutions to test the long-term stability of adsorption	0 - 80 d	5.8 - 8.3 (not controlled)	Batch studies showing a strong affinity of P for DWTR (9.1 mg/g), higher for Al-based. Slow P sorption kinetics by DWTR suggesting intra-particle diffusion in micro-pores and long-term stability of the adsorption process.	Makris et al., 2004; 2005; Makris and O'Connor, 2007
Islamabad,	Oven-dried, crushed,	Synthetic	0-360 min	3.0 - 9.0	Batch tests showing maximum P removal at pH 4.0 and 5.5 with two	Maqpool et al., 2015

Pakistan, (Al)	and sieved to <2 mm	solutions and municipal wastewater			different DWTRs. Optimized conditions removing 90% dissolved P and 70-80% condensed P from wastewater. Process better described by the Langmuir model.	
São Paulo, Brazil, (Fe)	As such	Added to municipal wastewater treatment plant	Over a 4-y period	Not given	The addition of DWTR to wastewater plants increasing removal efficiencies for solids (93%-96%), organic matter (92%-94% for BOD), and phosphorus (52%-88%), when compared to the period without DWTR addition.	Marguti et al., 2018
Halifax, Canada (Al)	Air-dried, crushed, and sieved <1.25 mm	Aquaculture wastewater and municipal effluent	-	3.0 - 7.0	Batch and fixed bed column tests showing 94-99% P and organic matter removal using 4-16g/L DWTR. Described by the Freundlich model.	Mortula and Gagnon, 2007a; b
Surat, India (Al)	Added for coagulation	Urban wastewater	Continuous flow	4.0 - 11.0	Batch tests showing high removal of COD and turbidity at a DWTR dose of 15 g/L and pH 9. Optimum conditions gave 79% P, 84% suspended solids, 78% BOD, and 99.7% total coliform removal from urban wastewater.	Nair and Ahammed, 2015
Meet Khames, Egypt (Al)	Oven-dried	Synthetic solutions	0 - 60 min	2.0 - 11.0	Batch studies showing maximum and fast P removal at pH 5.0 and 75°C in the first 20 min of contact. The process described by both Langmuir and Freundlich models.	Nawar et al., 2015
Victoria, Australia (Al) 4 locations of various ages	Oven dried and sieved to different sizes	Synthetic solutions	0-24 h	4.0-7.0	Batch studies showing no influence of age on adsorption. Highest adsorption of 6.7 mg/g at pH 4.0. The second smallest fraction of 1.18 mm showing the highest adsorption.	Nguyen et al., 2022a
Morgan, Australia (Fe)	Aggregate of 2 - 5 mm	Loaded with synthetic solutions	31 d	6.2 - 6.7 (initial values)	Constructed apparatus simulating the addition of DWTR on soils showing a strong capacity to remove P under aerobic and anaerobic conditions.	Oliver et al., 2011
Bangkok, Thailand (Al)	Dried, crushed, and sieved 0.3 - 0.6 mm and 0.6 mm	Synthetic solutions and wastewater	0 - 6 h 0 - 125 d 0 - 200 d	-	Batch and column experiments comparing DWTR and oyster shells showing effective P removal faster for DWTR and more efficient with smaller sizes. Adaptable to constructed wetland systems.	Park and Polprasert, 2008; Park, 2009
Dublin, Ireland (Al)	Dried, crushed, and sieved <2.36 mm	Synthetic solutions	0 - 24h	4.0 - 9.0	Batch and continuous flow experiments showing the highest adsorption at pH 4.0 for o-phosphate to a maximum of 10.2 mg/g. Stability of DWTR bed over 30 d to remove 80% P.	Razali et al., 2007
Australia (Fe)	Thickened sludge	Added to urban wastewater	0 - 810 d	7.2	Laboratory-scale with in-sewer addition of Fe-DWTR showing a decrease of P and dissolved sulfide and an increase of total COD and total solids.	Rebosura Jr. et al., 2020; 2021
Dublin, Ireland (Al)	Oven-dried, crushed, and sieved to 3 different fractions and mixed with Ca-alginate		0 - 124 h	3.1 - 12.0	Batch tests showing maximum P adsorption on pelletized beads of 3.1 mm with 2%(w/v) DWTR at pH 3.1. Smaller bead size, higher DWTR levels, and acidic pH conditions resulting in greater P adsorption rates and capacity (19.42 mg/g). Fits the intra-particle diffusion model and pseudo-second-order kinetic model with both Langmuir and Freundlich isotherms.	Shen et al., 2018
Dublin, Ireland (Al)	Used as such	Synthetic solutions	0 - 130 d	Monitored	Simulation tests showing DWTR as an adsorption matrix with aeration in floating treatment wetlands improving the concurrent removal of COD, TN, and TP, with average rates of 88%, 85%, and 90.2%, respectively.	Shen et al., 2019b
Brisbane, Australia (Al)	Oven-dried, ground, and sieved <1 mm used as a soil amendment	Synthetic solutions and soils	7 weeks of growth	Acidic soils 5.2 and 5.9	Sandy loam soils amended with 2–4 wt% DWTR significantly reducing Cd and As availability and uptake by vegetable *B. pekinensis* (see Table 1) and not limiting P uptake by plants.	Tay et al., 2017
Chuncheon, South Korea (Al)	Pulverized, air and oven dried, also pyrolyzed at 500 & 700°C for 1 h	Synthetic solutions	0 - 48 h	4.0 - 10.0	Batch tests showing maximum adsorption at pH 4.0. Faster kinetics and most effective P removal with DWTR pyrolyzed at 700°C. The similar adsorption capacity for air-dried and pyrolyzed DWTR. Chemisorption being the operative mechanism in the pseudo-second-order model.	Van Truong and Kim, 2021
Beijing, China (Fe, Al)	Air dried, crushed, sieved <1 mm, activated	Synthetic solutions	0 - 64 h	3.0 - 9.0	Batch tests showing enhanced P adsorption by heat and acid activation as compared to un-activated WTR. Maximum adsorption at acidic conditions	Wang et al., 2011

	at 600^{o}C, and treated with HCl 0.1 - 3.0 M				and decreasing with pH increase. Two-site Langmuir model. Activated DWTR maintained high P removal under different redox conditions.	
Beijing, China (Fe, Al)	Air dried, crushed, sieved <1 mm, citric, oxalic, and tartaric acids added	Synthetic solutions	0 - 61 d	5.0, 7.0, 9.0	Batch and column experiments showing that the effects of adding organic acids changing from inhibition to promotion with an increase in adsorption time. With pH increase, the inhibitory action of organic acids on P adsorption decreasing gradually changing and promoting adsorption.	Wang et al., 2012a
Nanjing, China (Al)	Oven-dried, crushed, sieved <100 mesh, and granulated at high T with organic binders	Synthetic solutions	24 h	7.0	Batch tests showing granulation with the best binder being $AlCl_3$ at a mass ratio of 8% and the best P removal rate being 87.71%. Starch being the best pore-forming agent at the optimum dosage of 4%. The optimal roasting temperature being at 500^{o}C for 2 h.	Wu et al., 2019
Dublin, Ireland (Al)	Air-dried, crushed, and sieved to different sizes	Synthetic solutions	0 - 48h	4.3 - 9.0	Batch tests showing higher adsorption at pH 4.3 and by smaller particles. Not a significant effect of competing anions. A separate study showing a slight increase in P adsorption over an 18-month aging of DWTR.	Yang et al., 2006a; b; 2008
Xi'an, China (Al)	Air-dried, crushed, and sieved to 2-50 mm	Municipal water in a laboratory-scale constructed wetland	0 - 190 d	Not given	Laboratory scale constructed wetland system showing high removal (99.5%) of P over the period. Removal efficiencies of 65% for chemical oxygen demand(COD), 68% for biological oxygen demand (BOD_5), and 34% nitrogen with a tidal flow strategy to enhance the wetland aeration.	Yang et al., 2011
Suzhou, China (Al, Fe)	Air-dried, crushed, and sieved. One portion calcined at 500^{o}C, one acidified and one calcined after acidification	Synthetic solutions, lakewater, and domestic sewage.	0 - 220 min	2.5 - 11.0	Acidification of DWTR caused a decrease in Al and Fe content. Batch test showing very efficient P removal from the synthetic, lake, and sewage water by acidified and calcined after acidification DWTR at optimum adjusted pH 4-6.	Yang et al., 2014
Dublin, Ireland (Al)	Air dried	Synthetic solutions	Up to 80 d	4.0 - 9.0	Efficient adsorption of P (up to 15.90 mg/g DWTR at pH 4.0). Freundlich as the best model to describe the process and Langmuir and Temkin being also appropriate.	Zhao et al., 2007
Dublin, Ireland (Al)	Air-dried, crushed, and sieved to 1.18-2.36 mm	Synthetic solutions Wastewater from reed bed systems	0 - 38 d 0 - 193 d	4.3 - 9.0 7.3 influent 7.1 effluent	Laboratory simulations through vertical and horizontal flow showing efficient removal of P and organic carbon with a decrease of COD and BOD_5 from synthetic solutions and wastewater. Optimal pH at 4.3. Separate studies showing similar results with DWTR from different sources.	Zhao et al., 2008; 2009; Zhao et al., 2010 a; b; 2011
Sea of Galilee, Israel (Al)	Air dried, crushed, and sieved <2 mm.	Modified with soil leachate and dairy wastewater	1 - 7 d 1 - 62 h for desorption	7.5	Batch studies showing the original non-treated DWTR showing an excellent capacity of P removal and, DOC to a lesser extent, from wastewater. However, the organically modified DWTR showing better slow desorption capacity tending to retain soluble reactive P and release OM and making it a good candidate for P supply.	Zohar et al., 2017

Table S4. Conditions of adsorption of other substances by DWTR and main observations.

Origin / (Based on Al, Fe or, Ca)	Treatment / Modification	Substance	Medium tested	Tested contact time	Tested pH	Main observations and comments	Reference
Adana, Turkey (Fe)	Oven-dried for DWTR, compared to Al and Fe hydroxides	Vegetable oil	Wastewater from refinery	30 min	5.0 - 11.0	Batch tests showing the best removal of oil and grease, COD, and TSS at acidic pH 6 and optimum dose of 1.1 g suspended solids by DWTR. Comparable performance of coagulated Al and Fe salts. Improved performance when adding FeCl$_3$.	Basibuyuk and Kalat, 2004
Marrakech, Morocco (Al)	Oven-dried, crushed, and sieved <2µm	Olive oil	Mill wastewater	30 min	4.5 - 8.5	Batch tests showing a removal rate of turbidity and COD varying from 59 to 93.5% and, from 49.4 to 68% depending on the nature of DWTR (wet or dry).	Chahid et al., 2015
Hong Kong, China (Al)	Oven-dried and compared to freshly precipitated alum	2 Dyes Dianix Blue FBL-E and Ciba-corn Yellow P-6GS	Synthetic solutions	30 min	8.3 - 10.5	Batch studies showing maximum adsorption of dyes at pH 9.13. The back-diffusion of dye can be controlled by the addition of fresh alum. Not recommended for the removal of hydrophilic dyes.	Chu, 2001
El-Beheira, Egypt (Al)	Dried and sieved to 2 mm (bulk) and 51µm, which was ball milled to <100 nm as nanoparticles	Dye Indigo Carmine (IC)	Synthetic solutions	5 - 24 h 0 - 200 min	2.0 - 11.0	Batch tests showing nanoscale particles prepared from DWTR removing 90% of dye at the optimum pH of 5, being more effective than the larger size of DWTR. The calculated Langmuir maximum adsorption capacity of nano DWTR being 5.6 times higher than that of bulk DWTR.	El-Kammah et al., 2022b
El-Beheira, Egypt (Al)	Dried and sieved to 2 mm (bulk) and 51µm, which was ball milled to <100 nm as nanoparticles	Pesticide Thiamethoxam (TMX)	Synthetic solutions and wastewater	5 - 24 h 0 - 300 min	2.0 - 11.0	Nano-DWTR being efficient for TMX removal at optimum conditions at pH 6–7, 100 mg of solid, and 180 min contact time. The process following Langmuir isotherm at 2.6 times higher than that of bulk DWTR. The remediation of TMX from wastewater of 77.9% and 70.3% for batch and column treatment, respectively. Can be re-used in 3 cycles.	El-Kammah et al., 2022c
Asseiceira, Portugal (Ca)	Dried	Olive oil	Olive oil wastewater	20 min 21 d (BOD)	10.5 - 12.5	Batch tests performed with 50 to 300 g/L DWTR, showing effective removal of COD, BOD, total and suspended solids, phenols, total volatile solids, oil and grease, and total phosphorus.	Fragoso and Duarte, 2012
Mumbai, India (Al, Fe)	Sun-dried, crushed, and sieved <256 µm	Dye Disperse Blue 79	Synthetic solutions	10 min	3.0 - 5.0	Optimum color removal of 53% obtained at pH 3.0 with a DWTR dose of 30 g/L and dye concentration of 75 mg/L obtained experimentally in batch test and predicted by the models.	Gadekar and Ahammed, 2019
Hong Kong, China (Al)	Used as such added to sewage raw water	SS COD	Sewage water	50 min	6.5 - 6.9 (DWTR) 7.2 - 7.8 (Sewage)	Batch studies showing suspended solids (SS) and chemical oxygen demand (COD) removal efficiencies improved by 20% and 15%, respectively, mainly due to the removal of particles from 48 to 200 mm. The appropriate dosage of DWTR determined to be 18–20 mg Al/L.	Guan et al., 2005
Dublin, Ireland (Al)	Air dried	Total Nitrogen	Piggery wastewater	99 - 383 d	7.2 - 7.6	Tidal flow constructed wetland systems showing enhanced total N removal under a high N loading rate. Improved N removal with intermittent aeration of the system.	Hu et al., 2012a; b
Thailand (Al)	Addition of used DWTR to test laboratory systems using fresh alum	Anionic surfactants	Wastewater (talcum powder and surfactants)	60 min	2.0 - 12.0	Batch tests showing the addition of DWTR and fresh alum at concentrations of 400 and 600 mg/L, respectively, enhancing the removal of TSS, turbidity, and TCOD to 76.2%, 99.5%, and 92.8%, respectively, at pH 10.0.	Jangkorn et al., 2011
Go-san, South Korea (Al)	Mixed with charcoal and bentonite in a pellet	NH$_4^+$ ions and antibiotics sulfathiazole and sulfa-methoxazole	Synthetic solutions	0 - 1560 min	7.5	Batch and column studies showing pelletized adsorbent efficient to remove 97% sulfathiazole and 72% sulfamethoxazole from solutions. Also efficient in removing simultaneously 47 and 71% of ammonium and phosphate, respectively. as reported in Table 2.	Jo et al., 2021b

Palapye, Botswana	Oven-dried, ground, and sieved <1.18 mm	Saline water	Real water	5 - 840 min	2.2 - 12.0	Batch tests showing maximum removal efficiency of SO_4^{2-}, Cl^-, and $NO3^-$ at 51.5, 22.6, and 100%, respectively, and for Na, Ni, and Mn ions at 100%, 100%, and 87.5%, respectively. Best described by the Freundlich model.	Letshwenyo et al., 2023
Aswan, Egypt (Al)	Air-dried, crushed, sieved <0.2 mm, and pyrolyzed at high T	Methylene blue (MB)	Synthetic solutions	20 - 90 h	3.0 - 9.0	Batch experiments showing the best removal of MB at 100 mg/L by a DWTR pyrolyzed at 700ºC, at pH 7.0. Fitting the Langmuir isotherm model.	Rashed et al., 2016
Tarn, France (Al)	Air-dried, crushed, and sieved <250 µm	H_2S	Synthetic gas mixture	0 - 700 h	Starting at pH 10.0	Fixed bed column studies showing the capacity of DWTR to adsorb H_2S (374.2 mg/g) being higher than that of several reported adsorbents. Knudsen diffusion as the main mechanism.	Ren et al., 2020
Hyderabad, India (Al)	Dried and sieved to various sizes	SO_2	Gas	0-60 min	-	Using 100 mL of gas over 0.8 gram of DWTR at 250, 500, and 710 µm particles and showing the fastest removal with smaller size.	Sirisha et al., 2012
Koszalin, Poland (Fe)	Dried and sieved at 45 to 250 µm	Dyes Ponceau 4R Brilliant blue FCF Malachite green	Synthetic solutions	0 - 24 h	3.5 - 9.5	Batch studies showing dyes Ponceau 4R and brilliant blue FCF not being adsorbed on Fe-DWTR due to its negatively charged surface. Malachite adsorption described by the Freundlich model.	Świderska-Dąbrowska et al., 2018
Suzhou, China, (Fe, Al)	Air-dried, crushed, and sieved. acid–alkali and ultrasonic treatments	Ammonium	Synthetic solutions	24 h	4.0 - 10.0	Batch tests showing non-modified DWTR not being an effective adsorbent for ammonium. The treatment involving acid and alkali ultrasonic modifications showing 80-90% removal of NH_4^+ at pH 7-8 and a maximum capacity evaluated by Langmuir isotherm to 5.1 to 6.1 mg/g.	Yang et al., 2015
Putrajaya, Malaysia (Al)	Air-dried, crushed, and sieved 250 -500 µm	Carbon dioxide	Gas mixture	0 - 40 min	Not given	Column studies showing adsorption being dependent on temperature with a maximum reported capacity of 32.56 mg/g. Isotherm being well-fitted with the Freundlich.	Yusuff et al., 2017; 2018
Beijing, China (Fe, Al)	Dried	Herbicide Atrazine (ATZ) (degradation)	Synthetic solutions	0 - 6 h	3.0, 5.0, 7.0	Batch tests showing DWTR being used as a catalyst for the activation of peroxymonosulfate (PMS) to remove ATZ and leading to more than 92% ATZ being removed. ATZ degradation being positively affected by higher PMS concentration, DWTR dosage and temperature, and low pH.	Zhang et al., 2018
Beijing, China (Fe, Al)	Air-dried, crushed, and sieved <0.15 mm	Pesticide Chlorpyrifos	Synthetic solutions and soils	0 - 72 h	4.10 - 7.21	Batch studies showing rapid followed by slower adsorption of pesticide at environmental pH 4-7. Inhibition at high ionic strength and in the presence of low molecular weight organic acids. Described by the pseudo-second-order model and Freundlich equation. Greater affinity for DWTR than to soil.	Zhao et al., 2013
Beijing, China (Fe, Al)	Air-dried, crushed, sieved <0.15 mm	Herbicide Glyphosate	Synthetic solutions and soils	0 - 36 h	4.0 - 10.0	Batch experiments showing significant enhancement of glyphosate removal for soils amended with DWTR and better retention at all tested pH.	Zhao et al., 2015
Beijing, China (Fe)	Dried and ultra-sonicated, washed before coagulation	Dissolved organic carbon	Raw water	-	8.2 (raw water)	Recycling sonicated, washed DWTS could enhance the removal of hydrophobic acids and effectively remove matter of molecular weight 3–30 kDa, but increased the relative presence of matter with a molecular weight<3 kDa.	Zhou et al., 2018

Table S5. Utilizations of DWTR in construction materials and environmental applications

Treatments / Modifications	Applications	References
DWTR is dried and crushed, (sometimes calcined or alkalized), added in various proportions to cement or other waste materials (e.g. ash, biosorbents) and cured or fired up.	Concrete or Cement or Cementitious composites or Mortar or Aggregates or Clinker	Ahmed et al., 2022; Altherman et al., 2023; Bohórquez González et al., 2020; Breesem et al., 2016; Chen et al., 2010; Ching et al., 2021; Dahhou et al., 2018; de Godoy et al., 2019; 2020; de Oliviera Andrade et al., 2018; El-Didamony et al., 2014; Fang et al., 2019; Frías et al., 2014; Gastaldini et al., 2015; Gomes et al., 2020; 2022; Hagemann et al., 2019; He et al., 2023; Hemkemeier et al., 2023; Huang et al., 2013; Jia et al., 2021; Kaish et al., 2018; 2021; Li et al., 2021; Liu et al., 2021b; 2022a; b; Ng et al., 2022; Owaid et al, 2014; 2019; Pham et al., 2021; Rodríguez et al., 2010; 2011; Ruviaro et al., 2021; Sales et al., 2011; Shamaki et al., 2021; Tantawy, 2015; Wang et al., 2018d; Xu et al., 2014; Yang et al., 2023; Yen et al., 2011
DWTR being dried, crushed, (sometimes calcined), mixed with clay or other materials (e.g. ash, biosorbents) in various proportions, and cured or fired up	Bricks or Paving blocks or Building Materials	Ahmadi et al., 2023; Benlalla et al., 2015; Chiang et al., 2009; Hassan et al., 2014; Huang et al., 2001; Lin et al., 2006; Liu et al., 2020a; b; c; 2021a; Rahman et al., 2019; Ramadan et al., 2008; Sajath et al., 2022; Tantawy and Mohamed, 2017; Zhao et al., 2016
DWTR being dried, (sometimes calcined), added to clay and other compounds in various proportions, and fired up	Ceramics or Tiles or Ceramsite	Cremades et al., 2018; Kizinievič et al., 2013; Huang et al., 2023; Ling et al., 2017; Monteiro et al., 2008; Teixera et al., 2011; Teoh et al., 2022; Wolff et al., 2015; Zamora et al., 2008
DWTR is dewatered and mixed with other compounds such as sand to produce geomaterials or alkalis and biosorbents or slag to produce geopolymers that could be added to cement	Geopolymers or Geomaterials or Geotechnical applications	Balkaya, 2015; Flemmy et al., 2022; Geraldo et al., 2017; Ji et al., 2020; Nimwinya et al., 2016; Waijarean et al., 2014
DWTR dried and crushed, fusion in NaOH, and hydrothermal treatment	Zeolites	Espejel-Ayala et al., 2013
DWTR added to soils or wetlands as a sorbent or to improve soil properties and in read construction	Soils and Wetlands or Geo-environmental applications	Bağriaçik and Güner, 2020; Caniani et al., 2013; Fiore et al., 2022; Nguyen et al., 2023

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