Journal of Scientific & Industrial Research
Vol. 83, May 2024, pp. 557-566
DOI: 10.56042/jsir.v83i5.2474

Construction Waste Modeling for the Republic of Serbia

Miroslav Čantrak[1], Darko Micić[2]*, Dunja Prokić[1], Lato Pezo[2], Ljiljana Ćurčić[1] & Marija Mladenović[3]

[1]Faculty of Environmental Protection, University Educons, str. Vojvode Putnika 87, 21208 Sremska Kamenica, Serbia

[2]Institute of General and Physical Chemistry, University of Belgrade, Studentski Trg 12-16, 11000 Beograd, Serbia

[3]Kolubara Građevinar, Nikole Vujačića 1, 11550 Lazarevac, Belgrade, Serbia

Received 08 June 2023; revised 22 December 2023; accepted 20 March 2024

Table S1 — Results of polynomial models

	a	b	c	d	e	f
	CW1					
M1	(−1.08 ± 0.15)E8*	(5.39 ± 0.73)E4*				
M2	(2.39 ± 1.25)E10^{n}	(−2.38 ± 1.24)E7^{n}	(5.91 ± 3.07)E3^{n}			
M3	(8.48 ± 539,671,500.00)E3^{n}	(2.91 ± 8,059.27)E5^{n}	(−3.15 ± 3,997.32)E2^{n}	(1.00 ± 660.93)E−1^{n}		
M4	(−8.50 ± 1,971.61)E7^{n}	(−1.61 ± 694.33)E6^{n}	(8.36 ± 1,011.73)E3^{n}	(−7.00 ± 498.35)E0^{n}	(0.00 ± 0.08)E0^{n}	
M5	(1.00 ± 0.00)E−1*	(3.18 ± 64.00)E5*	(−1.63 ± 30.17)E4*	(2.67 ± 44.70)E1*	(−1.46 ± 22.13)E−2*	(2.64 ± 36.53)E−6*
	CW2					
M1	(1.23 ± 3.40)E6^{n}	(−5.99 ± 16.86)E2^{n}				
M2	(−5.80 ± 2.86)E9^{n}	(5.76 ± 2.83)E6^{n}	(−1.43 ± 0.70)E3^{n}			
M3	(−1.70 ± 45.93)E9^{n}	(−3.50 ± 684.10)E5^{n}	(1.61 ± 33.98)E3^{n}	(−5.02 ± 56.29)E−1^{n}		
M4	(1.14 ± 200.77)E5^{n}	(−3.19 ± 728.37)E4^{n}	(−1.42 ± 10.93)E3^{n}	(1.44 ± 5.50)E0^{n}	(−3.58 ± 9.27)E−4^{n}	
M5	(1.00 ± 0.00)E−1*	(4.87 ± 295.21)E5*	(−1.00 ± 77.48)E1*	(−1.41 ± 43.27)E0*	(1.17 ± 28.67)E−3*	(−2.62 ± 0.00)E−7*
	CW3					
M1	(−2.19 ± 0.66)E5*	(1.09 ± 0.33)E2*				
M2	(−2.62 ± 6.24)E7^{n}	(2.59 ± 6.19)E4^{n}	(−6.40 ± 15.36)E0^{n}			
M3	(−1.92 ± 0.00)E7*	(1.55 ± 0.00)E4*	(−1.31 ± 0.00)E0*	(−8.33 ± 0.00)E−4*		
M4	(−3.85 ± 391.33)E6^{n}	(1.04 ± 8.21)E5^{n}	(−1.56 ± 11.25)E2^{n}	(7.98 ± 56.92)E−2^{n}	(−1.36 ± 9.55)E−5^{n}	
M5	(4.92 ± 1,450.25)E−1*	(−2.01 ± 575.24)E3*	(1.32 ± 152.76)E1*	(−1.74 ± 199.67)E−2*	(8.51 ± 980.60)E−6*	(−1.42 ± 0.00)E−9*
	CW4					
M1	(−7.36 ± 8.96)E4^{n}	(3.69 ± 4.44)E1^{n}				
M2	(−1.61 ± 0.74)E8**	(1.60 ± 0.74)E5**	(−3.96 ± 1.83)E1**			
M3	(5.05 ± 0.00)E6*	(−8.75 ± 0.00)E4*	(8.31 ± 0.00)E1*	(−2.03 ± 0.00)E−2*		
M4	(−3.02 ± 536.77)E3^{n}	(−1.56 ± 230.23)E3^{n}	(−3.76 ± 34.13)E1^{n}	(3.84 ± 16.94)E−2^{n}	(−9.63 ± 28.12)E−6^{n}	
M5	(2.61 ± 41.59)E1*	(−2.63 ± 51.11)E3*	(2.01 ± 9.47)E2*	(−3.15 ± 13.99)E−1*	(1.66 ± 6.93)E−4*	(−2.89 ± 0.00)E−8*

	CW5					
M1	(−1.81 ± 0.49)E5*	(8.97 ± 2.44)E1*				
M2	(1.69 ± 4.69)E7^{n}	(−1.68 ± 4.66)E4^{n}	(4.20 ± 11.55)E0^{n}			
M3	(−3.24 ± 2,038.00)E6^{n}	(1.31 ± 303.54)E4^{n}	(−1.07 ± 150.70)E1^{n}	(2.46 ± 249.42)E−3^{n}		
M4	(−1.05 ± 1,301.16)E5^{n}	(2.70 ± 408.87)E3^{n}	(4.44 ± 6,787.07)E−1^{n}	(−2.41 ± 354.50)E−3^{n}	(7.61 ± 603.70)E−7^{n}	
M5	(−1.25 ± 18.86)E3*	(1.74 ± 20.61)E3*	(1.82 ± 5.17)E2*	(−2.72 ± 7.58)E−1*	(1.35 ± 3.74)E−4*	(−2.23 ± 0.00)E−8*
	CW6					
M1	(−3.63 ± 0.84)E5*	(1.80 ± 0.42)E2*				
M2	(2.84 ± 0.27)E8*	(−2.82 ± 0.27)E5*	(6.99 ± 0.67)E1*			
M3	(−1.87 ± 130.73)E7^{n}	(1.69 ± 19.43)E5^{n}	(−1.53 ± 9.63)E2^{n}	(3.69 ± 15.90)E−2^{n}		
M4	(−2.11 ± 48.34)E4*	(−9.84 ± 0.00)E4*	(2.16 ± 0.00)E2*	(−1.42 ± 0.00)E−1*	(2.93 ± 0.00)E−5*	
M5	(1.00 ± 44.28)E−1*	(−4.91 ± 169.41)E−2*	(−4.43 ± 181.64)E−2*	(3.43 ± 0.40)E−2*	(−3.40 ± 0.00)E−5*	(8.44 ± 0.00)E−9*
	CW7					
M1	(−1.07 ± 0.09)E8*	(5.32 ± 0.46)E4*				
M2	(1.65 ± 0.77)E10**	(−1.64 ± 0.76)E7**	(4.09 ± 1.89)E3**			
M3	(8.45 ± 302,545.49)E3^{n}	(−3.03 ± 108,210.38)E1^{n}	(−2.62 ± 99.06)E1^{n}	(1.30 ± 24.14)E−2^{n}		
M4	(5.01 ± 486.21)E4^{n}	(−3.10 ± 108.07)E6^{n}	(8.58 ± 160.95)E3^{n}	(−6.24 ± 79.91)E0^{n}	(1.36 ± 13.23)E−3^{n}	
M5	(1.00 ± 0.00)E−1*	(9.66 ± 3,074.70)E3*	(−1.34 ± 336.21)E2*	(2.03 ± 48.95)E0*	(−1.93 ± 24.27)E−3*	(4.72 ± 0.00)E−7*
	CW8					
M1	(1.17 ± 0.75)E7^{n}	(−5.68 ± 3.71)E3^{n}				
M2	(−4.52 ± 7.05)E9^{n}	(4.49 ± 6.99)E6^{n}	(−1.12 ± 1.73)E3^{n}			
M3	(1.43 ± 312,229.91)E4^{n}	(4.27 ± 78,578.57)E2^{n}	(2.54 ± 5,837.65)E0^{n}	(−1.34 ± 1,301.64)E−3^{n}		
M4	(−1.44 ± 0.00)E8*	(−1.46 ± 0.00)E6*	(1.29 ± 0.00)E3*	(−1.25 ± 0.00)E−1*	(−6.73 ± 0.00)E−5*	
M5	(1.00 ± 0.00)E−1*	(1.95 ± 86.29)E5*	(5.35 ± 0.00)E3*	(−8.69 ± 0.00)E0*	(4.58 ± 0.00)E−3*	(−7.97 ± 0.00)E−7*

*statistically significant at p≤0.01 level; ** statistically significant at p≤0.05; ^{n} statistically not significant
a, b, c, d, e, f – regression parameters of equations

Table S2 — Goodness of fits

	Goodness of fit test							Residual analysis		
	x^2	RMSE	MBE	MPE	R^2	Skew	Kurt	Mean	SD	Var
CW1										
M1	7.96E+09	7.87E+04	4.66E+03	18.7	0.750	−0.70	0.11	4.66E+03	8.33E+04	6.94E+09
M2	7.11E+09	6.88E+04	7.18E+02	15.2	0.808	−0.11	−0.20	7.18E+02	7.30E+04	5.33E+09
M3	1.10E+10	7.81E+04	4.55E+03	18.6	0.754	−0.71	0.10	4.55E+03	8.27E+04	6.84E+09
M4	1.07E+10	6.89E+04	7.19E+02	15.2	0.808	−0.11	−0.20	7.19E+02	7.30E+04	5.34E+09
M5	1.43E+10	6.89E+04	7.28E+02	15.2	0.808	−0.11	−0.21	7.28E+02	7.31E+04	5.35E+09
ANN	3.45E+09	5.54E+04	7.92E+02	10.7	0.878	−0.05	−0.26	7.92E+02	5.87E+04	3.45E+09
SVM	5.10E+09	6.73E+04	−1.82E+04	15.1	0.833	−0.36	−0.07	−1.82E+04	6.88E+04	4.73E+09
CW2										
M1	4.36E+08	1.84E+04	−3.59E+02	133.8	0.011	1.69	3.13	−3.59E+02	1.95E+04	3.81E+08
M2	4.28E+08	1.69E+04	5.93E+02	147.5	0.170	0.49	1.07	5.93E+02	1.79E+04	3.20E+08
M3	5.13E+08	1.69E+04	5.95E+02	147.7	0.170	0.49	1.07	5.95E+02	1.79E+04	3.20E+08
M4	6.43E+08	1.69E+04	6.21E+02	149.1	0.170	0.45	0.99	6.21E+02	1.79E+04	3.21E+08
M5	8.55E+08	1.69E+04	5.93E+02	147.6	0.170	0.49	1.08	5.93E+02	1.79E+04	3.20E+08
ANN	2.49E+08	1.49E+04	1.19E+03	135.1	0.356	0.15	0.32	1.19E+03	1.57E+04	2.48E+08
SVM	3.26E+08	1.70E+04	−3.12E+03	158.8	0.191	0.89	1.94	−3.12E+03	1.77E+04	3.15E+08
CW3										
M1	1.94E+05	3.89E+02	−1.22E+01	89.3	0.298	0.89	0.17	−1.22E+01	4.12E+02	1.70E+05
M2	2.22E+05	3.85E+02	−7.92E+00	90.3	0.311	0.99	0.26	−7.92E+00	4.08E+02	1.67E+05
M3	2.67E+05	3.85E+02	−7.98E+00	90.2	0.311	0.99	0.26	−7.98E+00	4.08E+02	1.67E+05
M4	3.33E+05	3.85E+02	−7.98E+00	90.1	0.311	0.99	0.26	−7.98E+00	4.08E+02	1.66E+05
M5	4.51E+05	3.88E+02	1.09E+01	83.8	0.301	0.89	0.13	1.09E+01	4.11E+02	1.69E+05
ANN	1.10E+05	3.12E+02	−3.46E+01	38.4	0.559	0.41	1.64	−3.46E+01	3.29E+02	1.08E+05
SVM	1.72E+05	3.91E+02	−4.36E+00	76.3	0.303	0.65	−0.26	−4.36E+00	4.14E+02	1.72E+05
CW4										
M1	3.41E+05	5.15E+02	−2.28E+01	82.7	0.022	0.95	0.59	−2.28E+01	5.46E+02	2.98E+05
M2	3.15E+05	4.58E+02	3.58E+00	74.4	0.225	0.10	−0.07	3.58E+00	4.86E+02	2.36E+05
M3	3.77E+05	4.58E+02	3.58E+00	74.4	0.225	0.10	−0.07	3.58E+00	4.86E+02	2.36E+05
M4	4.72E+05	4.58E+02	3.73E+00	74.3	0.226	0.09	−0.06	3.73E+00	4.86E+02	2.36E+05
M5	6.29E+05	4.58E+02	6.87E+00	74.1	0.226	0.09	−0.07	6.87E+00	4.85E+02	2.36E+05
ANN	2.25E+05	4.47E+02	7.95E+01	67.9	0.285	−0.01	−1.06	7.95E+01	4.67E+02	2.18E+05
SVM	2.55E+05	4.76E+02	−1.05E+02	84.1	0.231	0.56	0.18	−1.05E+02	4.92E+02	2.42E+05
CW5										
M1	1.12E+05	2.95E+02	−1.10E+01	124.2	0.314	0.69	3.04	−1.10E+01	3.13E+02	9.77E+04
M2	1.32E+05	2.97E+02	−1.38E+01	122.1	0.308	0.42	3.30	−1.38E+01	3.14E+02	9.87E+04
M3	1.58E+05	2.97E+02	−1.38E+01	122.2	0.308	0.42	3.30	−1.38E+01	3.14E+02	9.87E+04
M4	1.98E+05	2.97E+02	−1.39E+01	122.0	0.308	0.40	3.32	−1.39E+01	3.14E+02	9.88E+04
M5	2.61E+05	2.95E+02	−1.61E+01	125.1	0.315	0.58	3.18	−1.61E+01	3.12E+02	9.76E+04
ANN	8.74E+04	2.79E+02	−1.91E+01	115.8	0.383	1.23	4.23	−1.91E+01	2.95E+02	8.70E+04
SVM	1.21E+05	3.28E+02	−6.15E+01	243.0	0.342	2.44	6.46	−6.15E+01	3.41E+02	1.17E+05
CW6										
M1	2.57E+05	4.47E+02	4.22E+01	110.9	0.537	0.81	−0.36	4.22E+01	4.72E+02	2.23E+05
M2	3.38E+04	1.50E+02	−4.40E+00	42.8	0.948	−1.16	2.13	−4.40E+00	1.59E+02	2.53E+04
M3	4.04E+04	1.50E+02	−4.42E+00	42.7	0.948	−1.16	2.13	−4.42E+00	1.59E+02	2.52E+04
M4	5.00E+04	1.49E+02	−4.89E+00	43.0	0.949	−1.17	2.09	−4.89E+00	1.58E+02	2.50E+04
M5	6.67E+04	1.49E+02	3.16E+00	42.5	0.949	−1.24	2.46	3.16E+00	1.58E+02	2.50E+04

ANN	1.16E+04	1.02E+02	−3.30E+01	41.1	0.979	−0.08	−1.67	−3.30E+01	1.02E+02	1.04E+04
SVM	3.94E+04	1.87E+02	−1.53E+01	44.0	0.919	−1.57	3.05	−1.53E+01	1.98E+02	3.91E+04
CW7										
M1	3.27E+09	5.04E+04	3.80E+03	44.4	0.880	−0.27	−0.96	3.80E+03	5.33E+04	2.84E+09
M2	2.67E+09	4.22E+04	1.07E+03	33.7	0.915	−0.45	−1.77	1.07E+03	4.48E+04	2.00E+09
M3	4.55E+09	5.03E+04	3.76E+03	44.3	0.880	−0.27	−0.98	3.76E+03	5.31E+04	2.82E+09
M4	4.02E+09	4.23E+04	1.10E+03	33.9	0.915	−0.45	−1.77	1.10E+03	4.48E+04	2.01E+09
M5	5.40E+09	4.24E+04	1.25E+03	34.5	0.914	−0.48	−1.77	1.25E+03	4.50E+04	2.02E+09
ANN	9.16E+08	2.85E+04	5.29E+03	17.5	0.963	−0.68	0.02	5.29E+03	2.97E+04	8.84E+08
SVM	1.86E+09	4.07E+04	6.08E+03	31.8	0.923	−0.57	−1.74	6.08E+03	4.27E+04	1.82E+09
CW8										
M1	2.03E+09	3.98E+04	−1.82E+01	15.2	0.121	0.73	0.70	−1.82E+01	4.22E+04	1.78E+09
M2	2.33E+09	3.95E+04	7.26E+02	16.3	0.135	0.23	0.11	7.26E+02	4.18E+04	1.75E+09
M3	2.84E+09	3.98E+04	−1.45E+01	15.2	0.121	0.72	0.70	−1.45E+01	4.22E+04	1.78E+09
M4	3.50E+09	3.94E+04	7.23E+02	16.3	0.135	0.23	0.11	7.23E+02	4.18E+04	1.75E+09
M5	4.66E+09	3.94E+04	5.88E+02	16.1	0.136	0.33	0.22	5.88E+02	4.18E+04	1.75E+09
ANN	1.16E+09	3.22E+04	−6.26E+03	14.3	0.467	−0.97	0.47	−6.26E+03	3.35E+04	1.12E+09
SVM	1.92E+09	4.13E+04	−9.67E+03	17.3	0.132	−0.31	−0.10	−9.67E+03	4.25E+04	1.81E+09