

The Potential of Recycled Materials used in Agriculture to Contaminate Food through Uptake by Livestock.

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Tables 3.1 to 3.6

Table 3.1 Contaminant occurrence in recycled materials and other potential input material

Potential contaminant sources	PCDD/F & PCB TEQ ng/kg	ΣICES 6 PCBs µg/kg	PBDEs Sum EC-10 µg /kg	BDE-209 µg /kg	PBDD/F & PBB TEQ ng/kg	PFOS µg/kg	PFOA µg/kg	PF Other µg/kg	*PCNs (Σ 12) ng/kg	α-HBCD µg/kg	β-HBCD µg/kg	γ-HBCD µg/kg
Recycled materials - Poultry												
Clean Wood Shavings (Control)	0.24	0.18	0.41	0.33	0.09	0.6	3	13	5.9	0.03	0.01	<0.06
Recycled cardboard	8.33	13.34	223	218	1.41	1.9	9	15	161.5	11.7	3.9	27
Dried paper sludge (DPS)	8.69	27.59	420	417	1.53	3.9	5	54	426.9	8.89	4.87	41
Recycled Wood shavings	0.18	0.19	0.35	0.27	0.07	<1.0	4	9	6.6	0.03	0.01	<0.01
Other inputs												
Chicken feed Starter	0.12	0.07	0.1	0.07	0.03	nm	nm	nm	nm	nm	nm	nm
Chicken feed Grower	0.05	0.07	0.09	0.06	0.03	nm	nm	nm	nm	nm	nm	nm
Recycled materials - Pigs												
Meat and Bonemeal Ash (MBMA)	7.89	0.4	0.84	0.72	0.42	<1.0	<1.0	7	23.9	<0.02	<0.01	0.01
Poultry Litter Ash (PLA)	32.74	0.44	0.23	0.13	0.16	<1.0	<1.0	7	54.8	<0.01	<0.01	<0.01
Biosolid	2.57	3.66	2536	2504	13.58	23	1.4	57	145	0.02	0.01	<0.35
Other Inputs												
Pig Feed Starter	0.05	0.18	0.12	0.09	0.04	0.19	0.12	1.94	1.04	0.01	<0.01	0.01
Pig Feed Grower	0.05	0.15	0.16	0.13	0.04	0.22	0.22	1.08 i	1.0	<0.01	<0.01	<0.01
Pig Feed Finisher	0.05	0.06	0.14	0.1	0.04	0.04	0.14	2.72 i	1.22	<0.01	<0.01	0.01
Pig Straw	0.17	0.25	0.52	0.42	0.07	nm	nm	nm	3.97	0.06	0.02	0.03
Pig soil pre-spread												
Control	1.03	0.36	1.5	1.39	0.17	0.46	0.6	1.91	10.83	0.04	0.01	0.04
MBMA	1.14	0.36	0.44	0.34	0.15	0.48	0.74	2.03	7.58	0.02	0.01	0.04
PLA	1.07	0.36	0.41	0.31	0.13	0.6	0.89	3.5	10.29	0.03	0.01	0.04
Biosolid	1.09	0.33	0.4	0.3	0.19	0.3	0.34	1.68	8.71	0.01	0.01	0.01
Pig soil post-spread												
Control	1.13	0.35	0.51	0.41	0.11	0.56	0.82	1.89	7.68	0.01	0.01	0.01
MBMA	1.09	0.37	0.6	0.46	0.11	0.51	0.68	1.78	7.48	0.02	0.01	0.01
PLA	1.12	0.32	0.42	0.33	0.14	0.51	0.67	2.48	6.99	0.01	0.01	0.01
Biosolid	1.2	0.32	9.47	9.33	0.16	0.55	0.83	2.03	8.7	0.01	0.01	0.01

i – indicative value. * Σ 12 PCNs include PCNs 52/60,53, 66/67, 68, 69, 71, 72, 73, 74 & 75. nm – not measured

Table 3.2 Contaminant *concentrations in broiler chicken tissues showing strong ↑ or some ↑ evidence of uptake from recycled material.

Recycled material Tissue	Cardboard	Dried Paper pulp	Wood shavings	Cardboard	Dried Paper pulp	Wood shavings	Cardboard	Dried Paper pulp	Wood shavings
	Meat			Skin			Liver		
PCB +PCDD/F TEQ (ng/kg fat)	- 0.52, 0.41	↑ 0.52, 0.88	- 0.52, 0.62	- 0.56, 0.28	- 0.56, 0.32	- 0.56, 0.33	0.49, 0.49	0.49, 0.71	0.49, 0.39
ΣICES6 (µg/kg fat)	↑ 0.73, 0.91	↑ 0.73, 2.93	- 0.73, 0.84	↑ 0.49, 1.17	↑ 0.49, 2.42	- 0.49, 0.33	1.02, 1.13	1.02, 3.69	1.02, 0.75
PBDEs Sum EC-10 (µg/kg fat)	- 2.4, 1.63	↑ 2.4, 5.1	- 2.4, 3.9	- 0.57, 0.85	↑ 0.57, 0.98	- 0.57, 0.67	2.1, 2.6	2.1, 6.1	2.1, 1.5
BDE-209 (µg/kg fat)	1.58, 1.42	1.58, 3.52	1.58, 2.69	0.33, 0.58	0.33, 0.75	0.33, 0.5	1.7, 2.2	1.7, 5.7	1.7, 1.2
PBDD/F & PBB TEQ (ng/kg fat)	- 4.1, 2.9	- 4.1, 2.2	- 4.1, 2.8	- 0.23, 0.28	- 0.23, 0.22	- 0.23, 0.42	0.73, 0.48	0.73, 0.57	0.73, 0.65
PFOS (µg/kg whole)	- 0.12, 0.07	- 0.12, 0.11	- 0.12, 0.06	nm	nm	nm	0.10, 0.07	0.10, 1.1	0.10, <0.05
PFOA (µg/kg whole)	- 0.14, 0.08	- 0.14, 0.04	- 0.14, 0.25	nm	nm	nm	0.13, 0.03	0.13, 0.08	0.13, 0.01
Sum, Other PFAS (µg/kg whole)	- 1.9, 1.2	- 1.9, 1.1	- 1.9, 1.0	nm	nm	nm	0.69, 0.31	0.69, 0.87	0.69, 0.27
PCNs (Sum 12) (ng/kg fat)	- 23, 19	↑ 23, 36	- 23, 13	↑ 10, 18	↑ 10, 23	- 10, 6.0	16, 14	16, 31	16, 17
α-HBCD (µg/kg fat)	x	x	x	x	x	x	<0.42, <0.29	<0.42, <0.32	<0.42, <0.30

*- paired value comparison – first value is median for control, second is median value for recycled material. nm – not measured

Highly divergent concentrations

Table 3.3 Contaminant concentrations in layer chicken tissues/eggs showing strong ↑ or some ↑ evidence of uptake from recycled material.

Recycled material	Cardboard	Dried Paper pulp	Wood shavings	Cardboard	Dried Paper pulp	Wood shavings	Cardboard	Dried Paper pulp	Wood shavings	Cardboard	Dried Paper pulp	Wood shavings
Tissue	Meat			Skin			Liver			Eggs		
PCB +PCDD/F TEQ (ng/kg fat)	↑ 0.27, 0.85	↑ 0.27, 2.0	- 0.27, 0.5	↑ 0.20, 1.4	↑ 0.20, 1.7	- 0.20, 0.79	0.27, 1.5	0.27, 1.9	0.27, 0.46	↑ 0.28, 0.88	↑ 0.28, 1.6	↑ 0.28, 0.46
ΣICES6 (µg/kg fat)	↑ 0.47, 5.95	↑ 0.47, 14.4	↑ 0.47, 1.21	↑ 0.39, 6.64	↑ 0.39, 11.0	- 0.39, 0.84	0.68, 10.8	0.68, 20.5	0.68, 1.09	↑ 0.43, 5.04	↑ 0.43, 14.9	↑ 0.43, 0.98
PBDEs Sum EC-10 (µg/kg fat)	↑ 1.6, 3.5	↑ 1.6, 10	- 1.6, 2.6	↑ 0.44, 2.9	↑ 0.44, 7.8	↑ 0.44, 1.4	3.4, 31	3.4, 13	3.4, 3.6	↑ 1.0, 11	↑ 1.0, 16	↑ 1.0, 1.2
BDE-209 (µg/kg fat)	↑ 1.28, 2.46	↑ 1.28, 8.15	- 1.28, <2.4	↑ 0.24, 1.63	↑ 0.24, 6.28	↑ 0.24, 0.86	3.2, 29.3	3.2,12.1	3.2, 3.11	↑ 0.92, 11	↑ 0.92, 15	↑ 0.92, 1.1
PBDD/F & PBB TEQ (ng/kg fat)	- 0.73, 1.1	- 0.73, 0.82	- 0.73, 0.75	↑ 0.29, 0.79	↑ 0.29, 1.0	↑ 0.29, 0.82	0.62, 0.74	0.62, 0.59	0.62, 0.43	↑ 0.26, 0.36	↑ 0.26, 0.36	- 0.26, 0.24
PFOS (µg/kg whole)	0.03,0.06	0.03, 0.12	0.03, 0.04	- 0.27, 0.28	- 0.27, 0.33	- 0.27, 0.19	0.22, 0.96	0.22, 0.51	0.22, 0.29	↑ 0.09, 0.60	↑ 0.09, 1.5	- 0.09, 0.09
PFOA (µg/kg whole)	0.02,0.06	0.02, 0.05	0.02, 0.04	- 0.60, 0.69	- 0.60, 0.51	- 0.60, 0.48	0.07, 0.10	0.07, 0.09	0.07, 0.07	↑ 0.04, 0.04	↑ 0.04, 0.06	- 0.04, 0.03
Sum, Other PFAS (µg/kg whole)	0.54,0.43	0.54, 0.75	0.54, 0.62	- 4.9, 4.3	- 4.9, 3.8	- 4.9, 5.1	1.7, 1.2	1.7, 1.1	1.7, 1.2	↑ 0.51, 0.75	↑ 0.51, 1.2	↑ 0.51, 0.69
PCNs (Sum 12) (ng/kg fat)	↑ 14, 81	↑ 14, 154	↑ 14, 22	↑ 7.4, 68	↑ 7.4, 74	↑ 7.4, 16	55, 120	55, 118	55, 12	↑ 4.3, 57	↑ 4.3, 137	↑ 4.3, 8.7
α-HBCD (µg/kg fat)	↑ <0.28, 0.71	↑ <0.28, 1.15	↑ <0.28, 9.26	↑ <0.06, 1.01	↑ <0.06, 0.87	↑ <0.06, 15.1	<0.24, 1.4	<0.24, 1.1	<0.24, 21	x	x	x

Highly divergent concentrations

Table 3.4 Contaminant concentrations in pig tissues showing strong ↑ or some ↑ evidence of uptake from recycled material.

Recycled material	Meat and Bonemeal Ash	Poultry Litter Ash	Biosolid	Meat and Bonemeal Ash	Poultry Litter Ash	Biosolid
Tissue	Meat			Liver		
PCB +PCDD/F TEQ (ng/kg fat)	↑ 0.21, 0.28	- 0.21, 0.19	- 0.21, 0.20	↑ 6.49, 6.14	- 6.49, 4.33	- 6.49, 3.69
ΣICES6 (µg/kg fat)	- 0.46, 0.50	↑ 0.46, 0.63	↑ 0.46, 0.58	↑ 0.99, 1.48	↑ 0.99, 1.39	- 0.99, 1.08
PBDEs Sum EC-10 (µg/kg fat)	- 0.39, 0.83	↑ 0.39, 0.72	↑ 0.39, 0.73	↑ 0.96, 1.4	↑ 0.96, 1.4	↑ 0.96, 2.5
BDE-209 (µg/kg fat)	- 0.23, 0.61	↑ 0.23, 0.57	↑ 0.23, 0.42	- 0.56, 0.51	↑ 0.56, 0.67	↑ 0.56, 1.84
PBDD/F & PBB TEQ (ng/kg fat)	- 0.21, 0.18	- 0.21, 0.17	- 0.21, 0.17	↑ 0.61, 0.74	- 0.61, 0.67	- 0.61, 0.64
PFOS (µg/kg whole)	↑ 0.03, 0.06	↑ 0.03, 0.42	↑ 0.03, 0.36	- 3.36, 2.56	- 3.36, 1.71	↑ 3.36, 4.93
PFOA (µg/kg whole)	↑ 0.14, 0.64	↑ 0.14, 0.43	↑ 0.14, 0.29	↓ 0.69, 0.40	- 0.69, 0.82	↑ 0.69, 1.22
Sum, Other PFAS (µg/kg whole)	- 1.53, 1.24	↑ 1.53, 1.75	- 1.53, 2.08	- 1.71, 1.69	- 1.71, 1.65	↑ 1.71, 2.71
PCNs (Sum 12) (ng/kg fat)	- 4.8, 3.8	- 4.8, 4.4	- 4.8, 3.9	↑ 22, 26	↑ 22, 26	- 22, 16
α-HBCD (µg/kg fat)	x	x	x	x	x	x

Highly divergent concentrations

Table 3.5 Comparison of measured contaminant concentrations in produced food versus regulation limits

Food	Measured			Regulation limit (EC1881/2006 - amended 2016)		
	PCDD/F TEQ ng/kg fat	PCDD/F +PCB TEQ ng/kg fat	ICES-6 PCB µg/kg fat	PCDD/F TEQ ng/kg fat	PCDD/F +PCB TEQ ng/kg fat	ICES-6 PCB µg/kg fat
Broiler muscle	1.01	1.39	4.4	1.75	3	40
*Broiler liver (whole wt.)	0.03	0.05	0.13	0.3	0.5	3
Broiler skin	1.21	1.29	3.3	-	-	-
Eggs	0.85	1.92	18.2	2.5	5	40
Layer muscle	0.98	2.44	19.6	1.75	3	40
*Layer liver (whole wt.)	0.06	0.14	1.54	0.3	0.5	3
Layer skin	1.1	2.91	34.4	-	-	-
Pig muscle	0.36	0.41	0.9	1	1.25	40
*Pig liver(whole wt)	0.36	0.38	0.17	0.3	0.5	3

* Liver is regulated on a whole weight basis

Table 3.6 Estimated Bio-transformation factors (BTFs) for muscle tissue, skin, liver and eggs

	Broiler chickens			Laying chickens				Outdoor Pigs	
PCDD/Fs	Muscle	Skin	Liver	Muscle	Skin	Liver	Eggs	Muscle	Liver
2,3,7,8-TCDD	90	49	62	58	100	69	35	1.2	7.5
1,2,3,7,8-PeCDD	93	81	56	112	99	45	43	1.3	8.0
1,2,3,6,7,8-HxCDD	60	15	39	38	78	72	52	2.0	21
2,3,4,7,8-PeCDF	93	31	73	78	97	91	63	1.7	98
1,2,3,4,7,8-HxCDF	123	24	104	59	84	86	52	2.8	88
1,2,3,6,7,8-HxCDF	74	22	62	38	83	55	36	2.0	87
2,3,4,6,7,8-HxCDF	87	26	73	48	84	74	31	1.3	95
Average all PCDD/Fs	110	33	92	47	79	61	38	1.4	46
PCBs									
PCB118	41	40	37	146	169	206	171	1.8	4.9
PCB126	95	77	75	143	211	177	157	2.3	14
PCB169	136	49	50	84	186	97	78	3.6	6.3
PCB138	57	51	82	173	163	326	162	6.3	14
PCB153	107	60	59	220	216	271	194	6.3	14
Average Indicator and DL-PCBs	49	31	42	111	125	135	105	2.1	6.2
Average Indicator PCBs	60	36	60	159	130	182	126	3.6	9.6