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Comparison of the Chemical Composition of Natural Fertilizers and Organic Waste †

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Abstract: This research concerns the comparison of chemical compositions and the content of basic nutrients, heavy metals, and 16 polycyclic aromatic hydrocarbons (PAHs), found in manure, sewage sludge, and digestate.

Keywords: fertilizers; waste; macroelements; heavy metals; PAHs

1. Introduction

One of the main factors relating to the negative human impact on the natural environment is the release of heavy metals and polycyclic aromatic hydrocarbons (PHAs), which pose a serious threat to living organisms. Their origin is both natural and anthropogenic. They easily infiltrate the air, water, and soil as a result of the combustion of fossil fuels, ore processing, etc., and they then enter the food chain of plants and animals [1,2]. They exert toxic, mutagenic, and carcinogenic effect on the human body [3]. Their content and paths of migration in the environment, as well as the waste products produced by man, are being examined more and more often [4]. Manure sewage sludge and digestate can be a valuable and relatively cheap source of nutrients for plants; however, it should be remembered that any waste must be subjected to a recovery process, after which it will again become a useful product [5].

The aim of this research is to compare the chemical composition of natural fertilizers and organic waste originating from the agri-food industry and the municipal economy.

2. Materials and Methods

Three types of manure (bovine, horse, and pig) were analyzed, as were the following waste materials: compost made at single-family houses, sewage sludge, sewage sludge after fermentation, settled sewage sludge, and digestate from an agricultural biogas plant. The basic nutrients they contained were determined as follows: materials; nitrogen, phosphorus, potassium, magnesium, and calcium; heavy metals; zinc, copper, chromium, nickel, lead, cadmium; and 16 PAH compounds. The collected sediment and dried manure was then mineralized in a mixture of nitric acid and hydrogen peroxide. Afterwards, the heavy metal content was analyzed by atomic absorption spectrometer (Thermo Scientific iCE3400). For the determination of the 16 PAHs, 1 g of the sample was extracted with hexane and dichloromethane. Analysis was then carried out using a GC/MS Agilent 7890B chromatograph.

3. Results

Most dairy sludge contained nitrogen and phosphorus, and a stabilized sediment. Less nitrogen was in the sludge after fermentation, but there was more phosphorus than in other waste. The natural fertilizers contained the smallest of these components, but many more contained potassium. The wastes most rich in magnesium and calcium were sewage sludge and compost. Heavy metals were mostly found in municipal sediments. Some, though much less, was found in the dairy settlement. There was a low content of metals in the other materials, the lowest of which was in manure (Table 1). Due to the low content of metals, all of the analyzed fertilizers and wastes can be used in agriculture. In the studied fertilizers and wastes, the most PAHs (16 compounds in all) were found in sewage sludge and municipal sewage sludge after fermentation. In other organic materials, PAH content was significantly lower (Table 2).

Table 1. Content of heavy metals and macronutrients in the tested samples.

No.	Zn	Cu	Cr	Ni	Pb	Cd	Ca	Mg	K
Unit	mg/kg s.m.	mg/kg s.m.	mg/kg s.m.	mg/kg s.m.	mg/kg s.m.	µg/kg s.m.	g/kg s.m.	mg/kg s.m.	g/kg s.m.
1	14.73	1.41	0.93	0.41	1.43	128.98	2.39	842.35	2.34
2	55.21	5.53	1.88	1.03	1.69	163.47	7.92	900.48	2.60
3	24.92	4.32	0.69	0.80	1.51	152.41	39.41	947.28	1.98
4	59.91	11.22	2.46	1.26	1.02	243.66	7.08	932.33	2.35
5	73.40	14.29	5.05	3.74	8.46	220.45	61.01	960.51	2.62
6	260.44	73.32	32.66	12.54	8.64	563.87	53.70	1648.61	3.15
7	78.38	5.22	5.51	5.23	2.07	487.11	36.42	1869.49	4.49
8	237.37	53.16	12.13	7.36	7.184	698.5	25.93	1788.15	3.65
9	117.85	22.67	3.54	2.32	2.45	110.68	10.54	1832.04	5.27
10	131.03	24.77	3.63	2.25	3.144	169.33	11.96	2158.52	5.49

1, horse manure; 2, pork manure; 3, bovine manure; 4, digestate from agricultural biogas plant; 5, home compost; 6, sewage sludge after fermentation from the sewage treatment plant in Białystok; 7, sewage sludge from the Mlekovita sewage treatment plant; 8, sewage sludge from the Sokółka sewage treatment plant; 9,second horse manure; 10, second pork manure.

Table 2. Polycyclic aromatic hydrocarbon (PAH) content in the tested samples.

	No.									
Compound	1	2	3	4	5	6	7	8	9	10
NAFTALEN	310.64	64.59	24.24	5.84	8.14	19.37	29.82	28.15	10.90	6.00
ACENAFTYLEN	1030.80	1.96	0.72	0.29	0.25	-	-	220.41	-	-
ACENAFTEN	741.12	25.14	9.68	5.74	25.98	3.98	34.81	913.95	-	-
FLUOREN	187.25	21.98	3.02	0.58	0.66	8.44	34.68	36.22	-	-
FENANTREN	932.77	100.75	22.01	4.93	4.30	33.48	118.24	45.83	12.58	-
ANTRACEN	141.65	9.75	2.02	5.64	0.35	7.77	30.71	4.72	-	-
FLUORANTEN	1209.12	60.19	30.93	11.31	3.60	28.84	116.80	55.42	12.84	7.49
PIREN	1064.81	52.76	30.95	10.74	4.10	27.06	96.59	50.26	12.70	7.04
BENZO[A] ANTRACEN	375.98	28.30	20.00	6.55	1.71	24.56	54.96	37.14	10.26	8.33
CHRYZEN	487.04	40.15	29.52	8.19	3.40	22.77	57.20	37.47	10.85	7.43
BENZO[B] FLUORANTEN	232.63	-	15.20	-	-	18.09	59.50	35.56	10.88	8.96
BENZO[K] FLUORANTEN	239.02	25.70	25.01	3.26	1.84	31.64	54.52	55.21	13.05	8.76
BENZO[A]PIREN	140.18	497.07	438.61		90.88	-	56.29	30.87	13.16	-
INDENO [1,2,3,C,D]PIREN	80.12	-	-	1.50	-	23.22	131.52	30.55	61.73	12.08
DIBENZO[A,H] ANTRACEN	6.87	-	-	-	16.91	-	-	-	-	-
BENZO[G,H,I] PERYLEN	97.24	-	-	-	-	-	49.46	24.76	19.85	-
∑	7277.25	928.33	651.90	64.56	162.14	249.21	925.09	1606.53	188.79	66.08

1, horse manure; 2, pork manure; 3, bovine manure; 4, digestate from agricultural biogas plant; 5, home compost; 6, sewage sludge after fermentation from the sewage treatment plant in Białystok; 7, sewage sludge from the Mlekovita sewage treatment plant; 8, sewage sludge from the Sokółka sewage treatment plant; 9,second horse manure; 10, second pork manure.

3. Conclusions

(1) All of the tested fertilizers and waste materials are a valuable source of basic nutrients for plants.
(2) The materials tested contained a safe amount of heavy metals and could be used for fertilization.
(3) Municipal and dairy sewage sludge contained more PAHs than natural fertilizers and other waste.

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