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ANALYSIS OF MACRONUTRIENTS DISTRIBUTION IN MIXED BIODEGRADABLE MUNICIPAL WASTE (MBMW) COMPOST: A CASE STUDY OF KAUNAS, ALYTUS, AND DAUGAVPILS REGIONS

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Abstract

Mixed Biodegradable Municipal Waste (MBMW) compost is rich in nutrient content and hence could prove to be of immense valuable in sustainable agriculture and soil fertility. For this purpose, the ratio of needed macronutrients (Calcium (Ca), potassium (K), magnesium (Mg), and phosphorus (P)) in different particle sizes in compost must be attained for maximum yield. Here, macronutrients composition of three sites with different fractions of MBMW compost samples are analyzed for Kaunas and Alytus, Lithuania, and Daugavpils, Latvia. The results demonstrate intense particle size-dependent regional difference in nutritional content. That serves to confirm the importance of particle size governing nutritional availability. The findings indicate that finer fractions (500 µm to 200 µm) have greater phosphorus and potassium, while coarser particles (> 5 mm) have greater calcium and magnesium. These findings are significant to improve MBMW compost nutrients recycling capacity as well as its utilization in agriculture in the future.

Key words: *mixed biodegradable municipal waste (MBMW), macronutrients composition, compost, particle size.*

Mixed Biodegradable Municipal Waste (MBMW) consist of considerable amount of organic waste and can be utilized to generate compost to sustain agriculture and treat waste disposed at landfill. MBMW composting converts it into a nutrient value product that can be utilized to promote plant growth through enhanced soil fertility, besides diminishing environmental effects on waste management. MBMW mixture, on the other hand, vary widely that is based on different factors such as its origin, native culture, and waste physical characteristics [1].

Macronutrients like calcium (Ca), potassium (K), magnesium (Mg), and phosphorus (P) all have significant role in plant development [2]. Availability of these nutrients in compost determine its efficiency as a soil conditioner. Particle size of compost also effects availability and leaching of these constituents to soil. Large particles slowly release the nutrients as they degrade, while smaller particles with high decomposition rate supply easily available nutrients to the soil [3].

Being an EU Directive (2008/98/EC), mechanical biological treatment (MBT) plants in different parts of Lithuania and Latvia are generating compost from municipal solid waste after a separation of the non-biodegradable fractions [4]. This research compares macronutrients composition of

MBMW compost samples from Lithuania and Latvia in different particle sizes > 5 mm, 2.5 mm, 1 mm, 500 µm and 200 µm. The objective is to establish regional nutrients trends as well as the influence of particle size on available nutrients for utilization, providing a general assessment for future use in agriculture.

MBMW compost samples were taken from two location in Lithuania, i.e., Kaunas and Alytus MBT facilities, and one location in Latvia, i.e., Daugavpils MBT facility. The samples were initially taken from composting facilities in the said locations, and then dried at 105°C for 8 hours in the laboratory to remove moisture. The dried samples were sieved using standard sieves to get six fractions in particle size: > 5 mm, 5 mm, 2.5 mm, 1 mm, 500 µm, and 200 µm.

Macronutrient content in compost was quantified through microwave digestion in triplicates for each sample. Aqua regia was utilized for sample digestion. The digestion of compost entitled heating the samples within a microwave digestion system to rupture the organic matrix and extract the nutrients into analyzable solution. After digestion, the samples were analyzed for calcium (Ca), potassium (K), magnesium (Mg), and phosphorus (P) by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), a highly sensitive method that allows accurate determination of these elements in the sample. The standard solutions were used to calibrate the ICP-OES, and the readings were made at characteristics wavelengths for each element for accuracy and reliability.

The four macronutrient concentrations were considerably different in the three study areas. The mean concentration of studied nutrients in the above-mentioned particle size fractions for each region is shown in Table 1.

The results agree with earlier observations of how particle size contribute to nutrient release in compost. Smaller particles have more surface area, and it has been shown to results in higher decomposition rates and fast release of nutrients [5]. In our finding, fine fractions (200 µm and 500 µm) from every region have higher concentrations of phosphorus and potassium. Thus, they can be used as readily available nutrients from these regions. In contrast, the increase in calcium and magnesium content in larger particles (> 5 mm) indicate that these fractions will be less available in the short term as a result of lower decomposition rates. However, they could act as a long term-nutrient pool by slowly releasing the nutrients to soil as the compost ages over time [3].

Table 1. Macronutrient Content Distribution in MBMW Compost Samples from Kaunas, Alytus, and Daugavpils MBT facilities.

Region	Size	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	P (mg/kg)
Kaunas	> 5 mm	43858.571	3443.967	18565.903	652.59
	5 mm	13727.11	2857.893	1946.021	1108.495
	2.5 mm	55491.0195	4888.947	4669.754	1650.461
	1 mm	41058.927	3770.838	4991.746	1494.261
	500 µm	28785.081	2761.078	4985.881	1495.727
	200 µm	27828.378	3326.606	4618.827	2135.382
Alytus	> 5 mm	63197.342	5215.085	4732.1423	1721.032
	5 mm	40352.249	5302.161	5283.129	2738.026
	2.5 mm	164837.823	13861.318	12283.175	5465.602
	1 mm	118211.35	16893.686	12938.592	6758.361
	500 µm	90200.008	14141.727	12121.399	6166.188

Region	Size	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	P (mg/kg)
Daugavpils	200 µm	115785.538	19106.368	16957.143	7523.354
	> 5 mm	72344.067	8698.911	12366.53	3177.594
	5 mm	132247.099	9708.919	24489.771	3233.853
	2.5 mm	106637.008	9330.254	14847.063	4628.984
	1 mm	101818.169	7621.616	13824.171	3587.438
	500 µm	75819.744	6668.811	11833.579	3516.648
	200 µm	90842.124	7994.673	14984.146	4136.595

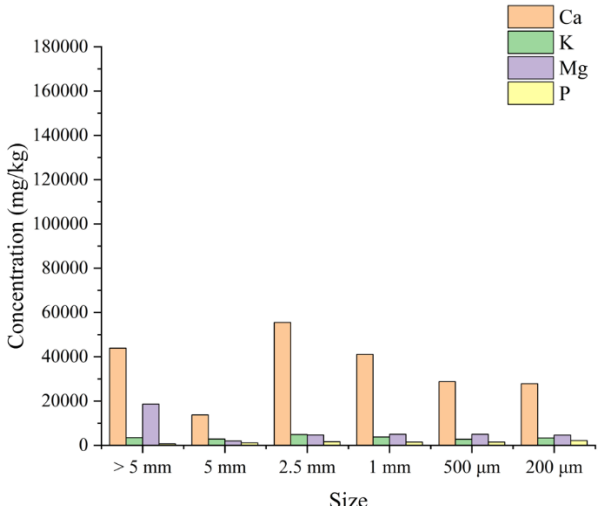


Figure 1: *Macronutrient Content Distribution in MBMW Compost Samples f rom Kaunas MBT facility*

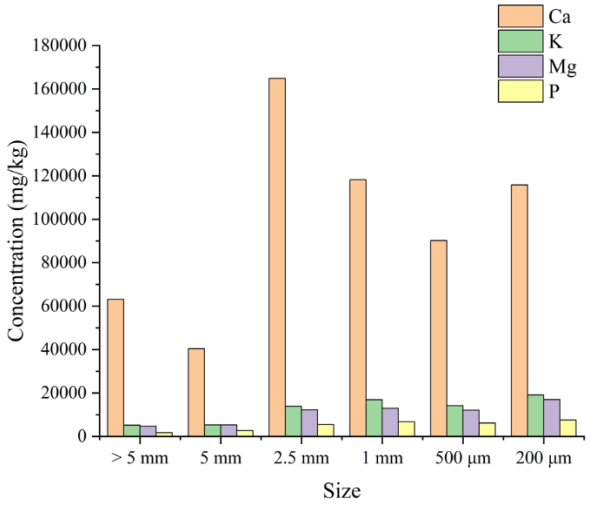


Figure 2. *Macronutrient Content Distribution in MBMW Compost Samples from Alytus MBT facility.*

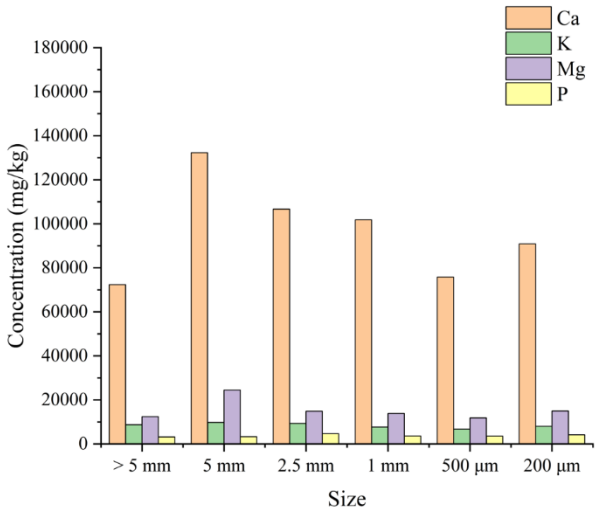


Figure 3. *Macronutrient Content Distribution in MBMW Compost Samples from Daugavpils MBT facility*

This study highlights the size-dependent variability in macronutrient concentrations in MBMW compost from Kaunas, Alytus, and Daugavpils MBT facilities. The findings indicate that the finer particle sizes are richer in potassium and phosphorus content, while larger particles contain more calcium and magnesium content. These results can help the authorities for better waste management and composting strategies to improve the quality of compost for agriculture use. Further research is needed over the time to assess the bioavailability of these nutrients and their long-term impact on soil health.

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АНАЛІЗ РОЗПОДІЛУ МАКРОЕЛЕМЕНТІВ У КОМПОСТІ ЗМІШАНИХ МУНІЦИПАЛЬНИХ БІОРОЗКЛАДНИХ ВІДХОДІВ (ЗМБВ): НА ПРИКЛАДІ РЕГІОНІВ КАУНАСА, АЛИТУСА ТА ДАУГАВПІЛСА

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Анотація

Компост із змішаних муніципальних біорозкладних відходів (ЗМБВ) має високу концентрацію поживних речовин і, отже, може бути надзвичайно цінним для сталого сільського господарства та збільшення родючості ґрунтів. З цією метою необхідно визначити співвідношення ключових макроелементів (кальцію (Ca), калію (K), магнію (Mg) і фосфору (P)) у частинках компосту різного розміру для досягнення максимального врожаю. У цьому дослідженні проаналізовано склад макроелементів у зразках компосту ЗМБВ із трьох регіонів — Каунас і Алітус (Литва), а також Даугавпілс (Латвія), з урахуванням різних фракцій за розміром частинок. Результати демонструють виражену регіональну різницю в поживному

складі, що залежить від розміру частинок і підтверджує важливість цього параметру для доступності поживних речовин.

Встановлено, що дрібні фракції (від 500 мкм до 200 мкм) містять більше фосфору і калію, тоді як грубіші частинки (> 5 мм) характеризуються вищим вмістом кальцію та магнію. Ці результати є важливими для підвищення здатності компосту ЗМБВ до повторного використання поживних речовин і його ефективнішого застосування в сільському господарстві в майбутньому.

Ключові слова: склад макроелементів, компост, розмір частинок, змішані муніципальні біорозкладні відходи (ЗМБВ).