RECYCLING OF ORGANIC WASTE: AN OVERVIEW OF PÁLINKA DISTILLERY MASH COMPOSTING

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Abstract

Organic waste generation has been extending to an alarming level in most areas of the world, and its sustainable management is required. In Hungary, the amount of organic waste is increasing significantly, especially in pálinka manufacturing - a Hungarian hard liquor - producing a great quantity of mash residue, mostly grape pomace spent wash, a non-hazardous food waste that is a suspension left over by the distillation of fermented spirits. Around two hundred thousand tons of fruit waste are generated annually, and its full recycling and legal disposal are unprecedented in Hungarian distilling plants, threatening the environment if disposed of incorrectly. In this paper, we focused on reviewing the Pálinka mash composting, where the biggest challenge for its treatment is its initial pH, around 4, which can be successfully neutralized with mineral additives. The applied additives were chosen by their beneficial physical, chemical, and biological qualities. Accordingly, andesite and alginite were employed in the experimental composting. The results of our observation have confirmed that the mineral additives can establish valuable compost or fertilizer, favourably altering the dynamics of the decomposition and synthesis reactions. As an experiment on mash composting technology, we also tested the mature mash compost in culture vessel experiments for heavy metal adsorption capacity of the ma tube mash compost using lettuce (Lactuca sativa) and tomato (Solanum Lycopersicum) as test plants. The plants were irrigated with lead (Pb), and iron (Fe) contaminated water, and then it was determined the metals accumulation capacity of the plants and growing media with an Atomic Absorption Spectrometer (AAS). The study could compare the rate of heavy metal accumulation by different plant parts and ratios of Pálinka mash compost in the growing media.
Keywords: *organic waste, compost, pálinka, mash residue, heavy metal accumulation*

SZERVES HULLADÉKOK ÚJRAHASZNOSÍTÁSA: A CEFREKOMPOSZTÁLÁS ÁTTEKINTÉSE

Összefoglalás

A szerves hulladék képződése a világ legtöbb részén aggasztó szintre nőtt, és fenntartható gazdálkodás kialakítására nagyobb szükség van, mint valaha. Magyarországon jelentősen növekszik a szerves hulladék mennyisége, különösen a pálinkagyártásban, főleg a törkölypálinka lepárlása során keletkezik sok maradék (cefremoslék), amely egy ártalmatlan élelmiszer-hulladék. Évente mintegy kétszázezer tonna gyümölcshulladék keletkezik, amelynek teljes körű újrahasznosítására és legális lerakására még nincs példa a magyar szeszgyárakban és a helytelen feldolgozása veszélyezteti a környezetet. Jelen írásunkban a pálinka cefre komposztálás lehetőségeinek áttekintésére fókuszáltunk, amelynek kezelésénél a legnagyobb kihívást annak kezdeti, 4 alatti pH-értéke jelentette, amelyet ásványi adalékanyagokkal sikerült semlegesítenünk. A felhasznált adalékokat előnyös fizikai, kémiai és biológiai tulajdonságaik

szerint választottuk ki. Ennek megfelelően a kísérleti komposztálás során andezitet és alginitet alkalmaztunk. Megfigyelésünk eredménye megerősítette, hogy az ásványi adalékok értékes komposztot képezhetnek, kedvezően változtatva a bomlási és szintézis reakciók dinamikáját. A cefre komposztálási technológiai kísérleteként az érett cefrekomposztot tenyészedényes kísérletekben is teszteltük a cefre érett komposzt nehézfém-adszorpciós képességére saláta (Lactuca sativa) és paradicsom (Solanum Lycopersicum) tesztnövények felhasználásával. A növényeket ólommal (Pb) és vassal (Fe) szennyezett vízzel öntöztük, majd Atomabszorpciós spektrométerrel (AAS) meghatároztuk a növények és a táptalaj fémfelhalmozódási képességét. A vizsgálat során össze lehetett hasonlítani a különböző növényi részek szerinti nehézfém-felhalmozódás mértékét és a pálinkacefrék-komposzt eltérő arányát a termesztőközegben.
Kulcsszavak: *szerves hulladék, komposzt, pálinka, cefremoslék, nehézfémek akkumuláció*
JEL kód: *Q53*

Introduction

The necessity of sustainable waste management is rising, especially facing the increase in organic waste generation worldwide, stimulating new approaches for feasible management method options like waste recycling for sources of nutrients and organic matter. Waste management is a huge environmental, social and economic issue nowadays because of the scarcity of practical approaches for its recycling and disposal (BURG et al., 2011). Sustainable management of organic waste is required to prevent scarcity of natural resources, reduce danger to human well-being, and maintain an overall environmental and ecosystem balance (KHALID et al., 2011).

Over the years, some solutions for resource recovery of organic wastes have been created, such as (1) recovery of the organics and nutrients by using directly in the soil or by composting, (2) energy generation potential by modification of the organics, or (3) production of new products by alteration of the organics such as recycling paper into new paper products. In this paper, composting was the chosen method for organic waste management because this procedure has been proven a great organic additive by providing humus and nutrients to poor soils, notably increasing crop yields and minimizing irrigation demands (HAUG, 1993).

One example of organic waste promoting challenges in management is the *grape pomace spent wash* or *mash*. According to BURG et al. (2011), there are 8 million tons of grape pomace accessible annually in Europe, which is still increasing. Grape pomace consists basically of the skin, pulp, and seeds of the grape and from the waste management point of view, it is classified as biotic waste generated in the Food-Drink-Milk sector (VILLENA et al., 2018; BURG et al., 2011).

In Hungary, the amount of organic waste is increasing significantly, especially in Pálinka manufacturing which produces a great quantity of *mash residue*. Pálinka is a traditional Hungarian fruit distillate made exclusively from fermented fruit mash, and its distillation process generates a significant amount of waste. BARABÁS and SZIGETI (2015) stated that nowadays, approximately 150.000 to 200.000 tons of fruit waste is produced annually in Hungary. The management of this type of waste produced during the Pálinka distillation process is a significant environmental issue.

Pálinka beverage is a Hungarian specialty, and its production is limited to Hungary and some areas of Austria (HARCSA, 2017). Its production is increasing significantly due to the permissive legislation of home distilling being a matter of serious concern as home distillation waste handling is uncontrolled and produces four or five times more waste than the industry (SIPOS, 2018).

During Pálinka distillation, merely 10% of the initial mash and raw materials may become the end product, so the residues generated by this process represent a considerable volume of the input (HARCSA, 2018). In the case of using grapes for Pálinka production, it generates a distilled by-product named *marc, mash,* or *grape pomace spent wash* where this fruit waste represents around 85% of the input material (BARABÁS - SZIGETI, 2015). The spent wash can represent a huge environmental risk because, at present, the complete recycling of wastes and their legal disposal requires significant expenditure from Hungarian distilling plants. On the other hand, *spent wash* (residue of brandy distillation) contains many nutrients that can be useful for future applications in agriculture as compost and/or fertilizer.

Due to the exponentially growing production of organic waste nowadays, the development of sustainable agriculture by mobilizing the recycling of this kind of material as a source of organic matter and nutrients is a great management strategy option (VILLENA et al., 2018). Nowadays, the disposal or utilization of the generated waste is a key issue of Hungarian Pálinka distillation, and some practices should be improved to solve these issues, such as its utilization for soil strengthening, composting, and disposal at wastewater treatment plants, biogas production, and foraging (BARABÁS - SZIGETI, 2015).

The *grape pomace spent wash* (residue of grape pomace distillation) can represent a huge environmental risk because, at present, according to HARCSA (2018), the complete recycling of this waste and its legal disposal is unprecedented in Hungarian distilling plants, threatening the environment if disposed of incorrectly.

Alternatively, the *grape pomace*, like most organic waste materials, can be beneficial in agriculture if applied as compost or crop fertilizer due to its high concentration of macro-and micro-nutrients, as it releases these nutrients gradually in the soil (PINAMONTI et al., 1997). Moreover, *like other composted materials*, *grape pomace* promotes the filtration of environmental pollutants and stimulates plants to improve their drought tolerance (DOBREI et al., 2005). It also has a positive effect on the soil structure, and due to this improvement, the oxygen distribution is more favourable in the soil (KOTROCZÓ – FEKETE, 2020).

According to ELEONORA et al. (2014), the *grape pomace* is a product for which the industry and scientists have tried to find an effective recycling and disposal method, and its disposal is getting hard as the production of its derivate grows.

The study of BURG et al. (2011) described the main restrictions of a direct application of fresh *grape pomace* in the soil, which consists of a long decomposition period for this material due to its adverse carbon and nitrogen ratio (between 40-45:1) and a meager improvement of soil conditions. These impediments can be suppressed by combining nitrogen and phosphatic fertilizers with *grape pomace.* Moreover, the direct incorporation of *grape pomace* into agricultural land can lead to severe problems since degradation products can inhibit root growth (NERANTZIS-TATARIDIS, 2006).

Some features of *grape pomace* constitution can promote obstacles in the composition process, such as a relatively high proportion of dry seeds which contain fiber, fat, acid, and oils, restricting microbial activity, and prolonging the decomposition time (DIAZ et al., 2011).

Another challenge about *grape pomace* is its low pH (3.7- 4.5), requiring adjustment before its application to the soil or composting to activate the microorganisms and ensure microbiological conversion. Then, to respond to its acidity, *grape pomace* can be mixed with some amendments for a better composting process, in this study, two minerals were chosen: *pyroxene-andesite* and *alginite*. These minerals were chosen due to their further properties to amend the compost's chemical, physical and biological characteristics, affecting mainly the number of nutrients like phosphorus and potassium. The mineral *alginite* is a starting agent for the improvement of soil and composting; it promotes the maturation of compost, deodorizes, and improves the water-binding ability of matured compost. This mineral was mined at Pula (Hungary), and its origin is from the biomass of fossil algae over several million years in volcanic craters. According to SZABÓ (2004), the organic material content of this mineral is around 5-50%. Moreover, *pyroxene-andesite* is a volcanic rock that contains some minerals such as phosphorus and potassium, which can increase the amount of these nutrients in the compost. It was mined in Bercel (Hungary) and is a byproduct of the milling of the main mineral product used in road building. According to DALMORA et al. (2020), this silicate rock-derived powder can be used to replace high soluble fertilizers because of its mineral's good dissolution rates, which can be applied in place of carbonate-based liming.

Over the years, some solutions for resource recovery of organic wastes have been created, such as composting. This method was chosen for organic waste management because this procedure has been proven as a great organic additive by providing humus and nutrients to poor soils, notably increasing crop yields, and minimizing irrigation demands (HAUG, 1993; KOTROCZÓ – FEKETE, 2020).

Composting is a relatively simple and cost-effective method of organic waste treatment, and it is based on mainly aerobic microbial decomposition of the organic compounds. The input material for composting is required to have a high moisture content and a good carbon-to-nitrogen (C: N) ratio to generate optimal compost. A good carbon-to-nitrogen ratio is important because it adds nutrients for the microbes to survive and to continue degradation (BERTRAN et al., 2004; KOTROCZÓ – FEKETE, 2020). Compost is the main product generated by composting and it can be characterized by being an organic soil conditioner that has been stabilized to a humus-like product, a material free of human and plant pathogens, and that is beneficial to plant growth (DIAZ, 2011; HAUG, 1993). In addition, composting promotes various benefits besides the use of compost as a soil amendment. It also provides an increase in the disposal site's lifespan and minimizes leachate quantity and quality in a landfill and the generated gases. The production of compost follows three steps, as cited by DIAZ et al. (2011): "(1) an initial, rapid stage of decomposition: (2) a stage of stabilization, and (3) an incomplete process of humification." Moreover, composting needs an optimal temperature, humidity, aeration, and pH to successfully produce high-quality compost. Some soil properties are enhanced by the application of composts, such as water content and water retention, aggregation, soil aeration, soil permeability, water infiltration, cation exchange capacity, pH buffering, resilience, or carbon sequestration; it also decreases surface crusting.

As already mentioned, composting is a practical solution for the waste management issue, especially for organic wastes, due to the biological stabilization of this material (GÓMEZ-BRANDÓN et al., 2011). In Hungary, the compost derived from Pálinka distillery mash is a mineral products; if stabilized by composting, it can be used in crop cultivation. The generation of compost and high-quality organic fertilizers would improve the soil characteristics to meet the high demand for agriculture in the country. The production of compost is not only a matter of waste management but also sustainable soil management in Hungary (BARTH et al., 2008). During the composting process, complex organic compounds such as carbohydrates and proteins and inorganic compounds are gradually decomposed, and some of the substances are oxidized to carbon dioxide and water. The main objective of composting is to generate a biologically stable material that will not rapidly decompose or promote undesirable rotting processes. Therefore, composting does not aim for the complete decomposition of input components but has a purpose of a steady matter (EPSTEIN, 1997).

Grape pomace composting represents an effective practice for its management and as a non-waste technology, composting is a recommended method according to the most recent waste management principles applied in the European Union (BURG et al., 2011). Then, composting is one viable procedure for effective utilization of *grape pomace* as a waste product promoting a material suitable for soil application by aerobic biodegradation, reducing the concentration of unstable compounds (ELEONORA et al., 2014). Unfortunately, the application of *grape pomace* compost has some limiting factors for its usage as fertilizer, such as problems related to heavy metals accumulation in the soil after a long time, causing issues in agriculture (KARACA, 2004; PINAMONTI et al., 1997).

Hence, the composting of grape pomace distillery waste into compost is a potential way of sustainably disposing of waste while generating a useful product.

Material and Methods

The experiment began in July 2019 with the analysis of the chemical and microbial parameters such as pH, Organic Matter, Moisture Ratio, Nitrogen forms, Potassium, and Phosphorus. The most important biological tests are the microscopic and dehydrogenase enzyme activity investigations. Each one of the treatments had a duplicate, and the analysis of the parameters happened once per month for seven months. Then, each month were analyzed parameters of 8 samples (4 treatments + 4 duplicates), 56 samples in total.

Material

The Pálinka distillery mash used for the composting experiments was provided by Pálinka Nemzeti Tanács (Pálinka National Council) located in Budapest (Hungary), and the pilot scale composting systems using this distillation residue were located at a private estate in Nógrád County. As already mentioned, one of the main issues regarding the usage of spent wash for composting is its low pH, and two additives were chosen to be mixed with Pálinka distillation residue: *pyroxene-andesite* and *alginite*.

The pilot scale composting system used for the experiments consisted of static piles **(Figure 1.)** with four different technological designs, administering additives to improve the initial adverse pH and significant water content of the mash slurry. These were: mash slurry + 3% andesite, mash slurry + 3% andesite + 3% alginite, mash slurry + 3% alginite, and mash with no additive (control).

Figure 1. Pilot Scale Composting Systems with thermometers (static piles)
Source: The authors (2020)

Methods

After the composting process, the mash compost was pre-treated and used in two experimental works to analyze its influence on heavy metal accumulation in the growing media and in different plant parts.

In the first experimental work (BORGES SILVA et al., 2021), the mash compost derived from the four types of technological composts cited above was placed in culture vessel experiments using lettuce as a test plant for lead accumulation capacity. From the mature composts, two mixtures were created: a 50-50% mixture with black peat and a 75% compost - 25% black peat mixture. The lettuce test plant was seeded in triplicates in each mixture; it was chosen as a test plant due to its rapid growth and good accumulative capacity (KOVÁCS et al., 2020). After reaching the required phenological phase (1 month), the plants were irrigated with a lead solution using different lead concentrations, considering the 6/2009. Government Decree on the "B" pollution limit for lead. Lead concentrations were as follows: 480 mg/dm3 (below limit value), 600 mg/dm3 (limit value), and 900 mg/dm3 (above limit value). Commercially available vegetable growing media was used as a control, and control samples were irrigated with tap water throughout the experiment.

In the second experimental work (BORGES SILVA et al., 2022), it was also used the mash compost in culture vessel experiments, but now the tomato plant was used as a test plant for iron accumulation capacity. Different from the first experimental work, in this study, there were three technological designs: 100% mash compost, 75% mash compost, 25% brown forest soil, 50% mash compost, and 50% brown forest soil.

The goal of these studies was to demonstrate how Pálinka mash compost affects metal accumulation in the growing media and in the plants. For iron accumulation analysis, we cultivated tomato plants (*Solanum Lycopersicum)* in a growing media composed of mature mash compost in three different ratios with soil (100%, 75%, and 50% compost), as mentioned above. The test plants were irrigated twice a week for two weeks with iron-contaminated water (500 mg/kg). Moreover, the tomato test plant was seeded in triplicates for each of the three mixtures of compost soil. Before the tomato plant cultivation and compost addition to the soil, the iron concentrations of the compost and the soil were measured, 190,65 mg/kg and 165,98 mg/kg, respectively.

After the elimination of the series of experiments, the growing media, as well as the roots and above-ground plant parts of the tomato plants, were processed separately. The samples were air-dried, ground, and then examined for iron concentration which was determined by Atomic Absorption Spectrophotometry (Aurora AI1200 AAS instrument).

Results

Physical, chemical, and biological parameters measurements

The pH results show that its values increased over the months, especially in the *grape pomace spent wash and alginite mixture* **(Figure 2.)**. We can also notice that the pH was already high (alkaline) at the beginning of the experiment. This, and the fact that the compost had a relatively low initial temperature (somewhat above 40 °C), show that the decomposing process had started earlier, and the provided source material had not been freshly distilled. The mineral *alginite* also has a protracting alkalizing effect that can be observed in the chart below.

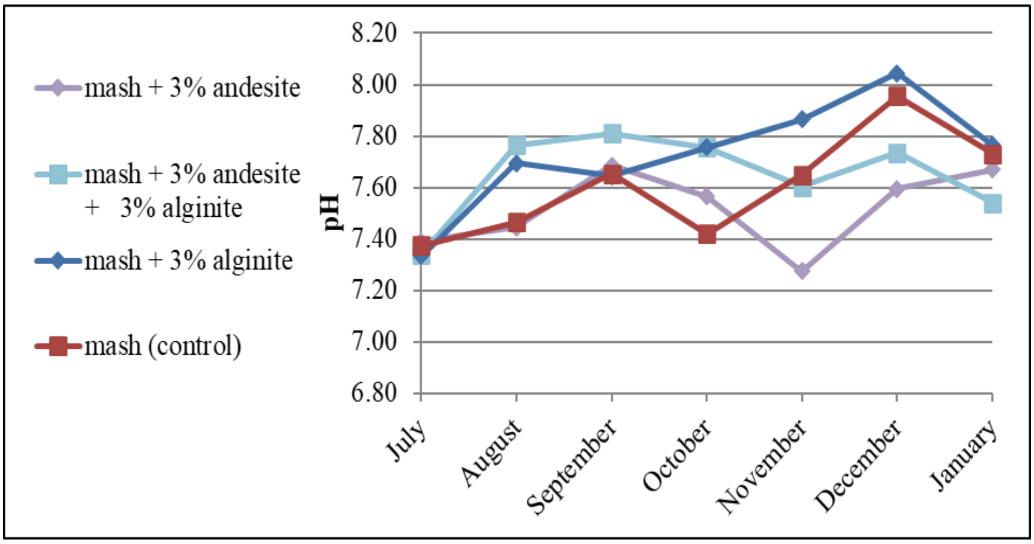

Figure 2. pH measurement of the composts

The phosphorus content increased over the months in all mixtures, especially in the *grape pomace Pálinka spent wash and andesite mixture* **(Figure 3.)**. According to PORDER and RAMACHANDRAN (2013), the minerals of *andesite* are rich in phosphorus, having in its composition around 1000 ppm of the mineral, which is released due to thriving microbial activity explaining the high content of phosphorus in the mixture *grape pomace Pálinka spent wash and andesite*. Besides microorganisms, the available phosphorus content also depends on pH; consequently, this parameter crucial for plant life is also important to investigate.

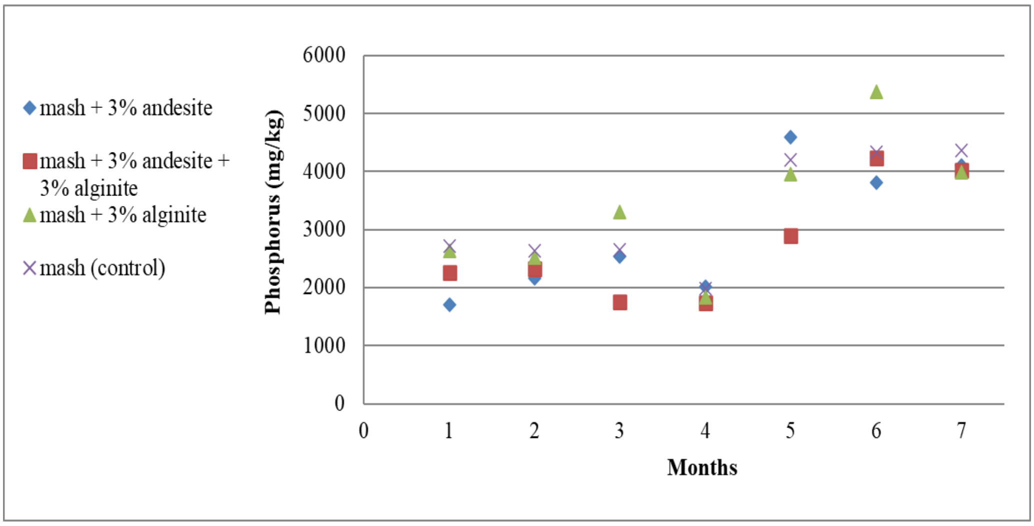

Figure 3. Phosphorus (P_2O_5) measurement of the composts

The diversity of microorganisms can be highly affected by pH because most organisms require neutral pH values to have optimum growth, and microbes can also alter the pH around them. To verify the microbial diversity, we can compare the pH and phosphorus figures for each compost treatment over the months **(Figure 4.)**. Analyzing the data, we can state that the November samples containing *andesite* exhibit a significant drop in pH and a rise in phosphorus. The probable reason for the phosphorus rise can be due to the presence of this element in the crystals of the minerals of *andesite,* and the drop of pH values in November samples could have promoted the release of phosphorus from this month. For this study, we tested total P_2O_5 content, and *andesite* seems to have the least phosphorus supply, which is still a very good reserve compared to the soil's estimated average parameter between 0,02 - 0,2%.

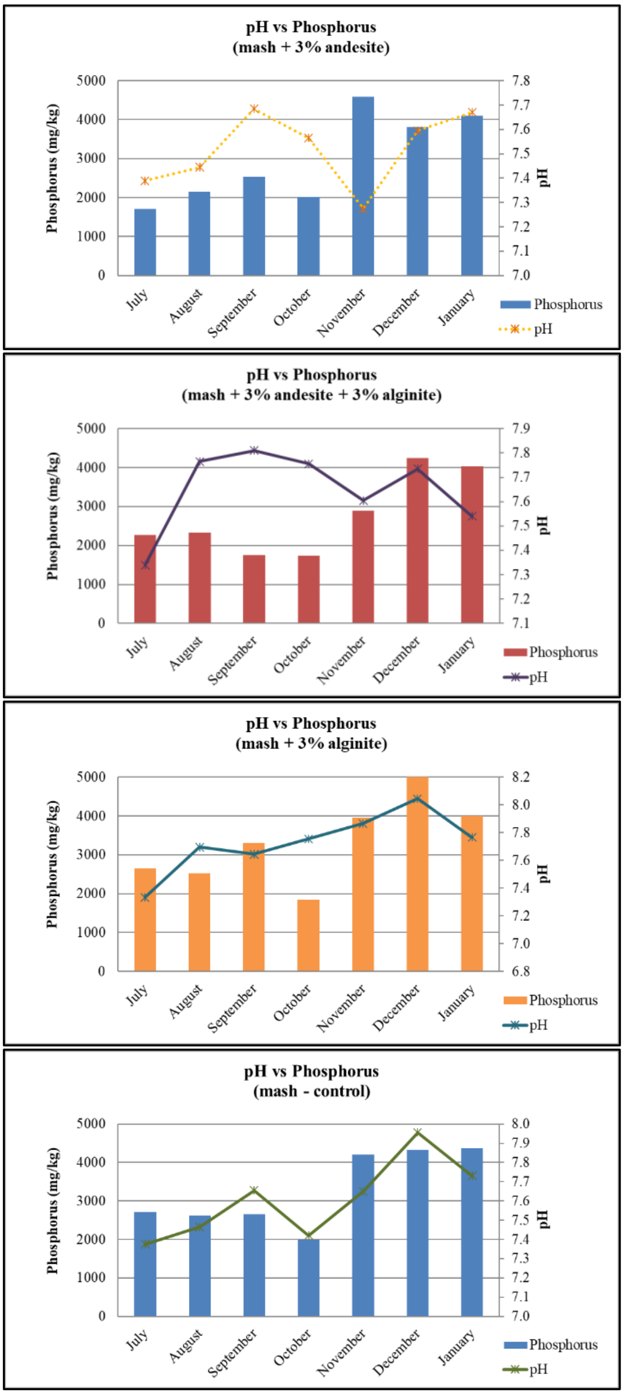

Figure 4. Correlation between pH and Phosphorus (P_2O_5) content in the compost samples

Potassium (K) is the third most important nutrient besides nitrogen and phosphorus; it is used in soils as inorganic fertilizer. The potassium quantity had a huge increase in the four compost treatments after October **(Figure 5.)**.

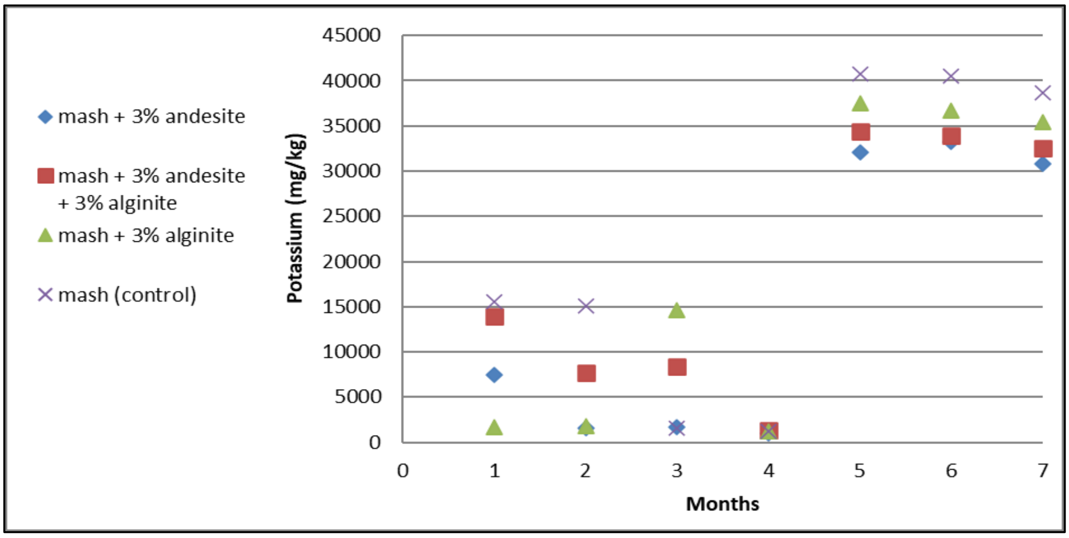

Figure 5. Potassium (K_2O) measurement of the composts

This increase in potassium after October correlates with the drop of pH in the mixtures with *andesite*. For the *control* and *alginite* treatments, the potassium levels increase with the pH rise **(Figure 6.)**.

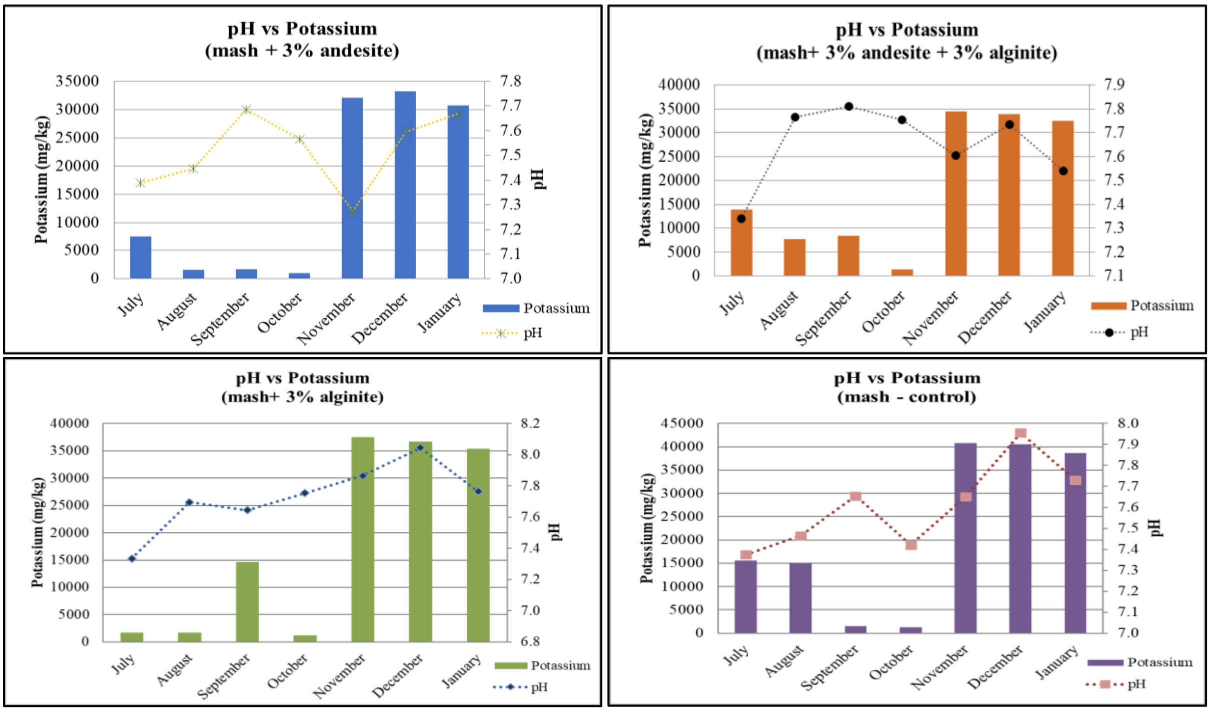

Figure 6. Correlation between pH and Potassium (K_2O) content of the composts

The ammonium content increased in all the mixtures through the months **(Figure 7.)**. This increase can be explained by the ammonification of the organic matter by decomposers increasing the NH_4 ions in the compost. This amount of ammonium produced over the months reflects the capacity of the compost for nitrogen mineralization.

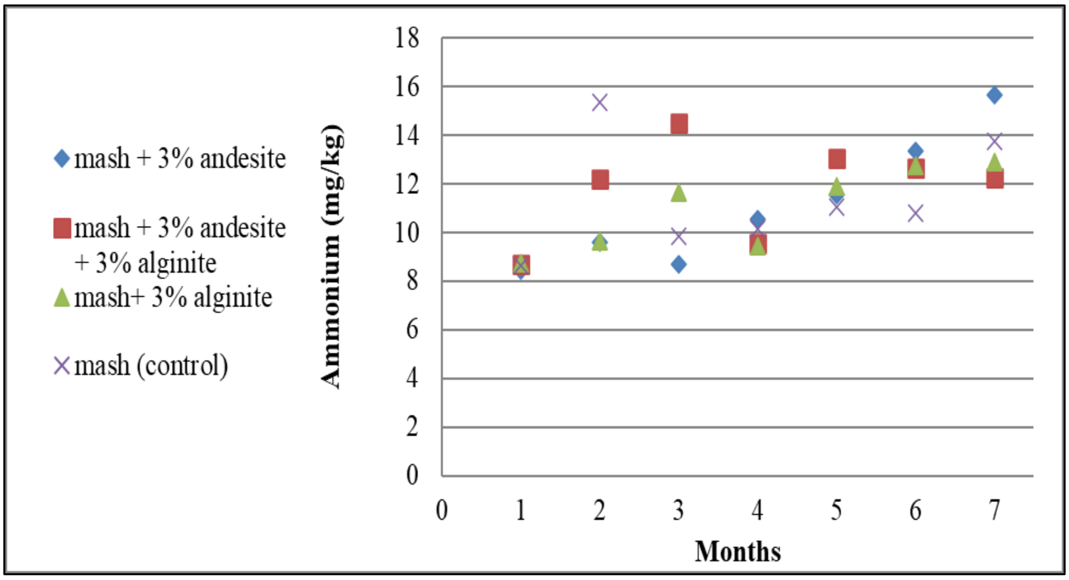

Figure 7. Ammonium measurement of the composts

The nitrate content increased in all mixtures over the months **(Figure 8.)**. The *grape pomace Pálinka spent wash* sample, and the *spent wash and andesite mixture* showed the highest values of nitrate. The nitrate must have increased because, after some time, more oxygen became available, and nitrification occurs (aerobic process), usually following ammonification.

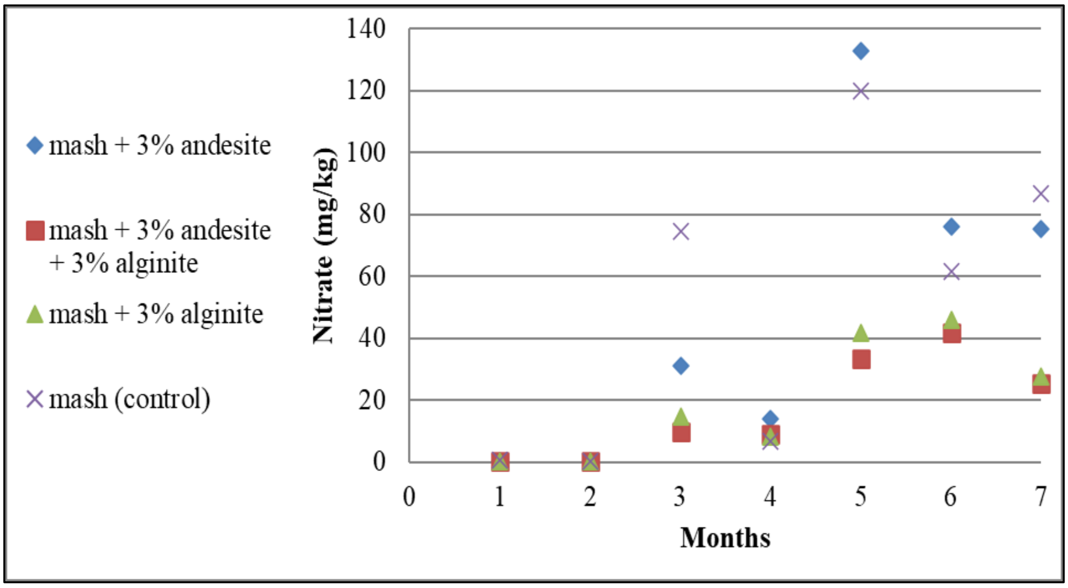

Figure 8. Nitrate measurement of the composts

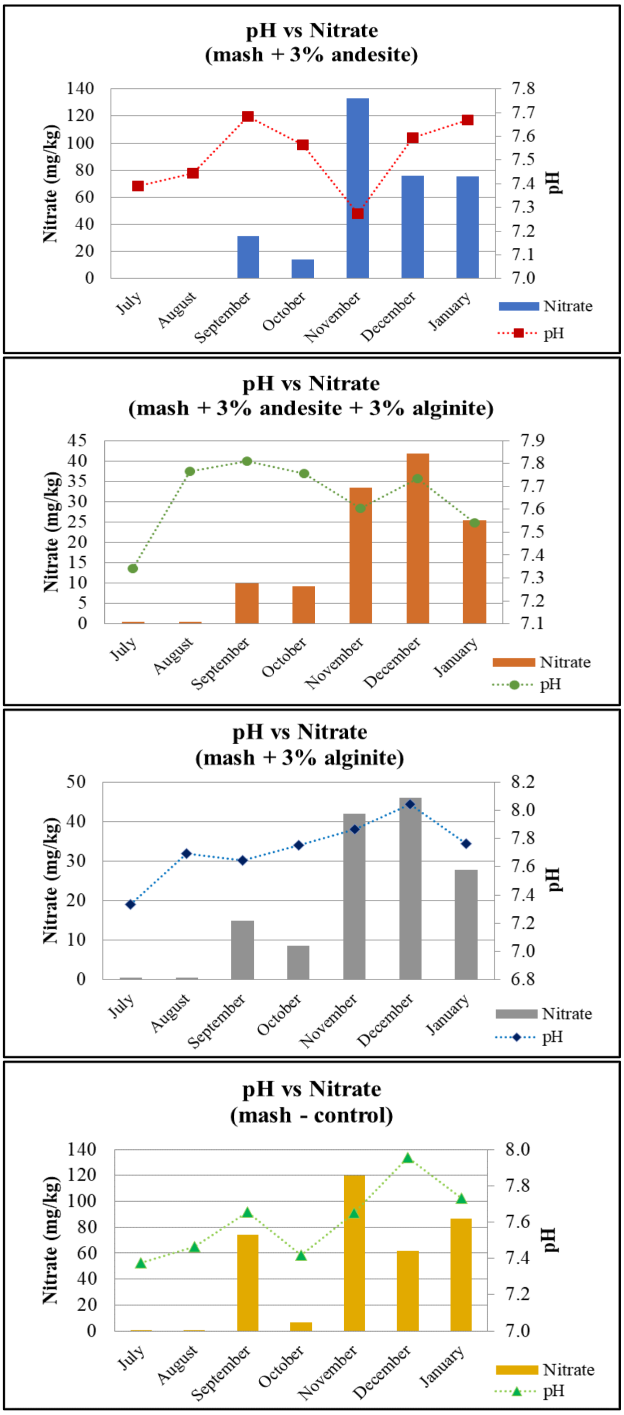

Figure 9. Correlation between pH and Nitrate content of the composts

Nitrogen forms are highly transformable; consequently, they change permanently, and the results are only approximate. In November, just like the levels of phosphorus and potassium, nitrification increased following the peak of ammonification. They respectively confirm a correlation between them along with pH **(Figure 9.)**.

Analyzing the macronutrients - nitrogen forms, phosphorus, potassium – measurements, we verify that in October, the level of these parameters decreased. The levels of NPK show a sharp increase in November, unveiling largely similar dynamics as they are accelerating after this period.

Loss on Ignition (LOI) test is recognized in inorganic analytical chemistry, particularly in the analysis of minerals and carbonate content in sediments, and it was used to estimate organic carbon content in the compost. This test allows volatile substances to escape at high temperatures, and the percentage of Loss on Ignition shows the organic matter content in the sample; the higher the loss on ignition appears, the higher the organic matter quantity present in the sample.

The values of LOI did not change much during the months, but we can notice that the largest amount is present in the *control* sample and did not change much in the samples containing the minerals of *alginite* and *andesite* **(Figure 10.)**. However, the *mixture of spent wash and alginite* showed a significant increase over the months (19%). It can be due to the properties of *alginite*; it has organic carbon and inorganic carbon in its composition that contribute to the compost. On the other hand, the minerals of *andesite* have very little organic and inorganic carbon in their composition. It can be noticed, analyzing the LOI results, that there is a pattern of the organic carbon results showing similar dynamics in the samples of the mixed composts: decreasing organic carbon content and reaching the level of that of the *control* later. The decomposing provokes carbon dioxide emission, and then it can be fixed from the environment in the synthesis.

Andesite establishes lower organic carbon content that increases after the first adaptation period. The reason may be that the *andesite* is capable of propelling microbial life that takes up CO_2. The course of the carbon cycle is quite balanced in the case of the *alginite mixture* and the *control*. We can conclude from the data so far that the carbon fixing potential of the *andesite* mixture is favourable as the original organic carbon content rises only here, having an increase of around 19% after the system is stabilized. The LOI results for October are inconsistent with the rest of the data; it must be a mistake in measurement.

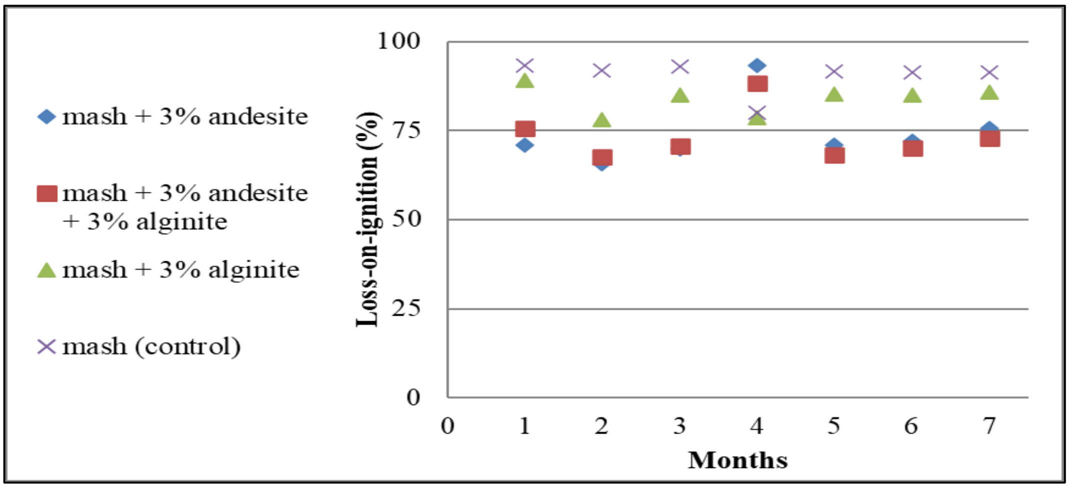

Figure 10. Loss on Ignition measurement of the composts

The moisture ratio decreased over the months for all the samples, especially in the *spent wash and andesite* mixture **(Figure 11.)**. Composting proceeds best at a moisture content of 40-60% by weight. At lower moisture levels, microbial activity is limited. At higher levels, the process is likely to become anaerobic and foul-smelling. At its present state, the compost presents good moisture levels; however, we must be concerned that the moisture data is showing a tendency to drop, which can cause very dry compost, limiting microbial activity. In the case of a pilot-scale experiment, taking samples from the composts adds up to such a level of volume loss that the system can become less stable and exposed to drying. Moisture is a very critical aspect of composting (KASZA et al., 2015).

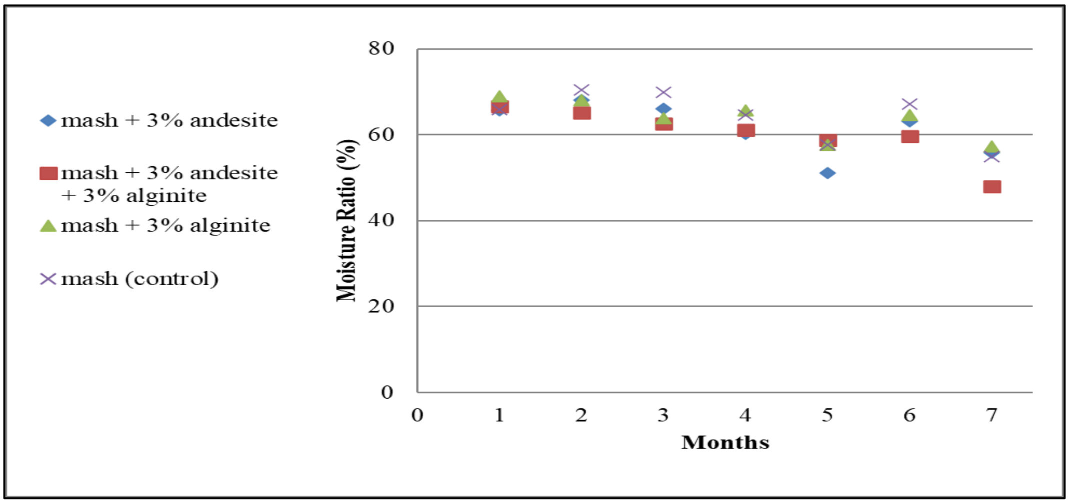

Figure 11. Moisture ratio measurement of the composts

For the microbial activity analysis, we measured the dehydrogenase activity (DHA) in the composts **(Figure 12.)**. A large amount of information about the biological characteristics of the soil is given by the determination of DHA. One characteristic of DHA, according to WOLINSKA and STEPNIEWSKA (2012), is that it strongly increases under anaerobic conditions.

The highest microbial activity was present in the *mixture of spent wash and alginite*; the added mineral having organic compounds seems capable of boosting the composting. On the other hand, *andesite* shows intensive microbial life at the beginning, then drops with time, which may indicate the settling of the transformation processes. The spent wash, *alginite, and andesite mixture* had results similar to the figures of the *control*. For this experiment, we chose a rich material that is proven by the *control* data showing intensive microbial activity characterizing valuable compost.

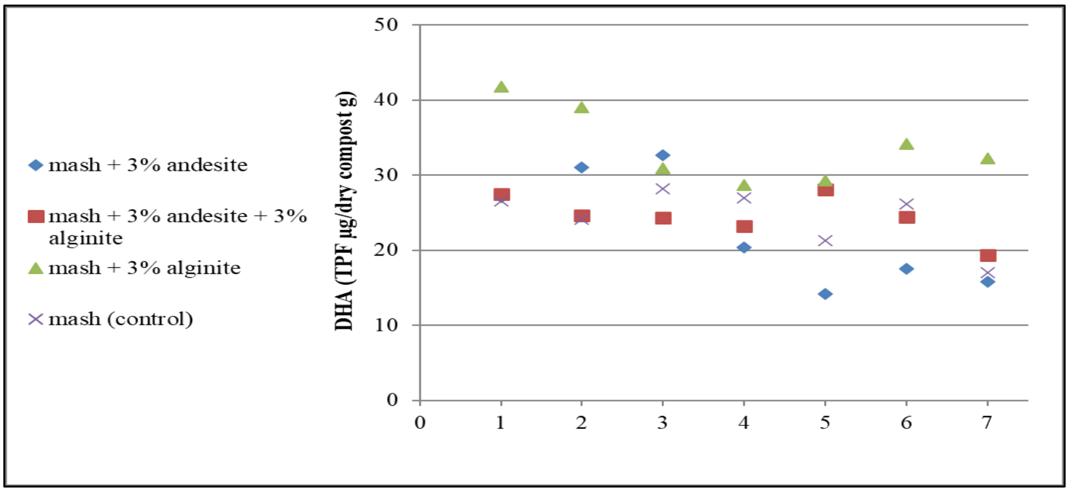

Figure 12. Dehydrogenase Activity (DHA) measurement of the composts

Heavy metal adsorption capacity – lead and iron

Based on the experimental work using (*Lactuca sativa*) as a test plant for lead accumulation capacity, it can be concluded that mash composts had a positive effect on plant development compared to control samples. The chemical studies showed increased potassium concentration in the mixtures containing 75% compost. As the lead content increased, the potassium content concentration decreased, but it was always higher in the mixtures containing 75% compost than in the mixtures containing 50% compost.

Table 1. Change of chemical parameters. The sample number indicates the additive: .1 – andesite, .2 andesite & alginite, .3 – alginite, .4 – no additive. The values show the effect of increasing lead concentration on macronutrients and organic matter.

Sample nr.	Mixture ratio	Lead contamination	Lead (mg/kg)	Phosphorus (mg/kg)	Nitrate (mg/kg)	Potassium (mg/kg)	Organic matter (%)
1.1	50% compost. 50% peat	above limit value	295.82	54.71	1.10	688.00	62.56
1.2			298.35	69.05	1.00	988.20	57.28
1.3			300.02	71.27	1.40	879.20	67.12
1.4			318.66	68.53	1.00	952.60	68.83
2.1	75% compost. 25% peat		349.67	70.10	1.00	1107.80	n.d.
2.2			277.28	78.96	1.30	1531.80	61.94
2.3			410.28	76.35	1.00	1655.60	71.36
2.4			326.11	75.44	1.40	1759.80	64.44
3.1	50% compost. 50% peat	limit value	323.28	66.31	0.70	837.80	63.55
3.2			270.42	73.36	0.70	993.40	59.02
3.3			332.94	72.83	0.70	908.60	68.48
3.4			340.21	67.10	1.00	1066.00	72.20
4.1	75% compost. 25% peat		325.55	69.70	0.90	1314.00	57.90
4.2			347.76	77.14	1.40	1734.60	60.01
4.3			323.12	75.83	1.00	1545.00	70.89
4.4			354.44	73.62	1.40	2684.80	78.35
5.1	50% compost. 50% peat	below limit value	318.41	59.27	1.10	996.00	66.19
5.2			275.94	68.27	1.00	1209.00	60.07
5.3			339.88	69.70	0.80	1090.00	69.22
5.4			348.16	65.27	1.50	1438.00	70.38
6.1	75% compost. 25% peat		321.49	65.92	1.20	1468.00	58.42
6.2			301.38	76.88	1.40	1746.80	60.79
6.3			332.53	75.31	0.60	2330.00	68.98
6.4			300.05	74.40	1.80	3146.40	74.63
7	control	no contamination	167.66	50.01	1.30	876.40	68.36
7			135.15	56.14	1.80	842.80	79.80
7			141.58	65.79	1.10	632.80	84.74

Lead binding was significantly affected by compost content. In the case of mixtures with 75%, compost content and higher lead binding were observed at the limit value and above the limit value. Alginite addition increased lead binding. The chemical results of our experiments are shown in **Table 1**.

An increase in lead concentration (similar to potassium ion) reduced the concentration of available nitrate ions in the compost. The lettuce could not assimilate the phosphorus due to the increase in lead concentration, so the phosphorus content of the compost also increased.

Based on the experimental work using *Solanum lycopersicum* as a test plant for iron accumulation capacity which concentrations are shown in **Table 2**.

Table 2. Effect of mash compost on iron concentration in growing media (GM), roots (R) and above-ground parts (P) of tomato plants (*Solanum lycopersicum*) cultivated in different compost-soil ratios. Avg. and SD indicate average and standard deviation

Iron concentration (mg/kg)			
Samples	**Ratio of mash compost and soil**		
	100% compost + 0% soil	**75% compost + 25% soil**	**50% compost + 50% soil**
GM1	356.15	341.28	250.58
GM2	379.56	335.89	262.81
GM3	390.36	339.21	259.78
Avg. GM	**375.36**	**338.79**	**257.72**
SD. GM	**17.49**	**2.72**	**6.37**
R1	290.25	335.26	412.58
R2	325.26	338.9	425.74
R3	330.14	350.6	418.93
Avg. R	**315.22**	**341.59**	**419.08**
SD. R	**21.76**	**8.02**	**6.58**
P1	220.36	255.96	279.24
P2	234.29	247.69	285.69
P3	225.28	251.36	297.93
Avg. P	**226.64**	**251.67**	**287.62**
SD. P	**7.06**	**4.14**	**9.49**

For a better iron concentration evaluation, a graph was compiled using the results from Table 2. comparing the ratio of compost-soil present in the tomato plants growing media and the average values of iron concentration for the growing media, roots, and above-ground plant parts (**Figure 13.**).

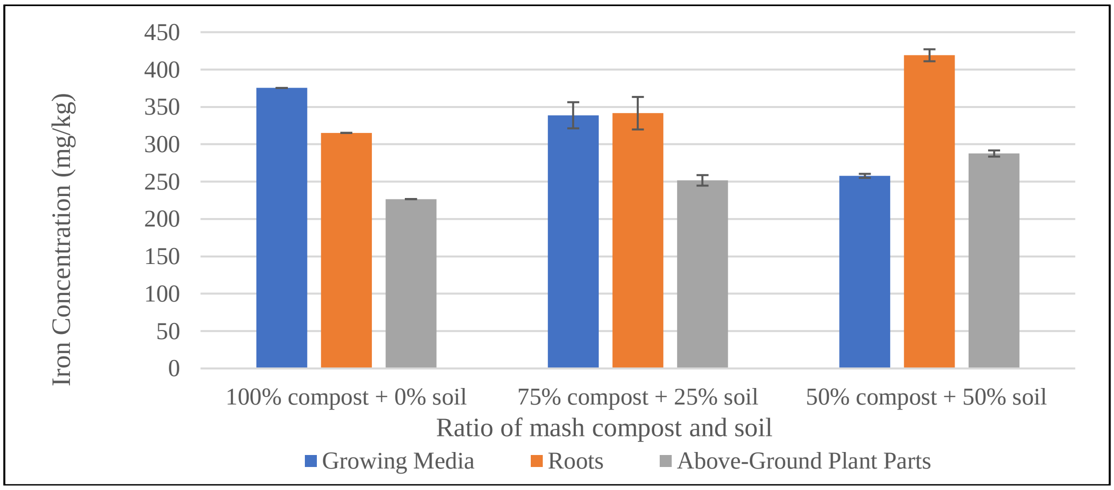

Figure 13. Average iron concentration values of growing media, roots and above-ground parts of *Solanum Lycopersicum* cultivated in three different compost-soil ratios.

Based on the results shown above, we can assert that the concentration of Fe was bigger in the media with a higher percentage of mash compost presence. Then, the compost was able to enhance the iron accumulation capacity in the growing media. This statement can be confirmed by analyzing the decrease in iron concentration as the percentage of compost also decreases. On the other hand, the accumulation of Fe in the roots increases when the percentage of compost decreases because the compost could adsorb Fe, increasing its concentration in the growing media but also decreasing the flow of Fe to the roots and to upper plant parts. Therefore, the above-ground plant parts of the tomato plants accumulate a smaller amount of Fe.

Conclusion

The present overview of Pálinka mash composting demonstrates that the compost made from this organic waste has great potential to become high-quality organic compost. Moreover, alginite and andesite promoted a good contribution to composting, especially in the improvement of nutrient concentration, moisture ratio, and pH. Then, it was possible to verify the qualifying effects of *andesite* and *alginite* on the dynamics and quality of composting *grape pomace Pálinka spent wash*. These effects can be expressed in a significant increase in macronutrient content in the composts, mainly in phosphorus and potassium. The minerals of *andesite* clearly improve the distillery spent wash in terms of nitrification and ammonification processes. The organic matter values also increased in the compost using *andesite* as an additive; however, the moisture ratio and dehydrogenase activity values decreased more than in the other treatments. Definitely, it shows signs of a complete compost. For *alginite*, the level of the parameters like pH, potassium, and phosphorus increases over time more than in the other treatments, with special attention to the potassium content that increases significantly. Thus, the agents of *andesite* and *alginite* have their own particularities regarding the dynamics in the compost, and both present good contributions to the composting. Moreover, the *grape pomace Pálinka spent wash* proves to be a rich material showing intensive microbial activity characterizing valuable composts.

Regarding the heavy metal accumulation by growing media and the test plant parts for lead and iron, it could be noticed the increase in lead concentration was affected by the availability of macronutrients. The samples with a higher compost ratio had higher lead concentrations; the humus materials adsorbed the lead, so their application had a positive effect on the physiology of the plants. The investigation of heavy metals in lettuce is still in progress, and the translocation factor can be calculated after all the results are known.

For iron accumulation, the samples with a higher compost ratio had a higher iron concentration in the growing media, which can be explained by the presence of humus materials in the compost that adsorbed the iron, so their application has a positive effect on the physiology of the plants. Hence, it was demonstrated that Pálinka mash compost directly affects and substantially affects how iron is accumulated in the growing media when mixed with compost and also in the tomato plant parts.

Therefore, the studies examined by this review paper about Pálinka mash residue and its composting conclude that *grape pomace spent wash* must be considered a great source of nutrients and organic matter for composting, providing a favourable environment for microorganisms and, furthermore for plants. Additionally, the waste concern related to Pálinka production can be tackled, promoting an environmental and sustainable solution.

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