Potentials of fish pond sediments composts as organic fertilizers

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Highlights

- Organic fish pond sediments from trout farming demonstrate potential for fertilization
- Mixing compost with cardboard and biochar increased the content of organic matter, phosphorus and total carbon
- The addition of biochar from wood chips to the finished compost has significantly affected the growth of *Phaseolus vulgaris L.*
- Composting of organic fish pond sediments can be an alternative to storing or landspreading

Abstract

Increased fish pond production is associated with the generation of waste such as fish pond sediments. . Fish pond sediments could be a valuable source of nutrients for growing plants, however they require further processing in order to be applied to soil such as composting. The aim of this work was to investigate in the laboratory scale the potential of fish pond sediments to be managed through composting with selected waste and to analyse the obtained compost and compost mixtures (M1, M2, M3) for fertilizing potential. The addition of cardboard and biochar from wood chips to the obtained compost improved the growth of roots of the cress significantly. Also, the content of carbon and nitrogen in the compost mixtures increased. The compost mixtures were added to soil and their impact was tested in pot experiment with *Phaseolus vulgaris L.*The addition of M1 (compost from fish pond sediments and 1% of biochar) to the soil had a significant impact on the growth of white beans.

Keywords: fish pond sediments, organic fertilizers, organic waste, composting

1. Introduction

In Europe in the period of 2012-2015, there was a significant increase in organic production of fish such as trout and salmon, by 100% and 24%, respectively. In Poland, the fish production market is growing every year. In 2010, it was 45,000 tonnes and in 2016 there were 51,000 tonnes [28]. However, in organic conditions breeding in 2015 there were 19,000 tons of fish [33]. However, fish shopping prices are revalibly higher than conventional breeding, therefore profitable to import fish from India, Bangladesh or Central America [14, 17]. For comparison, the unit cost of carp production for organic breeding is 7-8 PLN/kg (about 4 EURO) and is 30-40% higher in comparison to conventional breeding [1]. However, the difference in breeding and the quality of the fish obtained is significant. Conventional farms are characterized by denser arrangement of fish in the tank, for example 1000 pieces per ha whereas for organic it is about 600-750 pcs/ha. Organic fish are fed with organic certified cereals. The bottoms of the ponds are periodically limed or iron sulphate is added whereas in conventional ponds no preventive treatments are carried out [1]. In the case of conventional breeding, the amount of fish pond sediments generated is in the range of 148-338 kg, while in organic it is 8-11 kg per ton of fish [38]. Preventive treatments, organic feeding, certified feed, smaller amount of fish also have an impact on the quality of bottom sediments. What is more the oxygen content is important in the proper functioning of the ponds. In the case of conventional breeding, oxygen depletion occurs faster due to excessive bottom sediment. In organic farms, however, the oxygen concentration is maintained at the same level throughout the year [1]. Small amounts of organic sediments are not as dangerous as the excessive amount of bottom sediments from conventional breeding, because they also do not generated significant amounts of toxic gases like ammonia [3]. The risk associated with bottom sediments from conventional breeding is also associated with the means used in the ponds to eliminate unwanted organisms. In extreme cases, contamination such as insecticides, pesticides, heavy metals, among others arsenic, mercury, cadmium, chromium, beryllium and aluminum, cyanide can pose a threat to people and the water organisms which we eat. If accumulated in a significant amount in the human body they could be carcinogenic [4]. Organic bottom sediments are removed manually from the water reservoir. Depending on the volume of the tank, this process is repeated 2-3 times a year. Then, the sediments are dried in the air and used, for example, for soil fertilization (personal communications). However, sediments from conventional fish farms are formed in much larger quantities. Many applications are described in the literature, where, in addition to storage, they are subjected to biological processes and used for fertilizing purposes. Fertilizers from fish pond sediments have found application in the cultivation of such plants as *Lolium perenne*, *Lolium multiflorum*, *Lolium westerwoldicum*, fodder grass. Fish pond sediments they also found application as a material for building quays, road embankments. Also fish pond sediments there are used as one of the ingredients in feed for animal. Fish pond sediments can be also used for composting and vermicomposting to obtain composts. Small amounts could be used as an additive in energy recovery systems (e.g. biogas additive), and also as growth medium for algae [9, 12, 19, 21, 33, 40].

There are more examples of of using fish pond sediments from conventional farms than from organic ones.. But in both breeding systems, bottom sediments are formed and can be used in the process of composting. The overall goal of this study was to investigate the potential of fish pond sediments as a source of valuable nutrient for production of composts and analyze their the impact on plant growth. The aim of this work was to investigate in the laboratory scale the potential of fish pond sediments for composting with selected waste materials and to analyse the obtained compost and compost mixtures for soil fertilization. The scope of this paper included: (1) the analysis of the properties of fish pond sediments sampled from an organic trout farm (Poland), (2) composting of fish pond sediments mixed with selected waste materials, (3) analysis of selected properties of the obtained compost, (4) preparation of compost mixtures and the analysis of selected properties, (5) preparation of growing media by mixing soil with poor organic matter with the compost mixtures and the analysis of selected properties, and (6) the analysis of the impact of compost mixtures on growth and yield of *Phaseolus vulgaris L.*

2. Materials and methods

This study was conducted at the laboratories of the Institute of Environmental Engineering, Częstochowa University of Technology, Częstochowa, Poland.

2.1. Substrates and composting mixtures

Fish pond sediments (FPS) were used as a substrate, FPS were collected from the organic fish farm in Złoty Potok, Poland where organic rainbow trout (*Oncorhynchus mykiss*) is bred. Fish pond sediments were mixed with readily available bulking agents such as wheat straw (WS) and freshly cut grass (FG) in the following ratio: (FPS:FG:WS) 1:0.78:0.03 wet weight (1:1.43:0.09 dry weight).

Biochar used in this study was produced from woodchips and purchased from a commercial pyrolysis plant in Poland. This biochar demonstrated nitrogen content of 0.83% (TN), total organic carbon of 75.3% (TOC), ratio C/N of 231, pH of 7.4, conductivity 183 µS (EC), ash content 3.95%, moisture content 4.26% (MC). The content of individual chemical elements, phosphorus content of 0.054% (TP), Mg of 680 mg kg^{-1}, Hg of 0.011 mg kg^{-1}, Zn of 75.4 mg kg^{-1}, Cd of 0.368 mg kg^{-1}, Pb of 1.65 mg kg^{-1} [27].

2.2. Laboratory composting reactor

The 60 L laboratory composting reactor was equipped with the force aeration system, flow controllers, measurement sensors for temperature, and condensate and leachate collection sets [2, 6]. The system of aeration and drainage of leachates from the tank prevents the formation of anaerobic zones in the composter (which cause rotting of the mixture and the formation of unpleasant odors) [36].

2.3. Methods

2.3.1. Laboratory composting

The process of composting was carried out for 28 days. Temperature measurement was performed on a daily basis. Compost samples were collected before and during the process and analyzed for moisture content (MC), organic matter (OM), total organic carbon (TOC), Kjeldahl nitrogen (TN), pH.

2.3.2. Preparation of growing media for pot experiments

The obtained compost from fish pond sediments was mixed with the selected materials including cardboard and biochar from wood chips. The content of 1-2% biochar in soil affected the pH values [27]. Table 1 shows the weight ratio of compost with fish pond sediments, biochar from wood chips and cardboard.

Table 1. Compost from fish pond sediments amended with selected materials.

Ratios of mixtures	Compost mixutres		
	Compost from fish pond sediments with cardboard - Mixture 1 (M1)	Compost from fish pond sediments with biochar from wood chips - Mixture 2 (M2)	Compost from fish pond sediments with cardboard and biochar from wood chips - Mixture 3 (M3)
	(CFPS:C)	(CFPS:B)	(CFPS:C:B)
Dry weight	1:0.09	1:0.02	1:0.09:0.02
Wet weight	1:0.06	1:0.01	1:0.06:0.01

2.3.3. Physical and chemical analysis

The analysis of substrates and compost mixtures was made for moisture content (MC) by drying the samples at 105 ˚C to constant weight. The content of organic matter (OM) was determined by the loss on ignition of the dried mass in a muffle furnace at 550° C for 3 hours. Total nitrogen (TN) was determined by the Kjeldahl method. The content of phosphorus was determined by spectrophotometric method with ammonium molybdate [34] whereas the content of carbon was made using an organic carbon analyzer (TOC) in solid samples by high temperature (1200 ˚C) oxidation in the stream of oxygen or synthetic air [24]. The pH was measured with a laboratory pH multifunction device/conductometer/solometer. Analysis of trace amounts of chemical elements by means of inductively coupled plasma mass spectrometry (ICP-OES MS) was also carried out.

2.3.4. Phytotoxicity test

The degree of phytotoxicity of compost and mixtures M1, M2, M3 mixed with soil was determined. The experiment was performed using the seed germination bioassay test according to Mitelut (2011). In this test used cress seeds (*Cardamine L.*). The test was performed in four replications for each extract concentration of 0%, 25%, 50%, 75%, 100%. After placing the extracts and seeds on Petri dishes, they were incubated at 25˚C for 72 hours. After this time, the sprouted seeds were counted and roots length were measured. In contrast, the germination index of the seeds was calculated from the formula, $(G_i)=((G/G_0)*(L/L_0))*100$, units [%]. Where, G- the number of seeds that germinated in the sample analyzed, L- root length in the analyzed sample, units [mm], G_O- amount of seeds that germinated in a 0% control sample, L_0- root length in a 0% control sample,units [mm] [13, 26].

2.3.5. Pot experiment

In order to evaluate the effect of compost mixtures on soil properties and the plant growth and yield the pot experiment was performed. The obtained compost mixtures M1, M2 and M3 were mixed with soil to produce growing media for pot experiment. The soil sampled from around Częstochowa demonstrated susceptibility to drought and fell under the soil category I (loose sand, loose dusty, poorly loamy) [23].The soil was sieved through a sieve with a mesh size of 1.5-2 mm. Then, the air-dry soil was mixed with compost mixtures (Soil, Soil + Compost, Soil + Mixture 1, Soil + Mixture 2, Soil + Mixture 3) to produce growing media. Table 2 shows the weight ratio of the compost mixtures and the soil. The amount of compost was added so as not to exceed the nitrogen content per 1 kg of soil. In order to assure geochemical equilibrium the growing media 0, 1, 2, 3 were left for five weeks in a dry place at 20-24˚C [15] and proper moisture content was maintained by watering once a week [10].

Table 2. Soil mixed with the compost mixtures to produced growing media.

Ratios	Treatments			
	Growing medium (GM 0)	Growing medium 1 (GM 1)	Growing medium 2 (GM 2)	Growing medium 3 (GM 3)
	(S:Compost)	(S:M1)	(S:M2)	(S:M3)
Dry weight	1:0.03	1:0.03	1:0.03	1:0.03
Wet weight	1:0.07	1:0.07	1:0.07	1:0.07

After reaching the equilibrium the growing media 0, 1, 2 and 3 were again tested for water content (MC), organic matter (OM), phosphorus, Kjeldahl nitrogen, carbon (TOC) and pH measurement. The phytotoxicity test was carried out for growing media 1, 2 and 3.

The investigated growing media were transferred to the pots. Each pot contained 260 g of growing medium, i.e. 0, 1, 2 and 3. Each treatment was performed in five replications. Bean seeds were placed in the pots and kept in the laboratory with natural sunlight. Ordinary white beans (*Phaseolus vulgaris L.)* were selected because it is a leguminous plant, quickly germinating, has the ability to bind nitrogen, readily available [30, 41]. The beans also have low requirements for nitrogen. After three months of the pot experiment the plant biomass was removed from the soil, weighed, measured and dried.

3. Results and discussion

3.1. Characteristics of substrates, composting mixture, compost and composting mixtures, and growing media

3.1.1. Characteristics of substrates for composting

Table 3 shows the selected properties of the substrates used for composting. Fresh bottom sediments from the organic fish farm in Złoty Potok demonstrated high water content and alkaline pH. The P_2O_5 content was at the level of 13.88 mg g^{-1}. The determination was made on the basis of Egner-Riehm extraction. The phosphorus content in fish pond sediments ranged from 10.1-15.0 (medium) mg P_2O_5 per 100g soil [8]. Fresh grass and wheat straw showed similar content of total organic carbon.

Table 3. Characteristic of composting substrates.

Substrate	pH	Moisture content (MC)	Organic Matter (OM)	Total nitrogen	Total organic carbon (TOC)	Ratio C/N
Units	-	%	%	%	%	-
Fish pond sediments	7.61	63.48±1.72	30.38±2.13	0.41±0.18	10.19±0.45	25
Fresh grass	6.31	64.36±1.37	92.32±0.80	1.46±0.12	36.29±0.08	25
Wheat straw	6.60	8.25±2.12	95.80±0.61	0.45±0.08	36.84±0.43	82

Wheat straw had the highest C / N ratio. However had the lowest content of organic matter and total organic carbon. The addition of fresh grass and wheat straw increased organic carbon content in the compost mixtures [22].

3.1.2. Temperature during the composting

The organic fish pond sediments with fresh grass and wheat straw were composted for 28 days. The measurement of temperature inside the reactor and ambient was performed daily (Figure 1). Temperature during composting is the key parameter that determines the process dynamics. Among other things, it indicates when the active phase of composting has come to an end, because the temperature were decreasing [6].

The temperature increased in the initial phase (up to the 4th day) up to 52˚C. The composting mixture from the active transformation phase began to stabilize on the 12th day. Within the next 14 days, the temperature dropped to 22˚C (the dynamic transformation processes have stabilized).

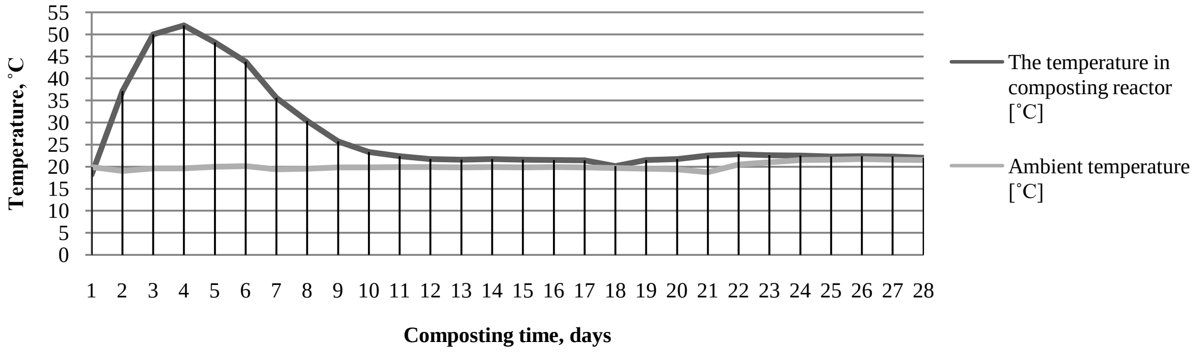

Fig. 1. Temperature during the 28 day composting process.

The average air flow rate was 35 l/min. Too much flow could cause difficulties in raising the temperature in the compost tank. However, too low, with high humidity of the composting material, could difficulties an even supply of oxygen to the entire mixture. Therefore, the flow rate initially set at 50 l/min was changed to 35 l/min.

3.1.3. Properties of the compost from fish pond sediments and compost mixture 1, 2, 3.

The obtained compost and compost mixtures 1, 2, 3 were analyzed for selected properties and the results are presented in Table 3. The water content increased after 2 weeks of composting – which is typical for experiments in laboratory composting reactors, and decreased at the end of the process. The C/N ratio dropped from 30 to 12 in the obtained compost. The C/N ratio of 15:1 is typical for stabilized compost [7]. This is also related to the decrease in the carbon content in the obtained compost. In the finished compost (End of composting) and compost mixtures M1, M2 and M3, the total nitrogen content and pH has increased which was related to the loss of organic matter and the processes occurring in the composter [16].

Table 3. Properties of the obtained compost from fish pond sediments.

Parameters	pH	Moisture content (MC)	Organic matter (OM)	Total organic carbon (TOC)	Total nitrogen (TN)	P_2O_5	C/N
	-	%	%	%	%	mg g^{-1}	-
Start of composting	7.06	72.25±1.41	51.34±2.84	19.56±0.06	0.95±0.28	136.88±0.01	21
Composting after 2 weeks	8.21	75.39±1.00	37.43±3.43	18.36±0.22	1.32±0.20	120.12±0.01	14
End of composting	8.54	71.64±2.55	32.56±3.58	17.42±0.49	1.43±0.16	147.36±0.01	12
Compost mixtures (M1)	8.55	70.35±1.52	41.78±3.19	19.74±0.71	1.26±0.12	113.66±0.01	16
Compost mixtures (M2)	8.64	72.73±0.87	39.31±0.88	18.37±0.44	1.23±0.20	126.41±0.01	15
Compost mixtures (M3)	8.53	71.21±1.10	40.70±0.69	19.66±0.23	1.16±0.18	115.41±0.01	17

The pH values increased over time after adding biochar and cardboard to the compost from fish pond sediments. The increase in pH in the initial stages of composting is associated with the release of ammonia which in the phase of ammonification and organic nitrogen mineralization is necessary during microbial activity. When the compost matures its pH value decreases and remains at about 7.5. The drop in pH, after about 25-29 days, can be caused by the oxidation of ammonium nitrogen, the release of H^+ as a result of nitrification. The release of a large amount of CO_2 and the production of organic and inorganic acids in the composting process, also reduces the pH [22]. The compost obtained in the experiment was alkaline. This pH is suitable for the growth of most plants [40]. The phosphorus content was high, classified as Class I (Evaluation of phosphorus and potassium contents in mineral soils, based on Egner-Riehm extraction). The determination was made on the basis of Egner-Riehm extraction [8].

3.1.4. Properties of the growing medium 1, 2, 3.

After the 5 week period for geochemical equilibrium, physicochemical analysis were performed, which were presented in Table 4.

Table 4. Growing medium parameters after 5 week period for geochemical equilibrium .

Parameters	pH	Moisture content (MC)	Organic matter (OM)	Total organic carbon (TOC)	Total nitrogen (TN)	P_2O_5	C/N
Units	-	%	%	%	%	mg g^{-1}	-
Control (Soil)	7.65	9.35±0.21	3.15±0.49	2.37±0.13	0.12±0.00	23.48±0.02	20
Growing medium 0	7.95	17.20±0.36	5.12±0.11	3.44±0.14	0.22±0.01	48.54±0.01	16
Growing medium 1	8.04	11.26±0.45	5.08±0.14	3.48±0.05	0.21±0.00	52.90±0.01	17
Growing medium 2	7.93	12.09±0.36	5.22±0.63	4.78±0.08	0.21±0.00	50.11±0.03	23
Growing medium 3	8.13	16.21±0.29	4.85±0.36	3.20±0.02	0.21±0.00	48.10±0.03	15

After five weeks physicochemical parameters of growing mediums were reduced. It was influenced by compost maturation, mixture stabilization, soil microorganisms activity, sprinkling once a week, which it could have caused leaching, evaporation [7, 15, 22, 37].

Growing mediums consisted of 0 (Soil with compost form fish pond sediments), 1 (soil, cardboard and compost from fish pond sediments), 2 (soil, biochar and compost from fish pond sediments) and 3 (soil, cardboard, biochar and compost from fish pond sediments). Growing mediums obtained similar physical and chemical parameters then Control (Soil).

3.2. Phytotoxicity test with *Cardamine L.*

Phytotoxicity test was performed for all the investigated growing media: control (soil), growing media 0, 1, 2 and 3 before and after the 5 week period for geochemical equilibrium.

After three days of incubation of cress seeds at 25˚C, the roots of the plant were measured. The figure (Fig. 2) shows the distribution of root length in millimeters, using different concentrations of extracts.

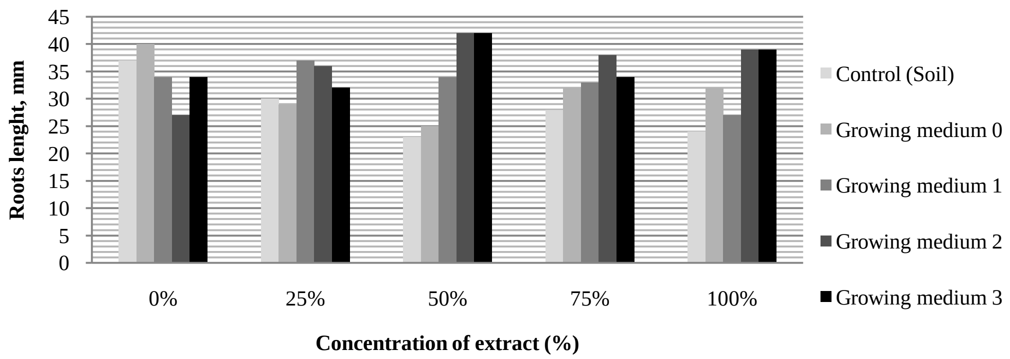

Fig.2. The length (L) of cress roots (*Cardamine L.*).

The roots length ranged from 35 to 42 mm. Roots observed in the growing medium 2 and 3 at a concentration of 50%, demonstrated the longest roots, 42 mm. The figure below (Fig.3) demonstrate the results that were calculated from the seeds germination index.

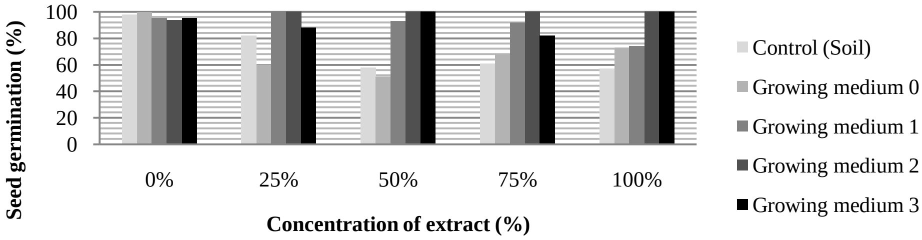

Fig.3. Germination index (G_i) of cress seeds (*Cardamine L.*).

Extracts from the growing media 1, 2 and 3showed a similar effect on seed germination. G_i was significantly higher than in the case of the soil (Control) and the growing media 0 (soil mixed with the obtained compost). Phytotoxicity test was performed after 5 week period for all the investigated growing media. The results are shown in figures (Fig. 4, Fig. 5).

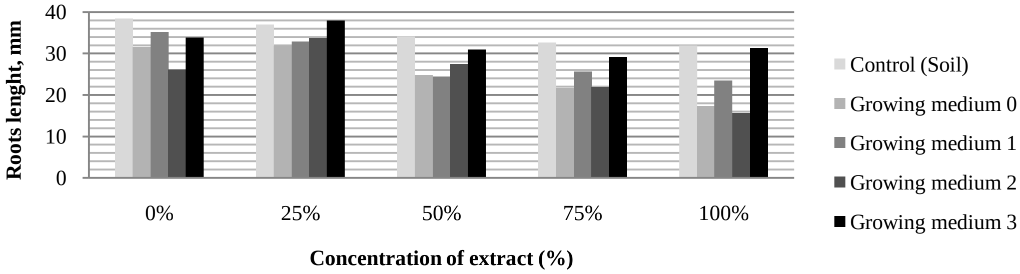

Fig. 4. The length (L) of cress roots after 5 week period of geochemical equilibrium.

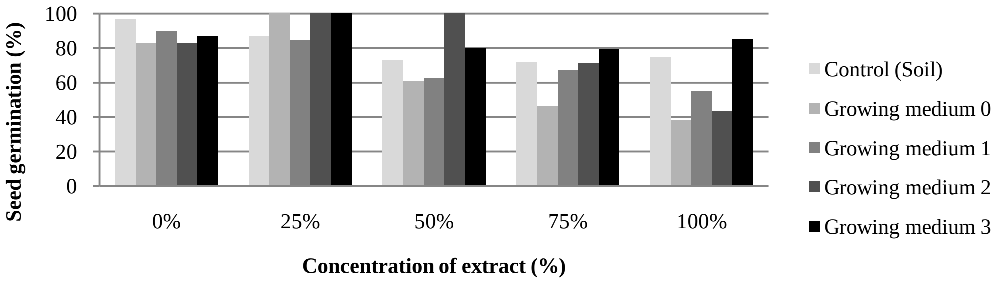

Fig.5. Germination index (G_i) of cress after 5 week period of geochemical equilibrium.

Decrease in root length was observed. The highest result was achieved with the Growing medium 3 sample, 38 mm, at a concentration of extract, 25%. The reduction in length and germination could result from lower contents in carbon and phosphorus. The C/N ratio and pH values also decreased [15].

3.3. Growth of *Phaseolus vulgaris L.*

After conducting basic analyzes, a vase experiment was prepared. Each soil mixture was made in five replications. In total there were 25 pots in which there were 260 g of soil with composts. Each container had water permeable material at the bottom, which counteracted the soil loss from the pot. After planting the seeds, the plants were watered regularly. After two, four and twelve weeks, photos were taken, presented in Tables 5.

Table 5. Growth and yield of *Phaseolus vulgaris L.*

Name of the sample	Growth of plants		
Time	After 2 weeks	After 4 weeks	After 12 weeks
Control (Soil)			

Growing medium 0			
Growing medium 1			
Growing medium 2			
Growing medium 3			

Significant plant growth was observed in the pots with growing media 2 and 3, they had the longest stems and many leaves. Table 6 presents a summary of plant measurements. It can be noticed that for five replicates, all seeds germinated only in the Growing medium 2. They also had the longest stalk.

Table 6. The average values of the measurements of *Phaseolus vulgaris L.*

	The length of the root	Length of the stem	Plant weight		Number of germinated seeds
Units	mm	mm	g, wet weight	g, dry weight	-
Control (Soil)	75±7.07	170±0.00	13.94±1.09	2.98±0.71	2
Growing medium 0	65±7.07	225±35.36	17.68±1.68	3.14±0.38	2
Growing medium 1	77±20.82	250±50.00	13.99±2.93	2.21±0.56	3
Growing medium 2	70±12.25	342±54.95	17.27±5.18	3.09±0.91	5
Growing medium 3	50±8.16	290±80.42	11.64±3.31	1.74±0.80	4

After completion of the pot experiment the investigated growing media were subjected to final physicochemical analysis. The results are presented in Table 7.

Table 7. Properties of the investigated growing media after completion of the pot experiment.

Parameters	pH	Moisture content (MC)	Organic matter (OM)	Total organic carbon (TOC)	Total nitrogen (TN)	P_2O_5	C/N
Units	-	%	%	%	%	mg g^{-1}	-
Control (Soil)	6.82	0.43±0.36	3.98±0.09	2.39±0.14	0.13±0.01	36.53±0.06	18
Growing medium 0	7.83	0.22±0.08	5.67±0.37	3.56±0.19	0.21±0.01	58.84±0.03	17
Growing medium 1	8.08	0.21±0.11	5.54±0.17	3.53±0.11	0.20±0.02	74.38±0.01	18
Growing medium 2	8.09	0.41±0.35	6.06±0.29	4.06±0.11	0.21±0.01	66.03±0.08	19
Growing medium 3	8.06	0.58±0.40	5.57±0.32	3.99±0.31	0.20±0.01	56.01±0.03	20

The final results of the physico-chemical analysis did not differ significantly from the results obtained after the 5-week stabilization. However, the C/N ratio in Growing medium 3 increased slightly from 15 to 20. The remaining mixtures also had a similar carbon to nitrogen ratio, around 20. An effect on this could have biochar, which slightly affected the increase in C/N [35].

The analysis of the trace amounts of chemical elements in all investigated substrates, composting mixture, the obtained compost mixtures and growing media was also carried out and the results are presented in Table 8. The obtained results were compared with the current legal standards regarding the content of heavy metals in fertilizers.

Table 8. The concentrations of trace amounts in the investigated substrates, composts, compost mixtures and growing media.

Units Dry matter, mg kg^{-1}	Fish pond sediments	Start of composting	Composting after 2 weeks	End of composting	Compost mixture 1	Compost mixture 2	Compost mixture 3	Control (Soil)	Growing medium 0	Growing medium 1	Growing medium 2	Growing medium 3
Ag	11.6	0.41	10.1	12.9	10.9	5.98	7.84	4.03	3.15	2.22	3.21	3.26
Al	368.4	230.1	286.4	235.7	286.6	251.9	349.9	588.1	734.4	761.4	765.6	810.2
As	0.56	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.92	1.44	1.11	1.39	1.78
B	2.96	2.64	3.12	3.06	2.86	3.16	3.06	<0.09	0.66	1.16	2.88	0.95
Ba	2.46	3.14	3.76	3.65	4.16	3.66	4.76	2.3	3.59	3.89	3.94	3.98
Bi	0	0	0	0	0	0	0	0	0	0	0	0
Ca	>67791	>48862	>52891	>52653	>51192	>53318	>48009	1828.8	8287.8	8510.4	9001	6926.8
Cd	0.55	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
Co	0.3	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Cr	10.6	8.81	9.31	7.04	7.69	8.41	8.6	3.31	6.12	7.7	6.93	6.8
Cu	7.72	5.87	6.8	6.54	7.97	6.51	7.29	1.41	2.57	2.97	3.69	3
Fe	1411.9	1166.2	1311.9	1160.2	1145.6	1227.2	1184	1915.3	2614.8	2714.5	2820.5	3123.6
Ga	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23	<3.23
In	2.5	<2.12	<2.12	<2.12	2.48	<2.12	2.2	<2.12	<2.12	<2.12	<2.12	2.69
K	117.2	1151.3	1181.8	1214.1	1083	1208.5	1086.7	105.2	265.3	261.3	288.5	250.3
Li	0.69	<0.33	<0.33	<0.33	<0.33	<0.33	<0.033	0.62	0.83	0.88	1	0.9
Mg	334.7	664.2	738.4	758.7	724.6	733.9	712.5	238.5	378	388.9	412.2	418.2
Mn	19.3	58.4	80.1	74.9	65.4	81.6	72.4	44.3	72.3	77.6	79.3	74.9
Na	58.4	80.5	81	83.2	87.9	71.7	70.5	47	70.9	72	82.8	75.6
Ni	2.05	0.96	1.08	1.141	0.85	1	1.27	0.45	1.07	1.58	1.91	1.69
P	796.7	918.3	986.6	1001.5	921.9	985.1	898.4	230.6	393	400.9	408	379.7
Pb	13.7	10.3	9.79	10.6	10.5	9.94	10.2	16.3	21.8	22.5	22.7	22.8
Sr	4.48	4.15	4.67	4.574	5.6	4.53	5.34	1.26	2.15	2.13	2.21	2.16
Ti	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15	<2.15
Zn	80.2	67.9	72.4	73.5	70.4	73.2	66.5	20.6	34.5	36.1	39.6	41.7

According to the Ordinance of the Minister of Agriculture and Rural Development of June 18, 2008 on the implementation of some provisions of the Act on fertilizers and fertilization. The chromium content should not exceed 100 mg kg^{-1} dry matter, cadmium <5 mg kg^{-1} dry matter, nickel <60 mg kg^{-1} dry matter, lead <140 mg kg^{-1} dry matter [32]. In the table above, these contents have not been exceeded.

4. Conclusions

Fish pond sediments from organic fish farming can be managed through composting with selected waste materials such as fresh grass and wheat straw. The obtained compost from fish pond sediments was used to prepare compost mixtures which were further used to prepare growing media.

The obtained results allowed formulation of the following conclusions:

1. The addition of cardboard and biochar from wood chips significantly affected the content of organic matter, total organic carbon, phosphorus and total nitrogen in compost mixtures. Biochar also affected the pH changes in the blends.

2. Growing mediums had a significant impact on the germination of *Cardamine L.* seeds. Sample Growing medium 2 (compost with additive 1% biochar from wood chips), showed the best fertilizing properties.

3. Substrates and later mixtures did not show impurities in the form of cadmium, chromium, nickel and lead. Growing medium mainly Growing medium 1, 2 and 3 significantly affected the germination and growth of *Phaseolus vulgaris L.* in the pots experiment.

Fish pond sediments and their potentials for soil fertilization are poorly described in the literature. Therefore, it was difficult to find other studies on composting of fish pond sediments and fertilizing potential to make the comparison and discussion

Further research is needed to understand how various factors such as type of fish, breeding system, feed, seasonality, management of pond, etc. affect the composition of fish pond sediments. In addition, one of the important aspect is microbiological safety of fish pond sediments.

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