COMPOSTING AND VERMICOMPOSTING OF SETTLEABLE SOLID FISH WASTE (MANURE) FROM COMMERCIAL TURBOT FARM

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1 INTRODUCTION

In Spain, the region of Galicia is the number one producer in turbot production because of its quality and quantity. It produces practically 95 per cent of the almost 8,000 tonnes that comprise the total national production. Galician producers contribute 85 per cent of the European production.

Fish farms produce large quantities of organic waste. This material can accumulate on the pool, as well as be suspended in the water column. Its composition is determined according to several parameters, such as the non-consumed scraps of feeding stuffs and excrements, or other organic droppings from fish. Waste management strategy must consider several issues, including requirements for the storage and disposal of wastes in an environmentally safe manner.

It is well known that the fish wastes have been used as organic fertilizer and nutrients for both agricultural purposes and for rehabilitation of degraded areas (Alfaro et al 2004, Mazzarino et al 1998). Fish sludge contains macro and micro nutrients, especially high levels of nitrogen and phosphorus. Sewage sludge mixed with different organic waste materials is now usual in composting experiments (Li et al., 2001; Mupondi et al., 2006, Roca-Pérez et al 2009). Composting is a generally accepted as a beneficial method of stabilizing the organic matter container in these wastes. The composting process kills the pathogens due to the heat generated during the thermophilic phase; the organic compositions in waste will be converted into stabilized humic substances through mineralization and humification with a significant reduction in volume. An odourless innocuous and stable organic amendment can be obtained by composting, and its use for improving soil structure and soil organic matter has been reported worldwide (Laos et al.2002).

Vermicomposting is essentially organic composting through earthworms and an ecobiotechnological process that transforms energy rich and complex organic substances into a stabilized vermicomposts (Bentize et al. 2000). The use of earthworm in sludge management has been termed as ‘vermistabilization’. Vermistablization represents a technology that is environmentally sound and relatively new technology that can be classified as an innovative and alternative technology (Surindra, 2009, Singh et al. 2010)

The aim of this work was to evaluate the feasibility of composting and vermicomposting solid fish waste (sludge) from commercial turbot farm with pine sawdust, wood shavings, algae and poultry litter as bulking agents.

2 MATERIAL AND METHODS

2.1 Materials

Sludge sampling was carried from commercial turbot farm located in O Grove, Ria of Arousa (Insuiña S.L.), which is the oldest one that produces this specie in Galicia. It generates 150t per year and a effluent volume between 1,000 and 1,500 m^3/h, of which around 60 m^3/h are prefiltered (with a rotary filter <200 microns). Sampling was carried out with the sludge which was sown in the pool and others were collected from the rotary filter. Six samples of sludge were taken during 2008-2009. The samples were stored in plastic containers and refrigerated until they reached the laboratory (<4ºC) Sludge was analyzer for pH, OM, macronutrients, micronutrients, heavy metals, pathogens, and electrical conductivity.

Outside composting experiments were conducted at Ponteareas (Pontevedra) during 2008-2009. The local climate is humid oceanic type, mean annual maximum temperature is 19,7ºC and minimum 9,1ºC, precipitation concentrated mainly in winter, with dry summers. Two different processes were employed composting and vermicomposting. The turning pile system was used for the composting process, using piles of 1m^3 and were placed in an open site to facilitate turnings. Temperatures were measured twice a day, at 0.50 m depth with a compost thermometer . The plastic box systems (30L) were used for vermicomposting. The boxs were placed in an open site.

Composting requires bulking agents in order to facilitate aeration and provide carbon sources for microorganisms. Pine sawdust, wood shavings, algae and poultry manure were used as bulking.

Selected waste mixtures – pine sawdust + sludge (3:1) (C1, compost 1), pine sawdust + fruit waste + sludge (1:2:1) (C2, compost 2), poultry litter+ sludge (1:3) (C3, compost 3), and wood shaving + sea algae + sludge (2.5: 1.5: 1)(C4, compost 4)- were composted during four months . The temperature variations during this process followed the typical three-phase pattern.

At the end of this process, worms of type, Eisenia andrei and Eisenia fetida, were added to C1 and C2 to initiate vermicomposting during a further two months (VC1 and VC2)

Compost and vermicompost samples was passed through a 2mm sieve and analyzed in triplicate for: pH, electrical conductivity (EC), ammonium (NH^+_4), nitrate (NO_3^-), phosphate (PO_4^{-3}), total organic carbon (TOC), total N (TN).

2.2 Methods

Compost pH and EC was measured in water extract, TOC and TN by elemental analysis (Leco CN-2000), heavy metal total content by acid digestion and analyzing with ICP-OES (Perkin Elmer Optima 4300 DV) for Cd, Cr, Ni, Pb y Zn and with AAS-CV (Varian SpectrAA-250 Plus) for Hg. The NH^+_4 , $NO_3^-$and PO_4^{-3} were extracted using acidified calcium chloride solution (0.1 M), according to the method developed by Houba et al. (2000), and analyzing with a segmented-flow auto analyzer (Bran Luebbe-AA3). *Echerichia Coli* was determined by membrane filtration (PNT/001) and immunoenzimático test (PNT/007) for determined *Salmonella sp.* Statistical analyses were carried on the software SPSS.

3 RESULTS AND DISCUSSION

Sludge from turbot farm was analyzer for pH, OM, macronutrients, micronutrients, heavy metals, pathogens, and electrical conductivity. Characteristics of fish manure are given en Table 1.

TABLE 1 **Characteristics of fish manure (dry weight basin).**

Parameters			Heavy metals ($mg.kg^{-1}$)		Limit ($mg.kg^{-1}$)
water content (%)		85.7 ± 0.7	**Hg**	0.093 ± 0.01	16
pH (H_2O)		7.56 ± 0.04	**Cd**	1.21 ± 0.1	20
% C		16.94 ± 0.5	**Cr**	53.26 ± 10	1000
% TN		2.59 ± 0.08	**Ni**	29.67 ± 0.6	300
% TOM		33.8 ± 1	**Pb**	34.95 ± 0.8	750
C/N		6.38 ± 1	**Zn**	718.8 ± 43,3	2500
PO_4^{3-} ($mg.kg^{-1}$)		550.0± 27,4	**Cu**	68.67± 3,24	1000
NH_4^+ ($mg.kg^{-1}$)		5.28 ±0.7			
NO_3^- ($mg.kg^{-1}$)		2.51 ± 0.3			
EC (ms/cm)		50.55 ± 1.6			
% salts		3.25 ± 0.03			
Pathogens	**Salmonella**	absence			
(ufc/100ml)	**E. coli**	absence			

Results showed a very high water content in fresh fish manure (86%), an organic matter content around 33.8 %, and a neutral pH (7.5), total N content with values around 3% of which >90% was in the organic form. Heavy metal content was much lower than the upper pollutant limits set by the European legislation. Electrical conductivity was very high (50.55 mS/cm), the salt concentration being about 3.25%. The C:N ratio was very low (6.3).

Two processes were used: composting and vermicomposting. The turning pile system was used to composting process and vertical system in plastic box for vermicomposting.

The direct vermicomposting (without previous traditional aerobic composting), was with selected waste mixtures (pine sawdust + fish manure and pine sawdust + fruit waste + fish manure). In initial trails, *Eisenia andrei* and *Eisenia fetida* were added but after 24 hours, the mortality was 100% due to high salt content. Therefore, an initial composting process was developed, with selected waste mixtures (C1, C2, C3 and C4) during four months. Then, after composting process, a vermicomposting process was conducted in C1 and C2, were inoculated with *Eisenia andrei* and *Eisenia fetida* for two months (VC1, VC2).

During preliminary composting process, physical changes were observed; volume, weight, odour and water content. The thermophilic composting period lasted for approximately 20d in all cases; the time which passed with temperatures over 55ºC was 48-54 h., time enough to satisfy requirements for processes to further reduce pathogens. Characteristics of vermicompost (VC1, VC2) and compost (C3, C4) are given en Table 2.

The results showed a important electrical conductivity decrease after composting and the vermicomposting process, VC1 and VC2 showed the lowest EC values (4,5 and 5,6 mS/cm), and C3 presents a slightly high value (8,06 mS/cm).

At the end of the compost and vermicompost processes, VC2 and C4 had a similar neutral pH (7.13 and 7.27). However, VC1 presents a pH value slightly lower (6. 62), it could be caused by nitrogen mineralization process; VC1 had the highest NO_3^- content.

VC1 had C/N slightly high (34,4), however C3 and C4 showed a C/N ratio of about 13-14.

The virtual absence of ammonium nitrogen in the final compost is a good indicator of their maturity (Roca-Pérez et al 2009). In this study the NH_4^+ content, in the finals vermicompost and compost, was around 101, 186, 703 and 285 mg.kg^{-1} in VC1, VC2, C3 and C4, respectively. These facts were consistent with other reports; thus, Zucconi and De Bertoldi (1987) established that an ammonium nitrogen value below 400 mg.kg^{-1} indicates mature compost; this may indicate that the composting process of C3 was slower.

The concentration of NH_4^+ was greater in the compost in comparison with fish sludge. With respect to nitrate, VC1 and C4 are the vermicompost and compost which has a higher concentration.

TABLE 2 **Chemical characteristics of vermicompost (VC1 and VC2) and compost (C3 and C4) (dry weight basin). Mean (standard deviation).**

	VC1	VC2	C3	C4
pH	6.62 (0.03)	7.13 (0)	8.065(0.07)	7.27(0.05)
EC (mS.cm^{-1})	4.78 (0.02)	5.06 (0.03)	12 (0.05)	7.04 (0.04)
N (%)	0.87(0.03)	1.54(0.06)	1.90(0.01)	1.04(0.32)
C (%)	29.9 (2.4)	37.22(0.2)	27.76 (0.25)	13.88(2.9)
OM (%)	59.8 (4.9)	74.4(0.4)	55.52 (0.5)	27.76 (5.8)
C/N	34.4 (2.6)	24.17(1.16)	14.61 (0.06)	13.58 (1.22)
NH_4^+ (mg.kg^{-1})	342.6(38.89)	644.24(40.65)	703.04(19.7)	244.44(2.46)
NO_3^- (mg.kg^{-1})	562.13(139.95)	212.07 (2.5)	21.12(3.37)	519.81(52.22)
NO_2^- (mg.kg^{-1})	n.d.	n.d.	15.17(1.64)	n.d.
PO_4^{3-} (mg.kg^{-1})	110.42(1.23)	108.41 (3.63)	46.2(3.37)	109.98(2.74)

EC: electrical conductivity; n.d.: not detected

4 CONCLUSIONS

The substrate evaluated in this study (fish farming sludge) was adequate for composting. The produced compost had a good nutrient value, low heavy metal content, low soluble salts and high stability. The results obtained suggest that these organic residues (composting and vermicomposting) have a potential use as fertilizers in agricultural and forest soils, which could reduce the direct risks of water pollution for the fish farming industry. Sludge composting and vermicomposting is a sustainable option.

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