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THE APTNESS OF NILE TILAPIA POND SLUDGE AS A BEDDING MEDIA FOR EARTHWORM GROWTH AND VERMICOMPOST PRODUCTION

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ABSTRACT

The disposal of aquaculture sludge (AS) from freshwater aquaculture system is causing serious pollution in waterways or in agriculture as organic fertilizer. Therefore, the present study investigated the potentiality of AS for vermicomposting and the influence of different types of AS on the vermicompost bio-chemical composition and earthworm growth performance. Ten treatments with five mixing ratios (40, 50, 60, 70 and 100%) were applied using sludge of either broodstock or fry Nile tilapia with peat moss, harnessing three species of earthworm (*Eisenia fetida*; *Perionyx excavaus*; *Lumbricus rubellus*) for 60 days.

The results showed that the concentration and type of AS had significant influence on earthworm weight gain % as well as on the chemical composition of the resulted vermicompost. The maximum weight gain % (111,4%) was recorded at 100% broodstock AS. The maximum phosphorus content in the produced vermicompost (VC) was determined in 40% broodstock AS. The maximum nitrogen content was recorded in 40% fry AS. The results elucidated that there was significant influence of the type of AS on both the Indole acetic acid and amino acids content of the resulted VC. However, their impact was insignificant on the abscisic acid and gibberellic acid contents of VC.

This study is an attempt for finding effective way to treat AS and produce biofertilizer that can improve the soil properties of aquaculture ponds and leads to improved water quality and hence fish productivity. Further studies are needed to manipulate the biochemical composition of vermicompost and its influence on aquaculture as biofertilizer.

Key Words: Aquaculture sludge, Vermicomposting; fish sludge treatment; earthworms; vermicompost; Nile tilapia broodstock sludge, Nile tilapia fry sludge.

INTRODUCTION

Fish aquaculture is an eminent industrial activity in Egypt with gross output increasing significantly in recent years that contributes with about 80 % of the total fish production in 2017 (GAFRD, 2017). However, this increase associates with an increase in produced wastes from aquaculture farms that are discard directly to the water bodies without treatment. Such disposal results in pollution problems in the form of increased suspended solids, higher nutrients levels, increase BOD and COD and a fall in dissolved oxygen that may ultimately result in eutrophication problem in the receiving waterways (Cripps, 1995). On the other hand, globally, biosolids wastes from aquaculture are generally disposed of through diversion to sewage treatment or septic system facilities, and the accumulated biosolids are applied as a soil amendment and low-grade fertilizer (Yeo and Binkowski, 2010). However, this approach is also confronted by the problems of emerging obnoxious odor, increasing BOD and COD that depletes oxygen level at the plant root zone and the potentiality of transporting pathogen (Birch *et al.*, 2010).

Applying vermicomposting technology, as recommended effective mean, for treating numerous waste streams such as animal wastes (Birch *et al.*, 2010), agricultural wastes and city refuse (Kale, 1995) as well as paper pulp (Elvira *et al.*, 1995) and producing rich nutrient bio-fertilizers in the term of vermicompost (VC) as well as producing biomass of high protein content earthworm have been documented through several studies (for review Sharma *et al.*, 2005). Drugs and vitamins as well as natural detoxicant substances can also be extracted from earthworm (Paoletti *et al.*, 1991) as the earthworm can be used as a bait for fish (Ghosh, 2004). However, there have been few studies on using fish sludge for vermicomposting, such as trout manure (Phung *et al.*, 2009), large recirculating aquaculture system, RAS (Yeo and Binkowski, 2010) and catfish manure (Birch *et al.*, 2010). At the University of Idaho, Rynk *et al.* (1998) attempted to evaluate the suitability of trout manure as a feedstock for vermicomposting.

The importance of VC has been showed by several studies. Chakrabarty *et al*. (2009b) reported the potentiality of using VC as organic manure directly in aquaculture. Ismail (1997); Chakrabarty *et al.* (2009a) showed that the bioactive substances in VC, such as growth promoters, enzymes and humic acids, can promote aquatic biota abundance and suppress pathogens. Chakrabarty *et al.* (2007) showed that vermicompost is free of side effects that are associated with direct application of raw waste and animal dung to water body such as increase BOD and the risk of pathogen transmission. Recently, Abd El-Hay *et al.* (2019) reported the potentiality of the vermicompost use in cultivation and production of microalgae *Spirulina platensis.* Furthermore, Musyoka *et al*. (2020) reported the potentiality of using vermicompost in fish nutrition.

The earthworm is generally classified into detrivores and geophages (Lee, 1985), feeding on plant litter, dead roots and other plant debris or on mammalian dung as well as ingest large quantities of organically rich soil (Ismail, 1997). Various workers have suggested that *Eisenia fetida, Lumbricus rubelus, Perionyx excavatus and Eudrilus eugeniae* could be used in sludge management (Sharma *et al*., 2005).

The quality of produced VC mainly depends on the quality and amount of the applied organic wastes, which also influences not only the size of earthworm population but also the species dominant and their rate of growth as well as fecundity (Dominguez *et al.*, 2000). Aquaculture sludge (AS) of different systems provides a consistent, uniform, and fine-grained source of waste that should produce a uniform and high quality VC as reported by (Yeo and Binkowski, 2010). Nevertheless, generally, the worms don’t tolerate fresh aquaculture sludge, they perform better in “aged” AS. Therefore, the Idaho studies suggested a period of acclimation as a necessary procedure before the worms would be growing and reproducing on aquaculture sludge (Yeo and Binkowski, 2010).

Thus the main objectives of the present study were to achieve more sustainability for aquaculture industry in Egypt for more future expanding by recycling the aquaculture sludge (AS) using earthworm and to increase the economic efficiency of the aquaculture industry through turning its wastes into valuable bio-fertilizer with an economic value in an attempt to reach intelligent aquaculture concept.

MATERIALS AND METHODS

The following study was carried out at the Central Laboratory for Aquaculture Research (CLAR), Agricultural Research Center (ARC) during April - May 2017, for 60 days, to investigate the vermicomposting potentiality of Aquaculture sludge (AS) from Nile tilapia broodstock or from fry concrete ponds by three species of earthworm (*Perionyx excavatus*, *Lumbricus rubellus* and *Eisenia fetida*).

The present study aimed to answer the following questions:

1- Is AS of Nile tilapia fish broodstock and fry ponds suitable feeding material for earthworm and for the vermicomposting.

2- Is it necessary to dilute AS by mixing it with a bulking material (such as peat moss).

3- What's the highest ratio of AS to bulking material (peat moss) can be applied in term of worm performance and the quality of produced vermicompost's.

Sludge collection and preparation:

Aquaculture sludge (AS) was collected from the concrete ponds of Nile tilapia *Oreochromis niloticus* broodstock and fry, at Nile tilapia hatchery belonging to CLAR; during fry harvesting from the broodstock ponds as well as from fry rearing ponds. The produced AS, with a moisture content of 96.5% and dried solid content of 3.5%, was collected in barrels and then spread out in a thin layer on a cement floor for drying over fourteen days, so it can be stored safely until being used.

Inoculation of earthworms:

Vermicomposting process was carried out in styrofoam boxes of 28 x 14 x 12.5 cm dimensions and area of 0.04 m^2. The mixture of three vermicomposting worms (*Eisenia fetida*; *Perionyx excavaus*; *Lumbricus rubellus*) was introduced in each box at 12 worms /500 g of media mixture. Each treatment was represented in triplicates containers and kept indoor with temperature at 25-29℃ and moisture at 65-80%. Ten treatments with five mixing ratios (Table1) of AS concentration percent (40%, 50%, 60%,70% and 100% of AS from either broodstock or fry ponds and the rest was of peat moss).

Table 1. The investigated mixing ratios of AS and peat moss as bulking materials.

Treatments	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
fry AS %	40	50	60	70	100
Peat moss %	60	50	40	30	0
Treatments	T_6	T_7	T_8	T_9	T_{10}
Broodstock AS%	40	50	60	70	100
Peat moss %	60	50	40	30	0

Vermicomposting were conducted for 60 days to reach full matured vermicompost, that preliminary determined through visual observation of material breakdown and homogenized.

At the end of vermicomposting, three substrate samples were collected from each box, each sample was representing the mixture of material throughout box for analysis. All worms were hand sorted from each box and weighed to calculate the weight gain %.

Determination of growth performance of worms:

Weight of the earthworm (biomass in wet weight) was measured using digital balance at the beginning and ending of the experiment. Weight gain percent was calculated as the difference between the final and initial weight divided by the initial weight of the worm biomass.

Weight gain of the worm biomass % = $100(W_f - W_i / W_i)$
Where, W_f = final weight, W_i = initial weight

Bio-chemical analysis of the vermicompost:

Vermicompost samples were dried in a ventilated oven at 70 ^{o}C until constant weight. Samples were grinded and sieved in 0.5 mm sieve for bio-chemical analysis. Organic matter was measured as loss in weight after ignition at 550°C for 3 h (Page *et al.*, 1982). Total phosphorus (TP) was measured using the dry ash method (Tavares and Boyd, 2003) for digestion then phosphorus was colorimetrically estimated using the vanadomolybdate method (APHA, 1985). Total nitrogen content was estimated by using Kjeldalh method (A.O.A.C., 1990).

Extractable nitrogen and phosphorus were extracted from 20g of sample in 80 ml of distilled water by shaking for 1h, subsequently; the extracts were passed through 0.45 µm cellulose acetate filter paper (Bray and Kurtz, 1945). The nitrogen was determined colorimetrically according to (Page *et al.*, 1982). While, phosphorus was determined colorimetrically with ascorbic acid method (Boyd and Tucker, 1992).

Plant growth hormones and Amino acids determination:

The plant growth hormones and amino acids contents of the produced vermicompost were determined at the National Research Centre (NRC). The plant growth promoters were determined according to the method for separation and purification of plant hormones auxin and abscisic acid based on mixed mode reversed-phase anion-exchange solid phase extraction and two-dimensional HPLC, developed by Dobrev *et al.* (2005). Amino acid analyses were carried out using an LC 3000 Eppendorf/ Biotronik amino acid analyzer using an H 125×type column at the NRC.

Statistical analysis:

Data were analyzed using SPSS program and one way analysis of variance (ANOVA) and the new LSD test were performed to determine significant differences among means (Steel and Torrie, 1980).

RESULTS

AS vermicompost and earthworm growth performance:

As it is noticed in Table (2), there were significant differences among the treatments in earthworm final weight and consequently, weight gain %, generally, in favor of concentration of both types of applied AS in the media. The significantly highest weight gain % was recorded in 100% As of broodstock followed by that of 70% of broodstock AS and then 100% of fry AS. Interestingly, at each AS concentration, the broodstock AS had higher weight gain percent than fry AS, but insignificantly.

Table 2. Earthworm growth performance (Means ± SD) under different percent of fry and broodstock sludge mixed with peat-moss as bedding media.

TREAT	Initial weight	Final weight	weight gain%
40% Fry Sludge	4.37± 0.395	7.175 ± 0.6 ^{e}	64.23 ± 1.60 ^{f}
50% Fry Sludge	4.464 ± 0.414	8.489 ± 0.786 ^{d}	90.19 ± 1.04 ^{de}
60% Fry Sludge	4.757 ± 0.13	9.204 ± 0.261 ^{cd}	93.49 ± 1.35 ^{cde}
70% Fry Sludge	4.681 ± 0.152	9.209 ± 0.389 ^{cd}	96.79 ± 7.52 ^{bcde}
100% Fry Sludge	4.732 ± 0.121	9.518 ± 0.276 ^{c}	101.54 ± 3.98 ^{bc}
40% Broodstock Sludge	5.197 ± 0.186	8.992 ± 0.357 ^{cd}	73.02 ± 3.74 ^{f}
50% Broodstock Sludge	5.087 ± 0.45	9.554 ± 0.755 ^{c}	87.94 ± 4.31^{e}
60% Broodstock Sludge	4.394 ± 0.184	8.704 ± 0.729 ^{cd}	97.87 ± 8.74 ^{bcd}
70% Broodstock Sludge	5.669 ± 0.15	11.492 ± 0.3 ^{a}	102.76 ± 5.92^{ab}
100% Broodstock Sludge	5.024 ± 0.376	10.603 ± 6.51 ^{b}	111.36 ± 9.99 ^{a}

Values are means of triplicates.
In each column, means with different superscript are significantly different ($P<0.05$).

AS for bio-fertilizer production:

As it showed in Table (3), fry AS showed higher organic matter and nitrogen content while the broodstock AS had higher phosphorus content. Peat moss as bulking material had by far higher organic matter, nitrogen and phosphorus contents.

The produced VC showed significant differences in organic matter with the significant highest content in 40% fry AS and the lowest content was found in 100% broodstock AS and 100% fry AS. At each AS concentration, the fry AS had higher organic matter content than that of broodstock AS.

The different concentrations of AS did not elicit any significant change in the mean total phosphorus content of the produced VC. However, there was a negative relationship between total phosphorus content of VC and AS concentration. In general, the VC has higher phosphorus content than the initial materials.

Mean total nitrogen content significantly varied ($P < 0.05$) among the different treatments. Maximum nitrogen content was recorded at the treatment of (40 % fry AS) followed by that in (50 % of broodstock AS). The lowest nitrogen content was measured in VC produced of 100% broodstock AS, 1.093± 0.1%, and that of 100% of fry AS, 1.13± 0.125%. As a general trend, as the concentration of AS increase there was a decrease in VC nitrogen content. However, nitrogen content of the produced VC was higher than that in AS types until the concentration of 60% of AS in the growing media.

The data presented in Table 3, revealed significant ($P < 0.05$) differences in the mean extractable phosphorus of the produced VC with a reversible relationship with the fry AS. However, there was no clear trend in the broodstock AS treatments, although there were significant differences among the different treatments.

From Table 3, it is also revealed that extractable nitrogen content was significantly ($P < 0.05$) higher in fry AS treatments than those in broodstock AS treatments. In general there is a positive relationship between extractable nitrogen content in VC and the AS concentrations. The highest extractable nitrogen content was registered in the treatment of fry AS at 60%. In general the produced VC had higher extractable nitrogen content than the initial materials. There was a positive relationship between the extractable nitrogen content and the concentration of AS in both types of AS.

Table 3. Vermicompost chemical composition (means ± SD) under different concentrations of fry and broodstock sludge mixed with peat-moss as bedding media.

TREAT	**OM %**	**TP %**	**TN %**	**extractable phosphorus (mg/g)**	**extractable nitrogen (mg/g)**
Fry sludge	26.55	0.157	1.437	0.0054	0.0027
Broodstock sludge	23.82	0.217	1.301	0.0052	0.00106
Peat moss	66.02	0.773	3.411	0.0033	0.0017
Chemical composition of Vermicompost produced from the different concentrations of Fry Sludge					
40%	26.02 ± 1.354 ^{a}	0.858 ± 0.081^{a}	1.689 ± 0.118 ^{a}	0.0062 ± 0.0001 ^{a}	0.0046 ± 0.0052 ^{bc}
50%	24.27 ± 0.544 ^{b}	0.847 ± 0.123^{a}	1.609 ± 0.0986^{ab}	0.005 ± 0.0004 ^{abc}	0.0098 ± 0.0028^{ab}
60%	22.74 ± 1.215 ^{bcd}	0.793 ± 0.146 ^{a}	1.465 ± 0.071^{abc}	0.0046 ± 0.001 ^{bc}	0.0112 ± 0.00115 ^{a}
70%	22.50 ± 1.015 ^{cde}	0.764 ± 0.14 ^{a}	1.38 ± 0.032 ^{bcd}	0.0039 ± 0.0008^{bc}	0.0104 ± 0.0010^{a}
100%	21.1 ± 0.983^{e}	0687 ± 0.117 ^{a}	1.13 ± 0.1253 ^{de}	0.0037 ± 0.0005^{c}	0.0106 ± 0.0013 ^{a}
Chemical composition of Vermicompost produced from the different concentrations of broodstock Sludge					
40%	23.00 ± 0.773 ^{bc}	0.922 ± 0.101^{a}	1.678 ± 0.2993 ^{a}	0.0049 ± 0.0013^{abc}	0.0026 ± 0.0035 ^{c}
50%	22.44 ± 1.116 ^{cde}	0.896 ± 0.072^{a}	1.688 ± 0.1091^{a}	0.0053 ± 0.0003^{ab}	0.0039 ± 0.0037 ^{c}
60%	22.3 ± 1.055 ^{cde}	0.872 ± 0.104 ^{a}	1.461 ± 0.2592 ^{abc}	0.0052 ± 0.0006 ^{abc}	0.0048 ± 0.0040 ^{bc}
70%	22.24 ± 0.537 ^{cde}	0.831 ± 0.095 ^{a}	1.286 ± 0.0857 ^{cde}	0.0046 ± 0.0011^{bc}	0.0069 ± 0.0004 ^{abc}
100%	21.29 ±0.509 ^{de}	0.724 ± 0.103^{a}	1.093 ± 0.1041 ^{e}	0.0042 ± 0.0006^{bc}	0.0069 ±0.0005 ^{abc}

n=3 replicates.
Different super script within the same column means significant difference ($P<0.05$).

Plant growth promoters and amino acids content:

The 100% of fry AS and boordstock AS treatments did not vary significantly with regard to the mean content of Abscisic acid, Gibberellic acid. However, there were significant differences ($P<0.05$) between the treatments in indol acetic acids and amino acids contents, in favor of fry AS.

Table 4. plant growth promoters and Amino acids contents (Means ± SD) in vermicompost of different origin fry sludge or broodstock sludge as bedding media.

Origin of vermicompost	Abscisic acid (g/100g)	Gibberellic acid (g/100gm)	Indole Acetic acid (g/100g)	Amino Acids (mg/g dry wt)
Fry sludge (100%)	0.0097 ± 0.0015^{a}	0.2033 ± 0.0306^{a}	0.062 ± 0.0046^{a}	0.56 ± 0.0361^{a}
Broodstock sludge (100%)	0.013 ± 0.003^{a}	0.1867 ± 0.0252^{a}	0.0347 ± 0.0045^{b}	0.39 ± 0.0458^{b}

n= 3 replicates.
Different super script within the same column means significant differences ($P<0.05$).

DISCUSSION

The present study showed that the earthworm growth performance was affected by the concentrations of aquaculture sludge (AS) as well as the type of applied AS, either fry AS or broodstock AS. These notices are matching with the finding of Vasanthi *et al*. (2011) who reported an increase in earthworm biomass by 94.26 % and 145. 18% in *E. eugeniae* growing on filter mud of sugar factory with cow dung or with jeevamirtham (mixture of cow dung, cow urine, plant residues and topsoil), respectively. Also, Yeo and Binkowski, (2010) reported higher growth rates of African night crawlers fed on AS of recirculating aquaculture system (RAS), 489% in overall worm mass with a 96% survival rate after four weeks, while those fed on commercial diet increased 415% with a 99.8% survival. Also, the weight of red worms *E. fetida* fed AS from RAS increased 224% percent with 73% survival after four weeks, while those fed on commercial diet had a 63% survival rate and a worm biomass increase of 187% after four weeks (Yeo and Binkowski, 2010). Moreover, the quality and amount of food material is reported to influence not only the size of earthworm population but also the species predominant and their rate of growth and fecundity (Dominguez *et al*., 2000). On the other side, Sepperumal and Selvanayagam (2015) reported that net reproductive rate of the earth-worms (*Eudrillus eugeniae*, *Eisenia fetida* and *Perionyx excavatus*) are not affected by sugar industry wastes (sugar bagasse) added to the feeding media.

Higher doubling rate in the other studies, than 111.4% during 60 days reported in the present study, can be attributed to four factors, culture conditions, feeding types or quality, earthworm species and the experimental containers. Ismail (1997) showed that under favorable conditions one pair of earthworms can produce 100 cocoons in 6 months, with incubation period of a cocoon is roughly about 3-5 weeks. Suthar (2007) found that worm production was associated strongly with the quality of the substrate, low nutrients in the substrate result in reduced worm production. Dominguez *et al*. (2000) also showed that the quality of organic waste is one of the factors determining the onset and rate of reproduction. Romano *et al.* (2018) achieved doubling rate of 1.98 when fed *E. Foetida* earthworm mixture of sheep droppings, cow dung and peanut shells for 181 days. Yeo and Binkowski (2010) showed that the doubling time, in number or biomass of the earthworm, depends upon the earthworm species, type of food and climatic condition, which explains the differences in the results of different studies. Furthermore, the quantity of food taken by a worm varies from 100 to 300 mg/g body weight/ day (Edwards, 1972). Even the culture space has influence on the worm growth rate. Yeo and Binkowski (2010) reported that earthworms thrive with faster growth rates in larger holding bins than that in small experimental containers with the same feeding materials. This may explain the relative lower growth rate in the present study than those reported in literatures.

In the present study, the maximum weight gain (111.4%) was achieved at 100% broodstock AS of the feeding media. However, Birch *et al*. (2010) investigated the feasibility of vermicomposting aquaculture sludge and found that worm reproduction appeared to be increased as the concentration of AS increased up to 80% of the feeding media, however they noticed that the treatment with 100% AS had the lowest number of juvenile worms. Birch *et al.* (2010) reported that bulking materials may be needed to enhance worm reproduction in aquaculture sludge (AS), where adding bulking materials (Rice straw or Water hyacinth) significantly increased the reproduction activity, particularly RS at 20%. Bhattacharjee and Chaudhuri (2002) also observed higher reproduction rate of *P.excavatus* in mixtures of cow dung with straw compared to cow dung alone. Birch *et al.* (2010) also confirmed that aquaculture sludge proportions close or equal to 100% are not optimal for worm reproduction. Marsh *et al.* (2005) also investigated the suitability of AS mixed with cardboard as feedstock for earthworm and reported that the highest growth rate occurring with feedstock containing 50% aquaculture sludge.

Birch *et al.* (2010) and Yeo and Binkowski (2010) showed that the nutrient content of vermicompost is strongly dependent on the initial substrate. Generally, the nutrient status of vermicompost produced from different organic wastes is; organic carbon 9.15 to 17.98 %, total nitrogen 0.5 to 1.5 %, available phosphorus 0.1 to 0.3 % (Kale, 1995).

Birch *et al.* (2010) determined comparable carbon content (10.7 ± 0.19%) in AS, where, in the present study the organic matter reached 23.82% in broodstock AS and 26.55% in fry AS.

Birch *et al.* (2010) determined higher phosphorus content (0.44 ± 0.01%) in AS than that applied in the present study, 0.22 % in broodstock AS and 0.16% in fry AS. However, less total phosphorus content was determined in vermicompost of AS alone or mixed with either rice straw or water hyacinth using *P. excavatus* as reported by Birch *et al.* (2010), whereas it was more than 0.6 % in the present study's vermicompost. Higher phosphorus content in vermicompost produced by mixing cow dung, garden soil and sugar bagasse in different ratios, more 1.5 %, is reported by Sepperumal and Selvanayagam (2015). Also, they mentioned that the vermicompost phosphorus content differ as different earthworm species used, 1.38, 1.57 and 1.67% using *Eudrilus Eugenia*, *Perionyx excavates* and *Eisenia fetida* as bioreactor, respectively. These results showed that the variance in chemical composition of vermicompost depend on the raw material as well as earthworm species that used to produce vermicompost.

In the present study the TP content of vermicompost was higher than those of the raw materials, which matches with the documented phenomenon of the increase of nutrients concentration during vermicomposting the organic wastes (Sepperumal and Selvanayagam, 2015). Higher phosphorus content in vermicomposts than in the original organic material is suggested to be due to increased phosphatase activity from the direct action of gut enzymes and indirectly by the stimulation of microorganisms (Orozco *et al*., 1996).

Arancon *et al*. (2003) reported comparable nitrogen content (1.9%) of vermicompost produced from cow dung, compared to that of the present study (1.093 -1.69%). Rupani *et al.* (2013) reported that total nitrogen content in vermicomposts may be ranged quite widely from 0.1% to 4% or more depending on the organic wastes used to feed earthworm. In comparison with the present study results, Birch *et al.* (2010) determined lower nitrogen content (0.4-0.9%) as a result of vermicomposting the AS alone or mixed with either rice straw or water hyacinth using *P. excavatus*. Marsh *et al.* (2005); Birch *et al.*, (2010) reported that the differences in vermicompost characteristics are mainly attributed to the differences in the practiced aquaculture systems (Intensive RAS, flow through system provided with filters), fishponds (earthen ponds or concrete ponds) and subsequently the collected aquaculture sludge characteristics.

Higher nitrogen contents in vermicompost produced by mixing cow dung and sugar bagasse using *E. Eugenia*, *P. excavatus* or *E. fetida*, 2.53-3.41% are reported by Sepperumal and Selvanayagam (2015). These results again confirm that variance in chemical composition of vermicompost depends on the raw material as well as earthworm species that used to produce vermicompost.

The decrease in TN in vermicopmost, in the present study, than those in the raw materials may be attributed to relatively long experimental period (60 days) without addition any new raw materials. Also, Sepperumal and Selvanayagam (2015) reported that there was a decrease in the TN content during vermicomposting stage of pre-composted materials.

One of the key variables which affect the ability of worm to vermicompost aquaculture sludge (AS) is the type and amount of Bulking materials mixed with it. The bulking material can also affect the efficiency of vermicompoting worms survival and reproduction rate (Dominguez *et al*., 2000 and Birch *et al*., 2010) as well as the nutrient composition of the final product (Garg *et al*., 2006).

Tomati and Galli (1995) concluded that cytokinins and auxins found in the vermicomposts are excreted by the earthworms. The plant growth regulators and other plant growth influencing materials i.e. auxins, cytokinins, humic substances etc, are also produced by microorganisms in VC, particularly fungi and bacteria, as reported by Atiyeh (2000a). The humic materials extracted from VC have been reported to also produce auxin-like cell growth (Muscolo *et al*., 1999).

In the present study, samples of 100% fry and broodstock AS were analyzed for plant growth promoters and amino acids to investigate the effect of different AS types on the VC contents of these bioactive substances. The results showed that the type of AS have a significant effect on the Indole acetic acid content as well as amino acids content of the produced VC. However, there was insignificant influence on both the Abscisic acid and Gibbrellic acid contents of the produced VC. These bioactive substances add an additional bio-value for the produced VC as plant/ plankton growth inducer, which can be considered as superior advantage over the conventional compost and the other organic fertilizers. Arancon and Edwards (2005) reported the existence of some biological factors in vermicompost other than nutrients, such as the plant growth-influencing substances e.g. plant hormones, humic acids or free enzymes, being responsible for the increase in growth of 28 ornamentals and vegetables. Several workers have reported the presence plant growth hormones such as auxins, gibberrillic acids and cytokinins in vermicomposts (Atiyeh *et al*., 2001) which could also explain the increases in growth and yield that occurred even at the lowest rate of vermicompost applications (2.5 t/ha) (Arancon *et al*., 2004). Ismail (1997); Chakrabarty *et al*. (2009a) showed that these bioactive substances can promote aquatic biota abundance and suppress pathogens. Chakrabarty *et al.* (2009b) reported the potentiality of using VC as organic manure directly in aquaculture. Moreover, Chakrabarty *et al.* (2007) showed that vermicompost is free of side effects that are associated with direct application of raw waste and animal dung to water body such as increase BOD and the risk of pathogen transmission. Abd El-Hay *et al.* (2019) used vermicompost vs chemical fertilizers in cultivation and production of microalgae *Spirulina platensis* and achieved significant increase in protein content . Furthermore, Musyoka *et al.* (2020) also reported the potentiality of using vermicompost in fish nutrition.

The present study showed that aquaculture solid-waste AS can be a suitable feedstock for earthworm worm and a good biofertilizer production, provided that established worms are fed the fish biosolids wastes in appropriate quantity and that their environment is within suitable tolerances for survival and growth. However, further studies are needed to enhance the vermicompost quality concerning nutrients content and accelerating the vermicomposting process rate by mixing AS with a variety of bulking materials. Our findings are in good accordance with Yeo and Binkowski (2010) who reported that AS from RAS bead filter is a suitable feedstock for both night crawlers and red worms. Our observation also lies in line with the Birch *et al.* (2010) findings using *P.excavatus*. However, the bulking materials (i.e. rice straw water hyacinth and other agricultural wastes) can be added to enhance the earthworm growth performance as well as the quality of produced VC.

CONCLUSION

The present study elucidated that Nile tilapia AS can be vermicomposted. Also, earthworms are considered as an excellent bioreactor for recycling aquaculture sludge to produce bio-fertilizer that can be successfully used as organic fertilizer in aquaculture as reported by (Chakrabarty *et al.*, 2009b). So, aquaculture wastes can be more profitably utilized for vermicomposting. Further studies concerning utilization of vermicompost and earthworm in aquaculture would be of great importance.

From the present study and the literature one could conclude that the concentration and composition of the fish sludge would ultimately influence the level of nutrients and plant growth promoters in the produced vermicompost.

Also vermicomposting generate rich nutrients bio-fertilizer supported with plant growth hormones and enzymes that may result in increase of crop yields and plankton as documented in several literatures. Further studies are recommended to investigate the impact of different bulking materials as well as different mixing ratios in term of the worm growth performance, VC nutrient levels and plant growth promoter contents.

REFERENCES

Abd El-Hay, R.A.E.; Y.T.A. Moustafa and E.M.E. Essa, 2019. The use of vermicompost in cultivation and production of *Spirulina platensis*. Egyptian Journal for Aquaculture, 9 (3): 01-12.

A.O.A.C. Association of Official Agriculture Chemists, 1990. Official Methods of Analysis of the Association of Official Analytical Chemists, 15th ed. Washington, D.C.

A.P.H.A. American Public Health Association, 1985. Standard Methods for the Examination of Water and Wastewater. 16th ed., Washington, D.C., p1268.

Arancon, N.Q. and C.A. Edwards, 2005. Effects of vermicomposts on plant growth. the International Symposium Workshop on Vermi Technologies for Developing Countries (ISWVT 2005), Los Banos, Philippines November 16-18.

Arancon, N.Q.; C.A. Edwards; P. Bierman; J.D. Metzger; S. Lee and C. Welch, 2003. Effects of vermicomposts on growth and marketable fruits of field-grown tomatoes, peppers and strawberries. Pedobiologia, 47: 731-735

Arancon, N.Q.; R.M. Atiyeh; C.A. Edwards and J.D. Metzger, 2004. Effects of vermicomposts produced from food waste on greenhouse peppers. Bioresource Technology, 93 (2): 139-144.

Atiyeh, R.M.; J. Dominguez; S. Subler and C.A. Edwards, 2000a. Changes in biochemical properties of cow manure processed by earthworms (*Eisenia andreii*) and their effects on plant-growth. Pedobiologia, 44: 709-724.

Atiyeh, R.M.; C.A. Edwards; S. Subler and J.D. Metzger, 2001. Pig manure vermicomposts as a component of a horticultural bedding plant medium: effects on physicochemical properties and plant growth. Bioresource Technology, 78: 11- 20.

Bhattacharjee, G. and P.S. Chaudhuri, 2002. Cocoon production, morphology, hatching patter and fecundity of seven tropical earthworm species- a laboratory-based investigation. J. of Biosciences, 27 (3): 283-294.

Birch, S.; R. Bell; J. Nair and C.V. Phung, 2010. Feasibility of vermicomposting aquaculture solid waste on the Mekong Delta, Vitnam: A pilot study. Dynamic Soil, Dynamic plant, 4 (1): 127-134.

Boyd, C.E. and C.S. Tucker, 1992. Water quality and pond soil analysis for aquaculture. Alabama agricultural experimental station. Auburn. Uni., 183 pp.

Bray, R.H. and L.T. Kurtz, 1945. Determination of total organic and available forms of phosphorus in soils. Soil Sci., 95: 39-46.

Chakrabarty, D.; S.K. Das and M.K. Das, 2007. Modelling of energy transformations in fertilized tropical fish ponds. Lakes and Reservoirs: research and Management, 12: 295-301.

Chakrabarty, D.; S.K. Das and M.K. Das, 2009a. Vermiwash: The balance diet for juvenile fish.16th West Bengal Kolkata,India, 290 pp.

Chakrabarty, D.; S.K. Das; M.K. Das and P. Biswas, 2009b. Application of vermitechnology in aquaculture. Dynamic Soil, Dynamic plant, 3 (2): 41-44.

Cripps, S.J., 1995. Serial practice size fractionation and characterization of an aquaculture effluent. Aquaculture, 133: 323-339.

Dobrev, P.I.; L. Havlícek; M. Vágner; J. Malbeck and M. Kamínek, 2005. Purification and determination of plant hormones auxin and abscisic acid using solid phase extraction and two-dimensional high performance liquid chromatography. Journal of Chromatography A, 1075 (1-2): 159-66.

Domjnguez, J.; C.A. Edwards and M. Webster, 2000. Vermicomposting of sewage sludge: effect of bulking materials on the growth and reproduction of the earthworm *Eisenia Andrei*. Pedobiologia, 44: 24-33.

Edwards, C.A. and J.R. Lofty, 1972. Biology of Earthworms1972; Chapman and Hall, London.

Elvira, C.; S. Mato and R. Nogales, 1995. Changes in heavy metal extractability and organic matter fractions after vermicomposting of sludge from a paper mill industry and waste water treatment plant. Fresenius Environmental Bulletin, 4 (8): 503-7.

GAFRD (General Authority for Fishery Resources Development), 2017. Year-Book of fishery statistics in Egypt (2008-2017), Cairo.

Garg, P.; A. Gupta and S. Sayta, 2006. Vermicomposting of different types of wastes using Eisenia foetida: A comparative study. Bioresource Technology, 97: 391-395.

Ghosh, C., 2004. Integrated vermi- pisciculture- an alternative option for recyclying of solid municipal waste in rural India. Bioresource Technology, 93:71-5.

Ismail, S.A., 1997. Vermicology: The biology of Earthworms. In Orient Longman Limited, Chennai, pp. 92.

Kale, R.D., 1995. Vermicomposting has a bright scope. Indian Silk, 34:6–9.

Lee, K.E., 1985. Earthworms: Their ecology and relationships with soils and land use. Academic Press, Sydney, Australia, pp.411

Marsh, L.; S. Subler; S. Mishra and M. Marinin, 2005. Suitability of aquaculture solids mixed with cardboard as feedstock for vermicomposting. Bioresource Technology, 96: 413-418.

Muscolo, A.; F. Bovolo; F. Gionfriddo and S. Nardi, 1999. Earthworm humic matter produces auxins-like effect on Daucus carota cell growth and nitrate metabolism. Soil Biology and Biochemistry, 31:1303-11.

Musyoka, S.N.; D. M.Liti; E.O. Ogello; P. Meulenbroek and H. Waidbacher, 2020. Using Earthworm, Eisenia fetida, to Bio-convert Agro-industrial Wastes for Aquaculture Nutrition. BioResources, 15 (1): 574-587.

Orozco, S.H.; J. Cegarra; L. MTrujillo and A. Roig, 1996. Vermicompostsing of coffee pulp using the earthworm *Eisenia fetida*: effects on C and N contents and the availability of nutrients. Biology and Fertility of Soils, 22: 162-166.

Page, A.; R. Miller and D. Kenney, (Eds.) 1982. Methods of Soil Analysis. Part 2, Chemical and Microbiological Properties. Amer. Soc. Agronomy, Madison, 1159 pp.

Paoletti, M.G.; M.R. Favrettoo; B.R. Stinner; F.F. Purrington and J.E. Bater, 1991. Invertebrates as bioindicators of soil use. Agriculture, Ecosystems and environments, 34: 341-62.

Phung C.V; N.B. Phuc; T.K. Hoang; and R.W. Bell, 2009. Recycling of fishpond waste for rice cultivation in the Cuu Long delta, Vietnam. In: Nair J, Furedy C, Hoysala C, Doelle H (Eds) Technologies and management for sustainable Biosystems, Nova Science Publishers, NY, USA, pp 87-93.

Romano, C.O.R.; J.O. Mendoza; E.S. Castro and J.R.T. Reyes, 2018. Substrates evaluation for the production of earthworm (*Eisenia foetida*). Centro Agrícola, 45 (4): 68-74, http://cagricola.uclv.edu.cu/.

Rupani, P.F.; M.H. Ibrahim and S.A. Ismail, 2013. Vermicomposting biotechnology: recycling of palm oil mill wastes into valuable products. Int. J. Recycl Org Waste Agricult., 2: 10.

Rynk, R.; K. Grabenstien and T.F. Hess; 1998. Fish manure as a potential feedstock for vermicomposting. Aquaculture '98. World Aquaculture Association. World Aquaculture Society Meeting, Feb. 20-22, 1998. Las Vegas, Nevada.

Sepperumal, U. and Selvanayagam S., 2015. Vermiremdiation of Sugar Industry Waste using Earthworms *Eudrilus eugeniae*,*Perionyx excavatus* and *Eisenia fetida*. European Journal of Zoological Research, 4 (1): 28-36.

Sharma, S.; K. Pradhan; S. Satya and P. Vasudevan, 2005. Potentiality of earthworm for waste management and in other uses- A review. The Journal of American Sceince, 1 (1): 4-16.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill, New York, NY.

Suthar, S., 2007. Nutrient changes and biodynamics of epigeic earthworm *Perionyx excavatus* (Perrier) during recycling of some agriculture wastes. Bioresource Technology, 98: 1608-1614.

Tavares, S. and C. Boyd, 2003. Comparison of a dry ash method with perchloric acid digestion for total phosphorus analysis of pond sediment. J. Aquaculture in the Tropics, 18: 239-244.

Tomati, U. and E. Galli, 1995. Earthworms, Soil Fertility and Plant Productivity. In: Proc. Int. Coll. on Soil Zool. Acta Zool. Fenn., 196: 11-14

Vasanthi, K.; K. Chairman; J.S. Michael; A. Kalirajan and A.J. Singh, 2011. Enhancing bioconversion efficiency of the earthworm *Eudrilus eugeniae* (Kingberg) by fortifying the filtermud vermibed using an organic nutrient .Online Journal of Biological Sciences, 11 (1): 18-22.

Yeo, S.E. and F.P. Binkowski, 2010. Processing Aquaculture System Biosolids by Worm Composting—Vermicomposting. NCRAC Technical Bulletins. 17. http://lib.dr.iastate.edu/ncrac_techbulletins/17.

ملاءمة مخلفات الأحواض السمكية للبلطى النيلى كبيئة غذائية لنمو ديدان الأرض وإنتاج سماد الفيرميكومبوست

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الملخص العربي

يتسبب التخلص من مخلفات الاستزراع السمكي في المياه العذبة في حدوث تلوث خطير في القنوات المائيه أو في الزراعة كسماد عضوي. لذلك، بحثت الدراسة الحالية في إمكانية إستخدامها لإنتاج السماد العضوي (الفيرميكومبوست) وتأثير الأنواع المختلفة من المخلفات السمكية على التركيب الكيميو-حيوي للفيرميكومبوست و نمو دود الأرض. تم تطبيق خمس نسب خلط باستخدام (٤٠-٥٠-٦٠-٧٠-١٠٠%) من المخلفات من أمهات أوزريعة البلطي النيلي مع البيتموس.

أوضحت النتائج أن تركيز ونوع المخلفات السمكية كان لهما تأثير ذو دلالة إحصائية على النسبة المئوية للزيادة فى وزن دودة الأرض وكذلك على التركيب الكيميائي للفيرميكومبوست المنتج. تم تسجيل أقصى٪ زيادة في الوزن (١١١,٤%) في معاملة ١٠٠٪ مخلفات أمهات البلطى النيلى. تم تقدير المحتوى الأقصى من الفوسفور في الفيرميكومبوست المنتج من ٤٠٪ مخلفات أمهات البلطى النيلى. بينما تم تسجيل المحتوى الأقصى من النيتروجين في الفيرميكومبوست المنتج من ٤٠٪ مخلفات زريعة البلطى النيلى. كما أوضحت النتائج وجود تأثير ذو دلالة إحصائية لنوع المخلفات السمكية على كل من حمض الأندول ومحتوى الأحماض الأمينية في الفيرميكومبوست المنتج. بينما كان تأثيرها غير ذي دلالة إحصائية على محتوى حمض الأبسيسك وحمض الجبريليك في الفيرميكومبوست المنتج.

تعد هذه الدراسة محاولة لإيجاد طريقة فعالة لمعالجة مخلفات ومزارع التفريخ وإنتاج سماد حيوي يمكنه تحسين خصائص التربة في المزارع السمكية وأحواض التفريخ ويؤدي إلى تحسين نوعية المياه وبالتالي إنتاجية الأسماك. ولكن هناك حاجة إلى مزيد من الدراسات للتعامل مع التركيب الكيمو-حيوي للفيرميكومبوست وتأثيره على الأستزراع السمكى كسماد حيوي.