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A Study on Composting of Aquaculture Sludge from Patapalem (SPSR Nellore) and its Suitability to different Crops

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ABSTRACT

The physico-chemical characteristics of aqua sludge collected from the bottom of aquaculture ponds in Patapalem, Nellore district (Andhra Pradesh), paddy straw from Live stock Research Station, Lam, Guntur and water hyacinth from Agricultural College Farm, Bapatla were used to make compost in various proportions and tested for their suitability as substrates in different crops. The sludge was acidic in nature and high in organic carbon, total nitrogen, phosphorous and potassium contents. The composting products with different combinations of aquatic sludge, paddy straw and water hyacinth were used to test the germination percent, height and weight of the three species of plants *i.e.*, *Cicer arietinum, Gossypium* species and *Vigna mungo*. The highest percent of germination, height and fresh weight of the plants were achieved at a ratio of 60:40 (aqua sludge: paddy straw) for sludge-straw composts, at a ratio of 60:40 (aqua sludge: water hyacinth) for the sludge-hyacinth composts and at a ratio of 70:10:20 (aqua sludge-paddy straw-water hyacinth) for sludge-straw-water hyacinth composts. Overall the results indicated that the sludge from aqua ponds has a potential to be used as compost material when mixed with either rice straw or water hyacinth.

Key words: *Aqua sludge, Compost, Bengal gram, Cotton and Black* Gram, *Paddy straw and Water hyacinth.*

Aquaculture has always been a special strength of Nellore district and will most likely continue to develop and increase in the future. However, an increased production is often followed by an increased pressure on the external environment leading to eutrophication and ecosystem damage. Management of aqua sludge has become one of the most important environmental issues. The problem of pollution can be solved only through the change in our attitude to consider waste not as a nuisance and its disposal as a great problem. But it can be considered as a source material for various other useful activities. Disposal of aqua sludge to natural systems poses an environmental threat (Smith, 1996) and is a waste of valuable nutrients (Lin and Yi, 2003). Bonanni *et al.* (1992) showed that aqua sludge plays an important role in the accumulation and regeneration of nutrients. Muendo (2006) reported the utility of aqua sludge to fertilize crops. Although sludge accumulation and nutrient retention in aqua ponds have been reported (Smith, 1996), quantitative data on aqua sludge and nutrient accumulation in aquaculture ponds and its potential as an agricultural nutrient input is still minimal. Lack of scientific documentation on quantitative and qualitative aspects of aqua sludge hampers wider adoption and promotion of aqua sludge use in agriculture.

Management of aquatic sludge is a challenging task, as it is very unstable. For sustaining aqua industry, viable methods for treating the sludge must be identified. Many management systems for stabilizing sludge have been developed, such as land application and the use of earthworms for stabilization.

Composting can provide a simple and cost effective method to treat the aqua sludge and at the same time use excessive organic matter and nutrients for enhanced production of different crops (Chauhan and Joshi. 2010). The combination of aqua sludge and water hyacinth or rice straw, which are easily accessible in Nellore areas can help to enhance the quality of the composting process, and the finished compost from this waste has been shown to improve the long-term soil fertility (Li *et al.* 2008 and Roca-Perez *et al.,* 2009).

This study aimed to analyse the physico-chemical characterstics and to identify the suitable ratio for composting products that consist of a combination of sludge from aqua ponds and water hyacinth or rice straw and to find out the best bulking material between paddy straw and water hyacinth. The suitability of the finished compost for raising of different crops, was assessed by recording the germination percent, height and fresh weight of three crops *Cicer arietinum, Gossypium* and *Vigna mungo*.

MATERIAL AND METHODS

Composting materials included aqua sludge from the bottom of a aqua pond and water hyacinth and rice straw from Live stock Research Station, Lam, Guntur and Agricultural College Farm, Bapatla respectively. The sludge from the bottom of the aqua pond and water hyacinth were collected and dried naturally for one week before experiment.

The study was carried out during 2017-2018, the composting experiment included 27 composting bags in nine treatments replicated thrice(Fig.1). Three different combinations were set up in compost experiment (one being a mixture of sludge and water paddy straw, one being a mixture of sludge and water hyacinth and one being a mixture of sludge and both paddy straw and water hyacinth). Composting bags were made of polypropylene to isolate the composting materials from external conditions. The bag dimensions were 20 cm in width and 40 cm in height. Each bag contained 5 Kg mixture of sludge and water hyacinth or rice straw or both (Table.2). A PVC pipe with size 3.5 (diameter) x 50 cm (height) was inserted in the centre of each bag and 8 mm diameter holes were drilled around the pipe to create aerobic conditions in the entire composting pile. The compost samples were analyzed for pH, EC, total organic Carbon and available Nitrogen at 30 days of incubation. At 60 days after composting samples were analised for pH by using pH meter (model. Systronics µ pH system 362), EC was determined by EC bridge (model. AD 310), organic carbon was determined by Walkley- Black method, total nitrogen and available nitrogen were measured by using Kelplus automatic nitrogen digestion and distillation unit (KELVAC-VA), available phosphorous was determined by ascorbic acid method (Spectro-photometer model. Elico SL 207 mini spec), total potassium was determined by using flame photo meter (model. Systronics photometer 130), calcium and magnesium were determined by EDTA method, available sulphur was determined by turbidimetric method and micronutrients such as Fe, Cu, Mn and Zn were determined by using Atomic Absorption Spectroscopy (Model. Varian spectra AA 220).

Table 1. Characteristics of aqua sludge from Nellore district, rice straw and water hyacinth

S. No	Characteristics	Aqua sludge	Paddy straw	Water hyacinth
1	pH	6.80	5.25	6.95
2	EC (dS m^{-1})	1.81	2.40	8.50
3	Organic Carbon (%)	6.06	35.05	33.15
4	Total nitrogen (%)	1.06	0.27	0.39
5	Available nitrogen (%)	0.04	-	-
6	Total phosphorous (g kg^{-1})	-	0.35	0.53
7	Available phosphorous (g kg^{-1})	0.05	-	-
8	Total potassium (%)	176.00	5.84	6.28
9	Calcium (g kg^{-1})	3.60	2.47	4.76
10	Magnesium (g kg^{-1})	2.73	4.23	4.08
11	Sulphur (g kg^{-1})	0.44	2.10	1.89
12	Iron (g kg^{-1})	36.61	0.85	1.75
13	Copper (g kg^{-1})	0.18	0.06	0.07
14	Manganese (g kg^{-1})	0.70	0.45	11.75
15	Zinc (g kg^{-1})	0.27	0.19	0.03

In the crop-growth experiment, each kind of plant (Bengal gram, Cotton and Black gram) were grown in 27 composting bags, including 9 treatments with triplicates (Table.4) (three sets of composts with different ratios of sludge-water hyacinth, three sets of composts with different ratios of sludge rice straw, two sets of composts with different ratios of aqua sludge, paddy straw and water hyacinth and one set with aqua sludge alone (control). The results from the experiment are shown in Table 3 as the mean of the triplicates. All the compost bags were operated under the same conditions, and received the same amount of water and temperature. The germination percent was recorded 5 days after sowing. Height and weight were recorded 21 days after sowing.

Table 2. Mixing ratios with aqua sludge and paddy straw or water hyacinth or both (Dry Weight basis)

Treatments	Constituent (% dry weight basis)		
	Aqua sludge	Paddy straw	Water hyacinth
T_1	100	-	-
T_2	80	20	-
T_3	70	30	-
T_4	60	40	-
T_5	80	-	20
T_6	70	-	30
T_7	60	-	40
T_8	70	10	20
T_9	60	20	20

Fig 1. Composting experiment with a combinations of aqua sludge + rice straw (9 bags on the left) and aqua sludge + water hyacinth (9 bags in middle), aqua sludge + paddy straw + water hyacinth (6 bags on right) and aqua sludge alone (control- 1 bag).

The data was analysed statistically by adopting the standard procedures.

RESULTS AND DISCUSSION

Quality of the Compost Products

The composting process lasted for 60 days. After 60 days, the compost products became dark brown, porous, and without any smell (Fig.2). After 30 days of incubation, pH, EC, TOC and AN in treatments containing water hyacinth at 20, 30 and 40 per cent ranged from (7.75-7.85), (2.2-2.90 dS m^{-1}), (6.47-6.82 percent) and (0.044-0.085 percent) respectively, treatments with paddy straw at 20, 30 and 40 percent ranged from (7.62-7.74), (1.67-1.80), (7.21-7.59 -1) and (0.056-0.083 percent) and treatments containing both paddy straw and water hyacinth at 10 , 20 percents and 20, 20 percent ranged from (7.75-7.77), (2.64-3.13 dS m^{-1}), (6.77-6.83 percent) and (0.084-0.095 percent) respectively and treatment containing only aqua sludge (control) was having pH, EC, TOC and AN of 6.88, 1.60 dS m^{-1}, 6.24 percent and 0.039 percent respectively. Similarly, Sommer *et al.* (2000) and Paredes *et al.* (2002) also reported pH values from 7.3 to 7.6 in olive mill waste water sludge compost and 7.5 ± 0.3 in tannery sludge compost at 30 days of composting respectively. Similarly, Haug, (1993) reported that the increased rates of aeration up to 30 days of composting tend to decrease CO2 level in the compost which in turns will tend to increased pH.

EC values increased at 30 days of incubation, it was expected due to the degradation of organic matter (Mena *et al.* 2002 and Karak *et al.* 2013), formation of organic acids and the release of mineral salts (such as phosphates and ammonium ions) through the decomposition of organic substances in aqua sludge composts (Gao *et al.* 2010 and Wang *et al.,* 2013).

The pH and EC were significantly higher with the treatments containing water hyacinth (T_5-T_9) than those treatments without water hyacinth (T_1-T_4).

Organic carbon was significantly higher in treatments containing paddy straw in three sets of experiments than those that of treatments without paddy straw.

Similarly, Paredes *et al.* (2002) also reported available nitrogen from 0.0083 to 0.0233 percent in Olive mill waste water sludge compost.

After 60 days of composting pH, EC and OC in treatments containing water hyacinth at 20, 30 and 40 percent ranged from (6.70-6.85), (1.14-1.44 dS m^{-1}) and (6.31-6.50 percent) treatments with paddy straw at 20, 30 and 40 percent ranged from (6.46-6.61), (1.05-1.13 dS m-1) and (6.70-7.47 per cent), treatments containing both paddy straw and water hyacinth at 10, 20 percent and 20, 20 percent ranged from (6.77-6.85), (1.05-1.45 dS m^{-1}) and (6.96-7.46 percent) respectively and treatments containing only aqua sludge (control) was having pH, EC, TOC and AN of 6.35, 0.86 dS m^{-1} and 6.24 %. Similarly, Somer *et al.* (2000) and Saiya and Katoppo (2015) also reported pH from 6.6 to 7 in tannery sludge. Present results were in agreement with the reports of other workers (Singh 2009 and Tumuhairwe 2009 and Brito *et al.,* 2010).

The gradual decrease pH was observed from 30 days of incubation to 60 days after composting. According to Ko *et al.* (2008) and Karak (2010) this is due to the generation of acid-type organic compounds of low molecular weight produced during decomposition of the most labile organic matter fraction present in agricultural waste and fish pond sediment. (Table 3) shows that the reduction of EC in all treatments in three sets of experiments at 60 days of composting. According to Kalamdhad *et al.* (2008) this is due to solubilization of metallic ions, volatilization of ammonia and the precipitation of mineral salts in composting process (Wong *et al.,* 1995).

Total organic carbon percent decreased significantly at 60 days of composting in all treatments in three sets of experiments compared to 30 days. This difference was associated with the nitrogenated materials of aqua sludge and consequence of carbon volatilization as CO2 (Benito *et al.*, 2003). Bernal *et al.* (1996) reported the similar finding with two types of compost, consisting of sweet sorghum bagasse with either sewage sludge or a mixture of pig slurry and poultry manure. Zhu (2007) reported that the TOC content decreased with composting, and stabilized in curing phase when composting was carried out aerobically with swine manure and rice.

Primary nutrients such as TN, AN, AP and TK contents in treatments containing water hyacinth at 20, 30 and 40 percent ranged from (1.08-1.60), (0.045-0.080), (0.095-0.130 g Kg^{-1}) and (0.327-0.350), treatments with paddy straw at 20, 30 and 40 percent ranged from (1.04-1.49 percent), (0.056-0.073 percent), (0.074-0.116 g Kg^{-1}) and (0.290-0.331 per cent) and treatments containing both paddy straw and water hyacinth at 10, 20 percent and 20, 20 percent ranged from (1.55-1.79 percent), (0.076-0.090 percent), (0.129-0.205 g Kg^{-1}) and (0.340-0.410 percent) respectively and treatments containing aqua sludge alone (control) was having 1.02 percent of TN, 0.033 per cent of AN, 0.060 g Kg-1 AP and 0.258 percent of T K. Similarly, Xuan-Thanh Bui *et al*. (2015) also reported 0.49 percent of total nitrogen in sludge-straw compost and 0.56 % in sludge-water hyacinth compost.

Similar values of available nitrogen ranged from 0.011 to 0.049 per cent were reported by Tumuhairwe *et al*. (2009) in fish pond sediment and market crop wastes and paredes *et al.* (1997) in olive mill waste water sludge compost. Xuan-Thanh Bui *et al*. (2015) obtained the similar results with sludge-straw compost and sludge-water hyacinth compost. (Table.3) shows that available phosphorous content gradually increased during composting process than in the initial composition of co-compost materials in all treatments in three sets of experiments. On similar lines Ganesh Chandra Dhal *et al*. (2012) also reported that the water solubility of phosphorous decreased with the humification which led to phosphorous solubilisation during the decomposition and then subjected to further immobilization by the compost accelerator microorganisms which ultimately resulted in increase of phosphorous content. James Shelton *et al.* (1997) reported 0.2 percent total potassium in compost prepared from fish pond sludge.

Secondary nutrients such as calcium, magnesium and sulphur contents in treatments containing water hyacinth at 20, 30 and 40 percent ranged from (5.47-5.79 g Kg^{-1}), (3.45-3.64 g Kg^{-1}) and (0.58-0.61 g Kg^{-1}) treatments with paddy straw at 20, 30 and 40 percent ranged from (4.01-4.76 g Kg^{-1}), (2.63-2.91 g Kg^{-1}) and (3.73-4.10 g Kg^{-1}) treatments containing both paddy straw and water hyacinth at 10, 20 percent and 20, 20 percent respectively ranged from (6.20-7.47 g Kg^{-1}), (3.73-4.10 g Kg^{-1}) and (0.63-0.69 g Kg^{-1}) respectively and treatments containing only aqua sludge (control) was having the calcium content of 3.25 g Kg^{-1}, 2.52 g Kg^{-1} and 0.45 g Kg^{-1} respectively. Similarly, Shelton *et al*. (1997) and Eva Broad *et al.* (2012) also reported magnesium values of 2 and 3 g Kg^{-1} in aqua sludge compost respectively.

Micronutrients such as iron, copper, manganese and zinc contents in treatments containing water hyacinth at 20, 30 and 40 percent ranged from (33.33-42.90 g Kg^{-1}), (0.191-0.240 g Kg^{-1}), (7.12-7.48 g Kg^{-1}) and (0.269-0.280 g Kg^{-1}) treatments with paddy straw at 20, 30 and 40 percent ranged from (27.40-40.20 g Kg^{-1}), (0.170-0.237 g Kg^{-1}), (0.62-0.70 g Kg^{-1}) and (0.200-0.248 g Kg^{-1}) treatments containing both paddy straw and water hyacinth at 10, 20 percent and 20, 20 percent respectively ranged from (34.00-35.60 g kg^{-1}), (0.195-0.204 g kg^{-1}), (7.79-8.17 g kg^{-1}) and (0.302-0.362 g kg^{-1}) respectively and treatments containing aqua sludge alone (control) was having 26.70 g kg^{-1} of Fe, 0.161 g kg^{-1} of Cu, 0.62 g kg^{-1} of Mn and 0.196 g kg^{-1} of Zn.

Present results about the presence the total micronutrients such as Fe, Cu, Mn and Zn were in agreement with the results of CARD (Collaboration for Agricultural and Rural Development) (2009) who reported about 39.00 g kg^{-1} Fe, 0.0163 to 0.035 g kg-1 Cu, 0.5 g kg^{-1} Mn and 0.2 to 0.4 g kg^{-1} in aqua sludge collected from 12 fresh water ponds of Giang province, Vietnam.

Comparatively the pH, EC, AN, TN, AP, TK, Ca, Mg, S, Mn and Zn contents in composts was significantly higher in treatments containing water hyacinth than those in treatments with paddy straw. There was a significant difference in all mentioned above nutrients among treatments in composting experiments.

Table 3. Characteristics of compost products

Treatments	At 30 days of				At 60 days after composting													
	pH	EC	TOC	AN	pH	EC	TOC	TN	AN	AP	TK	Ca	Mg	S	Fe	Cu	Mn	Zn
T_1	6.90	1.60	6.20	0.04	6.40	0.86	6.20	1.00	0.03	0.06	0.26	3.30	2.50	0.50	27.00	0.16	0.60	0.20
T_2	7.60	1.80	7.20	0.06	6.50	1.05	6.70	1.00	0.06	0.07	0.29	4.80	2.90	0.50	40.00	0.24	0.70	0.25
T_3	7.70	1.70	7.40	0.07	6.60	1.10	6.90	1.40	0.06	0.09	0.31	4.40	2.80	0.50	32.00	0.18	0.60	0.22
T_4	7.70	1.70	7.60	0.08	6.60	1.13	7.50	1.50	0.07	0.12	0.33	4.00	2.60	0.50	27.00	0.17	0.60	0.20
T_5	7.80	2.90	6.50	0.04	6.70	1.14	6.30	1.10	0.05	0.10	0.33	5.80	3.60	0.60	43.00	0.24	7.50	0.28
T_6	7.80	2.80	6.70	0.08	6.80	1.34	6.40	1.50	0.07	0.13	0.33	5.50	3.60	0.60	39.00	0.22	7.40	0.27
T_7	7.90	2.50	6.80	0.09	6.90	1.44	6.50	1.60	0.08	0.13	0.35	5.50	3.50	0.60	33.00	0.19	7.10	0.27
T_8	7.80	2.60	6.80	0.08	6.80	1.05	7.00	1.60	0.08	0.13	0.34	6.20	3.70	0.60	34.00	0.20	7.80	0.30
T_9	7.80	3.10	6.80	0.10	6.90	1.45	7.50	1.80	0.09	0.21	0.41	7.50	4.10	0.70	36.00	0.20	8.20	0.36
Mean	7.65	2.31	6.88	0.07	6.66	1.18	6.76	1.30	0.00	0.10	0.30	5.20	3.20	0.50	34.00	0.20	4.50	0.26
SE(m)	0.00	0.05	0.08	0.00	0.05	0.03	0.03	0.00	0.00	0.00	0.10	0.20	0.10	0.00	1.00	0.00	0.00	0.01
CD (p=0.05)	0.01	0.13	0.23	0.00	0.15	0.08	0.09	0.20	0.00	0.00	0.30	0.70	0.30	0.00	5.00	0.01	0.10	0.04
CV	0.06	3.38	1.99	0.80	1.30	3.79	0.74	11.00	7.00	3.40	3.10	7.80	6.80	1.50	3.00	2.83	2.00	9.05

Fig 2. Compost products from sludge – straw, sludge-water hyacinth and sludge- straw – water hyacinth after 60 days.

Germination percentage, height and weight of crops with Compost Products

Among the crops grown on the sludge-straw, sludge-water hyacinth and sludge-paddy straw –water hyacinth composts, the composts with a 60:40 ratio of aqua sludge and paddy straw/water hyacinth and 70:10:20 ratio of aqua sludge, paddy straw and water hyacinth had the most positive impact on the germination %, height and weight of three crops (Bengal gram, cotton and black gram) (Table 5).Crops grown on the sludge straw composts had better growth than those grown on the sludge-hyacinth and sludge-straw-water hyacinth composts due to higher TN and TOC content. Crops grown on a sludge-straw compost with 60:40 ratio had a better germination percent, height and fresh weight (for example in Bengal gram- Germination percent- 96, height -29.1 cm and weight- 0.55 g) than those grown on 60:40 ratio of sludge (Bengal gram- Germination percent- 82, height -25.07 cm and weight-0.29 g) and 70:10:20 ratio (Bengal gram- Germination percent- 89.33, height -26.60 cm and weight-0.36 g). Xuan-Thanh Bui *et al.* (2015) also reported similar results in heights and fesh weights of vegetables such as *Brassica Juncea* and *Ipomoea Aquatica* were raised on composts from aqua sludge and paddy straw compost sludge and water hyacinth compost. In this experiment height and fresh weight of *Brassica Juncea* and *Ipomoea Aquatica* were was more in aqua sludge-paddy straw compost (17.4, 28.6 cm) and (0.66, 3.14 g) than aqua sludge-water hyacinth compost (12.5, 23.3 cm) and (0.40, 2.70 g) respectively.

Overall, the crops grown on compost material were higher and heavier and had a different colour, as compared to those not grown on the compost material. The results show that the compost products, especially sludge- straw compost (T_4), have a significant positive impact on crop growth than composts from all treatments. It indicates that the use of composted aqua sludge with rice straw or water hyacinth is a promising alternative to chemical fertilizers to enhance the agricultural production in Nellore district, Andhra Pradesh.

CONCLUSION

The research results indicated that, Aqua sludge can be made into compost comfortably either with rice straw or water hyacinth. The optimal ratios of aqua sludge and paddy straw for the different compost mixtures were 60:40 for aqua sludge and rice straw/water hyacinth, and 70:10:20 for aqua sludge, paddy straw and water hyacinth. At these ratios, test results showed that crops grown on composts from sludge-straw had a better growth than sludge-hyacinth. Based on test results between paddy straw and water hyacinth, paddy straw was the best bulking material.

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