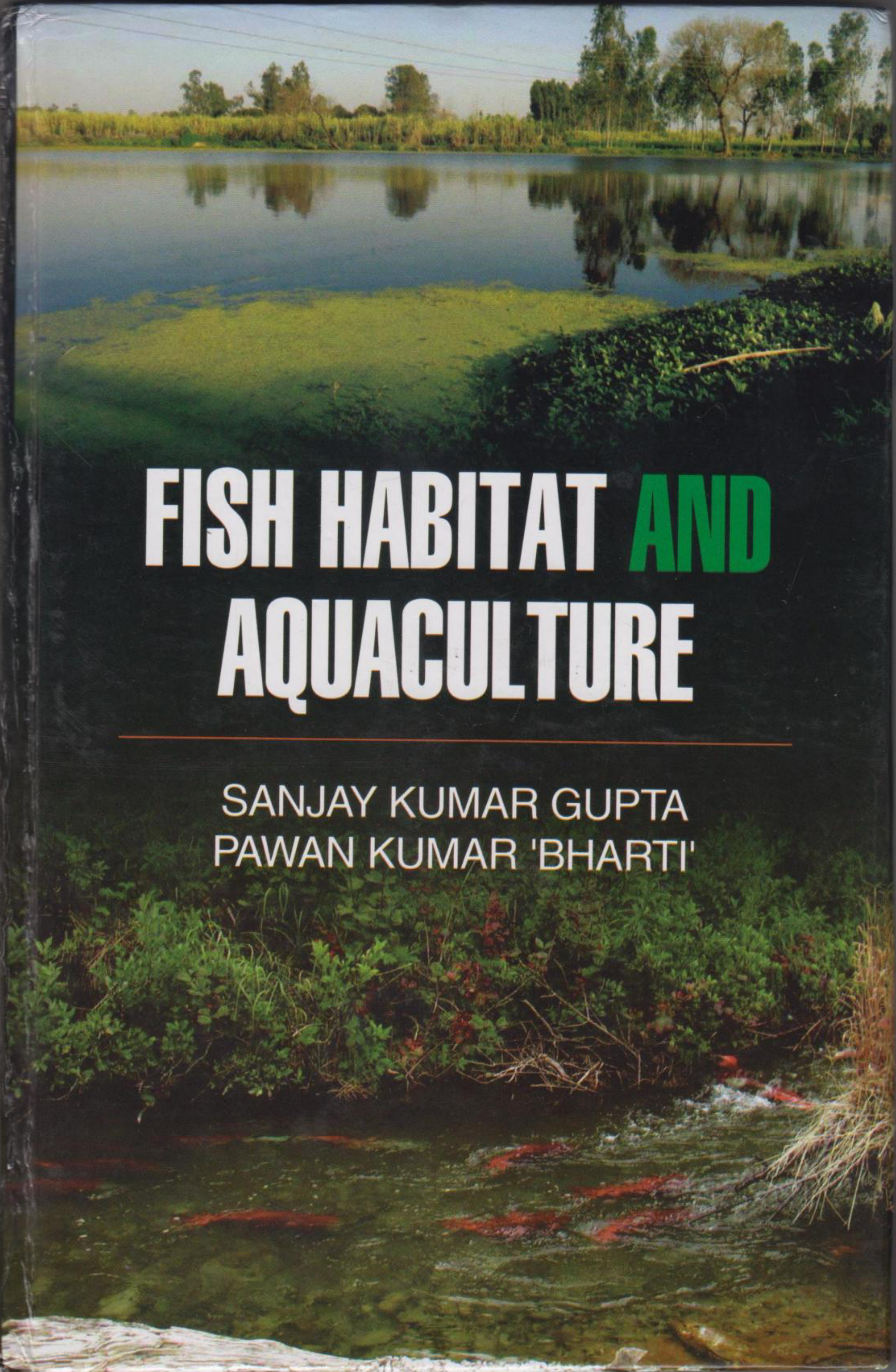

FISH HABITAT AND AQUACULTURE

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Sustainable Composting of Aquatic Weeds and Animal Excreta for Utilization in Aquaculture

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ABSTRACT

In order to compost and utilize aquatic weeds along with different organic manures in aquaculture different combination of substrate macrophytes and animal excreta (i) cow manure (ii) poultry manure (iii) *Salvinia* + cow manure (0.5:0.5) (iv) *Eichhornia* + cow manure (0.5:0.5) (v) *Eichhornia* + poultry manure (0.5:0.25:0.25) (vi) *Eichhornia* + cow manure + poultry manure (0.625:0.250:0.125) were mixed with 20% moisture and incubated at room temperature for sustainable composting for a period of four months and samples were drawn at bimonthly intervals and resultant slurry samples collected from the containers were analyzed for moisture, chemical and bacterial populations. An increase in the available nutrient component from the organic substrates was clearly observed in the present study. The mean heterotrophic bacterial populations and amylolytic bacterial populations were in the ranges of 8.54 - 14.34×10^8/g and 4.5-6.0×10^7/g. Cellulolytic and pectinolytic bacterial populations did not show much difference. The mean counts of methanogenic bacterial populations were in the ranges of 5.4-9.9 × 10^6/g with higher counts in cow manure.

Key words: Aquatic Weeds, Compost, *Eichhornia, Salvinia,* Manure.

INTRODUCTION

Pond fertilization is widely used in India and other countries to increase plankton production and fish growth (Wohlfarth and Schroeder, 1979; Atay and Demir, 1998). Fertilizing fish ponds with manure is a way to increase production and utilization of both raw and processed organic material in carp culture is common in aquatic systems (Das, 1996; Hargreaves, 1998). Prolonged use of organic manures reduces production efficiencies and cause microbial and parasitic diseases. With increasing costs of chemical fertilizers as well as awareness regarding the possible environmental hazards of continued application of both organic and chemical fertilizers, bioprocessed composite fertilizers are proposed in aquaculture practices.

Composting involves treatment of biodegradable wastes through microbial activity of bacteria, fungi and actinomycetes to upgrade and increase their usability (Gray *et al.*, 1971; Gaur, 1982; McCarthy and Williams, 1992; Gaur and Sadasivam, 1993; Ghazifrad *et al.*, 2001; Neklyudov *et al.*, 2008). In developing countries it is an important technology for technologists and rural farmers as well as a treatment option for utilization of biological wastes. Composting organisms need carbon for energy, nitrogen for growth, oxygen and sufficient moisture levels. Raw materials used for composting vary significantly in their carbon and nitrogen levels. It is the best method to produce organic fertilizer. Composting of animal wastes is a common phenomenon in both plant culture and fish culture activities (Gray and Sherman, 1969; Poincelot, 1974; Khalil, 1996; György Füleky and Szilveszter Benedek, 2010). In agriculture to restore the productivity crop waste biomass recycling and compost application is a good alternative (Gajdos, 1992; Gaur and Singh, 1993; Gaind and Nain, 2007). Applying composted soil conditioners and mulches to land has many benefits. The organic matter and nutrients in soil conditioners can increase soil fertility, provide a benefit to plant nutrition and promote revegetation. Mulches provide surface cover, reduce runoff, erosion (Wong *et al.*, 2005) and conserve soil moisture. Sewage treatment and composting of municipal solid waste involves reduction and changes in the microbial community (Herrmann and Shann, 1997; Khalil *et al.*, 2001). Similarly aquatic weed composting along with animal excreta is of great use in organic and low input aquaculture (Biddlestone and Gray, 1985: Chanalya *et al.*, 1992; Insam *et al.*, 1996).

Crawford (1983) gave an elaborate review on composting of agricultural wastes. Different types of raw materials are recycled in compost preparations

(Gray and Biddlestone, 1981; N'dayegamiye and Isfan, 1991; Gaur, 1997; Laine *et al.*, 1997; Ryckeboer *et al.*, 2003). Numerical model of organic matter decomposition and practical aspects of compost engineering were described Nkasaki and Ohtaki (2002) and Haug (1993). Chemistry and microbiology of different types of wastes and their composting have been studied by several workers (Bernal *et al.*, 1998; Goyal *et al.*, 2005). Inbar *et al.* (1990, 1993) studied different approaches to compost maturity process and its characterization. Kwon *et al.* (2011) monitored antibiotic residues in manured-based composts. Dolliver *et al.* (2008) opined that antibiotics present in raw materials get degraded during composting. Forgarty and Tuovinen (1991) studied the microbiological degradation of pesticides in yard waste composting. Recycling of rural and urban wastes was studied by Gaur and Singh (1995). Composting is carried out in open or closed piles and reactors at normal or high temperatures (Pedro *et al.*, 1999). Wolverton (1975) and Amon *et al.* (1999) studied the emission of NH_3, N_2O and CH_4 from composted and anaerobically stored farmyard manure and water hyacinth. Use of compost for peat substitution has a large potential for emission savings and from a global warming perspective it could be preferable to use compost on land (Boldrin *et al.*, 2009). Nutrient, carbon and mass loss during composting of beef cattle feedlot manure was studied by Eghball *et al.* (1997). Yu *et al.* (2007) studied microbial community succession and lignocellulose degradation during agricultural waste composting. Carpenter-Boggs *et al.* (1998) and Klamer and Bath (1998) used phosphlipid fatty acids and carbon source utilization patterns to track microbial community succession in developing compost.

AQUATIC WEEDS EICHHORNIA AND SALVINIA, CONTROL METHODS AND UTILIZATION

The aquatic weeds are major menance in rivers, lakes and ponds leading to low productivity due to their invasion and destroy the livelihoods of the communities that depend on them. *Eichhornia* and *Salvinia* are important free floating aquatic weeds have high growth rate and ability to infest a wide range of freshwater habitats have created many ecological, economical to social problems (Williams, 1956; Gopal, 1976; Henderson and Cilliers, 2002). *Salvinia* is a slow flowing fresh water fern and regarded as a weed because of its rapid growth and it becomes difficult to control. Infestation of *Eichhornia* and *Salvinia* disrupts aquatic ecosystems and affects native animals and plant life. In different water bodies and waterways they decrease the quality of water leading to accumulation of organic matter and also stagnate waterways (Gopal, 1987; Dorahy *et al.*, 2009). *Salvinia* mats are also habitats for mosquitoes. Edwards and Clayton (2002) opined that aquatic plants are environmental indicators of lake health. Heavy metal pollution is a global problem and if these metals are present in sediments of different types of water bodies then they reach the food chain through these plants and aquatic animals. In small quantities, certain heavy metals are nutritionally essential for a healthy life, but large amounts of any of them may cause acute or chronic toxicity. Phytoaccumulation of these trace elements by wetland plants may reduce heavy metal pollution (Salt *et al.*, 1995; Zhu *et al.*, 1999).

Methods for controlling water hyacinth include conventional control (manual or mechanical removal) and chemical control, but both approaches have proven generally inadequate and very expensive to apply in areas of high infestation. Reduction or elimination of aquatic weeds is possible through well planned management strategies which includes preventive and control (biological, physical, chemical, eco-physiological) measures. Higher aquatic weeds are controlled by properly selected herbicides that include bispyribac-sodium, carfentrazone-ethyl, diquat dibromide, endothall compounds, flumioxazin, fluridone, 2, 4-D, glyphosate, imazamox, imazapyr, triclopyr, penoxsulam, sodium carbonate peroxyhydrate, and nutrient reducers (Durbow, 2014). The Chironomus larvae can dig into the bulbiform petiole of water hyacinth, the petiole will be broken and decomposed soon and also the canker of water hyacinth will fall off. So this larva will be a native natural enemy of water hyacinth for controlling its invasion (Gao and Li, 2006). The West Indian Manatee (*Trichechus manatus*) has been widely suggested as a means of biological control of aquatic weeds (Haigh, 1991). Singh *et al.* (1967), Thompson *et al.* (1988) and Sheikh and Zaragar (2008) utilized grasscarp for control of aquatic weeds. A successful weed control programme depends on the resources available, the weeds present and the ability to carry out effective control methods. Herbicides have the added disadvantage of causing possible adverse environmental effects, and they must be applied carefully and selectively (Bateman, 2001).

Effective utilization of huge biomass of *Eichhornia* and *Salvinia* has to be used for waste water treatment, animal and fish feed, soil conditioner, heavy metal and dye remediation, electricity generation, substrate for bioethanol and biogas production, antioxidants, medicines and components in compost for sustainable aquaculture development (Wile and Niel, 1975; Mara, 1976; Rath and Dutta, 1991; Ray and Das, 1992; Dushenkov *et al.*, 1995; Barker, 1997; Faskin *et al.*, 1999; Joachim *et al.*, 2000; Reyes and Fermin, 2003; Williams, 2005; Singh *et al.*, 2012). These aquatic weeds usually occurring in organic rich eutrophic water bodies as weeds can be harvested manually, processed and utilized as organic manures in fish culture ponds. Composting of aquatic weeds allows safer reuse of the nutrients and organic matter contained in the weed material. These materials do not decompose easily because of higher carbon and low nitrogen levels. Keeping in view the importance of weed control and their reutilization as aquatic bioresources the present communication is based on the combination of substrates macrophytes and animal excreta. Microbial processing of these organic matters enhances the degradability of the substrates, faster nutrient release for which microbial inoculants are introduced in different forms (Finstein and Morris, 1975; Moriarty and Pullin, 1987; Ayyappan *et al.*, 1992; Chambers *et al.*, 2000). To make aquaculture sustainable, microbial processing of organic matter prior to application in an aquatic system renders the substrate less resistant to decomposition through conversion of complex molecules to simpler ones, in addition to providing biomass. Compost prepared from these aquatic weeds is lighter than ordinary soil.

COMPOSTING OF AQUATIC WEEDS AND ANIMAL EXCRETA

The manurial and macrophyte inputs like cow manure, poultry manure, *Eichhornia* and *Salvinia* were processed in glass containers in different combinations: (i) cow manure; (ii) poultry manure; (iii) *Salvinia* + cow manure (0.5:0.5); (iv) *Eichhornia* + cow manure (0.5:0.5); (v) *Eichhornia* + poultry manure (0.5:0.25:0.25); (vi) *Eichhornia* + cow manure + poultry manure (0.625: 0.250: 0.125). The above ingredients were mixed with 20% moisture and incubated at room temperature for a period of four months, with samples drawn at bimonthly intervals. The resultant slurry samples collected from the containers were analyzed for moisture, chemical and bacterial populations.

METHODS OF ANALYSIS

Chromic acid method was used for analyzing carbon content of sediment samples and the final values were expressed as percentages. The total nitrogen content of the sediment samples was estimated by Kjeldhal's method of digestion, distillation and titration and the final values were expressed as percentages. Bray's technique with ammonium fluoride as extract was used for analyzing available phosphorus with measurements in UV-Vis Spectrophotometer (Hitachi, 150-20) at 660 nm. The final concentration was calculated from the standard graph and values expressed as mg PO_4/100g of sediment (Allen, 1989).

The dilution plate count technique was employed for enumerating aerobic heterotrophic bacteria and amylolytic bacteria in both water and sediment. The colonies, after incubating for 48 hours were counted and populations calculated. The Most Probable Number (MPN) method was employed for enumerating aerobic and anaerobic cellulolytic bacteria (Imshenetskii medium) and pectinolytic bacteria (medium) in water and sediment with potato as the pectin source. The medium was inoculated with successive dilutions of the samples in triplicates. Observations on the number of positive tubes in each dilution were used for computing the bacterial counts from MPN tables (Rodina, 1972; Collins and Lyne, 1976). Roll tube method was employed for enumerating the methanogens in water and sediment samples with 1ml of inoculum mixed with 4ml of Baker's medium and further incubated with an atmosphere of carbon dioxide. The colony-forming units on the walls of the test tube were counted and populations computed (Jones *et al.*, 1987).

RESULTS

The result of the laboratory analysis helped to assess the nutrient status of the processed substrates. The mean dry matter contents of the processed substrates (i) cow manure; (ii) poultry manure; (iii) *Salvinia* + cow manure (0.5:0.5); (iv) *Eichhornia* + cow manure (0.5:0.5); (v) *Eichhornia* + poultry manure (0.5:0.25:0.25); (vi) *Eichhornia* + cow manure + poultry manure (0.625:0.250:0.125) were 20.63, 36.14, 18.53, 15.71, 16.59 and 19.44% (Table 5.1). Poultry manure showed higher values of dry matter (36.14%), organic carbon (30.55%), total nitrogen (2.70%) and phosphorus (8.26%). The mixture of *Salvinia* and cow manure (0.5:0.5) showed low values of organic carbon and phosphorus. The nitrogen contents of the substrates were observed to increase with period of processing. The input nitrogen level had a clear effect on the resultant values as indicated in mixtures with poultry manure. An increase in the available nutrient component from the organic substrates was clearly observed in the present study (N'dayegamiye and Isfan, 1991).

Table 5.1: Mean Composition of Raw and Processed Organic Material

Sl. No.	Organic Substrate	Moisture (%)	Organic Carbon (%)	Total Nitrogen (%)	Phosphorus (%)
1.	Cow manure	79.37	35.14	1.44	0.80
2.	Poultry manure	63.86	30.55	2.18	1.6
3.	*Salvinia*+ Cowmanure (0.5:0.5)	81.47	31.5	1.22	0.76
4.	*Eichhornia*+Cow manure (0.5:0.5)	84.29	37.27	1.34	0.78
5.	*Eichhornia*+Cow manure +Poultry manure (0.5: 0.25: 0.25)	83.41	35.37	1.56	0.88
6.	*Eichhornia*+Cow manure +Poultry manure (0.5: 0.25: 0.25)	80.56	33.33	1.54	0.85

The corresponding mean heterotrophic bacterial populations were 8.54, 13.83, 13.80, 8.30, 14.34 and 13.26 × 10^8/g, suggesting the increased bacterial activity in resistant substrates on amendments with organic manure, resulting in conditions similar to manures with low carbon-nitrogen ratios like poultry manure. Similarly the mean counts of amylolytic bacteria in all the substrates were 4.5, 5.2, 6.0, 3.8, 4.8 and 4.5 x 10^7/g (Table 5.2). The variations in the counts of cellulolytic bacterial populations, both aerobic and anaerobic, were not considerable. The pectinolytic bacteria did not show much difference. The methanogenic bacterial populations were high in cow manure as compared to other substrates, with mean values of 9.9, 6.7, 6.9, 7.1 and 5.4 × 10^6/g owing to its high initial inoculum as also susceptibility to bacterial degradation (Zumft, 1992; Cotner and Biddanda, 2002; Riddech *et al.*, 2002; Narihiro *et al.*, 2003).

Table 5.2: Mean Bacterial Populations in Raw and Processed Organic Material

Sl. No.	Organic Substrate	Aerobic Heterotrophic Bacteria, No. x 10^8/g	Amylolytic Bacteria, No. x 10^7/g	Aerobic Cellulolytic Bacteria No. x 10^4/g	Anaerobic Cellulolytic Bacteria No. x 10^3/g	Pectinolytic Bacteria No. x 10^5/g	Methanogenic Bacteria No. x 10^6/g
1.	Cow manure	8.54	4.5	46	15	1.19	99
2.	Poultry manure	13.83	4.2	35	6	1.26	67
3.	*Salvinia*+ Cow manure (0.5:0.5)	13.8	6.0	46	9	1.19	64
4.	*Eichhornia*+Cow manure (0.5:0.5)	8.3	3.8	67	14	1.22	69
5.	*Eichhornia*+Cow manure+ Poultry manure (0.5: 0.25: 0.25)	14.34	4.8	40	13	1.22	71
6.	*Eichhornia*+Cow manure+ Poultry manure (0.625 : 0.250 : 0.125)	13.26	4.5	13	10	1.22	54

The study indicated the possibilities of recycling of aquatic macrophytes into the production process of aquatic ecosystems through substrate processing measures incorporating animal excreta both as sources of microbial inoculants as well as supplements to modify the nutrient composition of the substrates for higher nutrient availability.

CONCLUSION

Aquatic weeds infesting water bodies need to be harvested and potentially used for developing commercial feeds and in fertilization. Energy recovery from aquatic plants and animal wastes is important to satisfy the increasing demand for raw materials and resultant energy is of great use in agriculture, landscaping and aquaculture. The use of inorganic fertilizers can be reduced and large amount of organic matter gets added into the system. Composting process should be managed according to the requirement and availability of raw materials. The chemical and biological data provided by analysis of the different manurial and macrophyte inputs provides important information about the nutrient status of compost with different combinations and further utilization in aquaculture systems. Further studies are required to determine best methods for processing and supplying as manurial inputs for sustainable aquaculture and different other uses to develop weed based energy harnessing technology.

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FISH HABITAT AND AQUACULTURE

The present book mainly deals with aquaculture and fisheries environment and updates the subject matter and problems to incorporate new concepts and issues related to aquaculture and fisheries environment. The extensive use of illustration is intended to increase the understanding and the concepts in context of the modern scenario. The book includes chapters contributed by outstanding experts and scientists from recognized institutions. This book would be of immense benefit to researchers, scientists, academician, students, entrepreneurs and fishers working in the field of aquaculture, limnology, freshwater ecology, aquatic ecosystem, environmental pollution and fisheries.

CONTENTS

Biomarkers of Environmental Contamination in Fish; Multi-faceted Role of Mussels; Farming of *Macrobrachium rosenbergii* A Prospectful Alternative to Tiger Shrimp having Attributes of Environmental Concerns; Organic Fertilizers and Organic Fish Farming System; Sustainable Composting of Aquatic Weeds and Animal Excreta for Utilization in Aquaculture; Water Treatment Technology; An Account on the Morphometric and Meristic Traits of *Bagarius yarrelli* (sykes) from the Eco-habitat of River Brahmaputra with a Note on its Conservation Prospect; Aquaculture Development and Sustainable Environmental Management Towards Food Security; Probable Candidate Species of Exotic Fish for Promotion of Diversified Aquaculture in India; Coliform Bacterial Populations in Aquatic Environments; Organic Aquaculture

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