A STUDY ON PHYSICO-CHEMICAL CHARACTERISTICS OF AQUACULTURE POND SEDIMENTS AND ITS EFFECTIVE UTILIZATION FOR PLANT GROWTH

SEENA RADHAKRISHNAN AND D.S. JAYA

Asian Journal of Environmental Science, Vol. 3 No. 1 : 35-38 (June, 2008)

SUMMARY

The present study was focussed on the investigations on the physico-chemical characteristics of aquaculture pond sediments and its utilization for terrestrial agriculture, thereby reducing the pollution problems caused by pond aquaculture practices. For this study, sediments were collected from an aquaculture pond rearing *Heteropneustes fossilis* at Balaramapuram in Thiruvananthapuram district. Physico-chemical characteristics of sediments were determined. The sediment is acidic in nature, and the organic carbon, total nitrogen and potassium contents were very high. A pot experiment using plants to assess the nutrient status of aquaculture pond sediments was also conducted. Two species of plants *i.e.*, *Vigna unguiculata* L. cv. KANAKAMONY and *Lycopersicon esculentum* Mill. cv. VIJAY were treated with different quantities of aquatic pond sediments. The effect of sediments on plant growth and physico-chemical characteristics of amended soils were also analyzed. The results revealed that pH, electrical conductivity, organic carbon, sodium and potassium contents were increased in amended soil after harvest compared to that of the garden soil. Biochemical analysis of plant leaves showed the increased synthesis of total proteins, carbohydrates and photosynthetic pigments in the plants grown in sediment amended soils. The combination of aquaculture sediment with potting mixture triggered the growth of plants. This study reveals the nutrient value of aquaculture pond sediments and the effective use of these sediments as a fertilizer / conditioner for land based agriculture.

See end of the article for authors' affiliations

Correspondence to :
D. S. JAYA,
Department of Environmental Sciences, University of Kerala, Kariavattom P.O., THIRUVANANTHAPURAM, (KERALA) INDIA

Accepted : April, 2008

Key words : Pond sediment, aquaculture, nutrient, cow pea, tomato.

The practice of fish culture in shallow waste water sedimentation pond is quite popular. Aquaculture is now recognized as a major problem in fresh water, estuarine and coastal environment leading to eutrophication and ecosystem damage. Management of aquaculture pond sediments 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 pond sediments 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 sediments play an important role in the accumulation and regeneration of nutrients. Muendo (2006) reported the utility of pond sediment to fertilize crops. Although sediment accumulation and nutrient retention in pond sediments have been reported (Smith, 1996), quantitative data on sediment 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 pond sediments hampers wider adoption and promotion of pond sediment use in agriculture.

The present investigation was undertaken to find out the physico-chemical characteristics of aquaculture sediment and to assess the morphological and physio-biochemical changes in plants grown in sediment amended soils.

MATERIALS AND METHODS

Sediments were collected from an earthern aquaculture pond of size 9 m x 3 m x 1.8 m at Balaramapuram in Thiruvananthapuram Dist. (Kerala), during the month of October 2006 and analyzed for its physico-chemical properties using standard methods as recommended by APHA (1995) and Gupta (1999). Cowpea (*Vigna unguiculata* L. cv. KANAKAMONY) and tomato (*Lycopersicon esculentum* Mill. cv. VIJAY) were selected as test plants. Sixteen test plants of each variety (7 days old) were transplanted with two plants in each pot and were subjected to three different treatment combinations with 3 kg potting mixture containing garden soil, sand and cow dung in the ratio 1:1:1. Experimental design is given in Table 1.

Sediment treatment was done at two stages of plant growth. First treatment was at the time of transplantation

Table 1 : Experimental Design

Plant Species	Groups	Treatment		
		1st Phase	2nd Phase	Total
Cow pea	CW – 1	2 gm	2 gm	4 gm
Test plants	CW - 2	4 gm	4gm	8 gm
	CW – 3	6 gm	6 gm	12 gm
Control	CC	-	-	
Tomato	TM – 1	2 gm	2 gm	4 gm
Test plants	TM – 2	4 gm	4gm	8 gm
	TM – 3	6 gm	6 gm	12 gm
Control	TC	-	-	-

and latter at 30th day of transplantation. Plants of both variety grown on potting mixture without sediments was treated as control. All plants were maintained in green house conditions and irrigated with tap water for 60 days. Soil and mature plant samples were taken from each pot and the agro-botanical characteristics like plant height, dry matter content and specific leaf area were noted in the control and experimental plants. The plant leaves collected were analyzed for total chlorophyll, chlorophyll –a, chlorophyll–b, carotenoids, total carbohydrates, proteins, total phosphorous, calcium, sodium, potassium and total nitrogen following the procedures of Sadasivam and Manickam (1996), Singh and Purohit (2003) and Gupta(1999). Sediment amended soils were also analysed for its physico-chemical characteristics using the standard procedures. (APHA,1995., Gupta,1999).

RESULTS AND DISCUSSION

The physico-chemical characteristics of garden soil, aquaculture pond sediments and soils collected after experimental period was given in Table 2. Comparing to garden soil, aquaculture pond sediments are rich in nitrogen, potassium and organic carbon. Sediment rich in organic matter, nitrogen and phosphorus accumulates in fish ponds during culture (Boyd *et al.*, 2002). The main source of nitrogen in the pond bottom is the organic wastes and fish excreta. Accumulated sediments in fish culture pond have high potential as nitrogen and phosphorus fertilizer (Muendo, 2006). The deposition of organic matter results in increased availability of all nutrients (Agemian, 1997). Soil organic matter act as the chemical reservoir of various essential plant nutrients (Singhvi *et al.*, 2006).

Table 2 : Changes in the physico-chemical characteristics of garden soil, sediments and amended soils. (Values given are means of three replications)

Parameter	Garden soil	Pond sediments	Soils after 60 days			
			CC	CW-3	TC	TM-3
pH	5.57	6.70	6.51	6.64	6.65	6.77
EC (mS)	0.56	0.62	0.66	0.66	0.66	0.66
Chloride (mg/gm)	0.14	0.28	0.14	0.21	0.14	0.25
Nitrogen (mg/gm)	0.14	0.56	0.14	0.14	0.14	0.14
Phosphorus(mg/gm)	0.700	0.208	0.046	0.049	0.046	0.052
Potassium (mg/gm)	1.06	3.95	1.40	1.68	1.40	1.62
Sodium (mg/gm)	1.46	2.86	1.80	2.84	1.80	2.06
Organic matter (%)	0.93	1.78	2.86	4.61	2.66	3.26
Organic carbon (%)	0.54	1.38	1.89	2.60	1.54	1.90

Morpho-physiological characteristics of test plants show positive responses with the sediment treatment at successive concentration. Agro-botanical characters like plant height, dry matter content and specific leaf area of plants were measured and results are given in Table 3. It was observed that there is a successive increase in the height of plants as concentration of sediments amended to the soil increased. The height of both cowpea and tomato control plants were less than that of the test plants. In tomato test plants, the TM-2 and TM-3 groups are of same height, but the plants in the TM-3 group showed branching. Thamburaj (1994) found that organically grown tomato plants were taller with more number of branches. Both test plants studied showed dry matter yield greater than that of the control plants.Comparing the two test plants studied, tomato leaf shows more specific leaf area than that of cow pea.

Table 3 : Agro-botanical characters of plant species. (Values given are mean of three replications)

Parameter	Cow pea				Tomato			
	CC	CW-1	CW-2	CW-3	TC	TM-1	TM-2	TM-3
Plant length (cm)	125	130	208	235	54	64	70	70
Dry Matter (gm)	8.98	9.16	9.21	9.23	2.123	2.15	2.28	2.37
Specific leaf area (cm^2/g)	44.69	50.07	52.49	57.47	72.74	79.47	82.86	85.25

Pigment concentration of the two plants species are estimated and is given in the Table 4. The present study shows that there is an increase in total chlorophyll content and carotenoids in the leaves of test plants compared to that of the control plants. The carotenoid content and chlorophyll content were maximum in plants (TM-3 and CW-3) and it indicates that photosynthetic rate was also increased with amendment of aquatic sediment.

Concentration of nitrogen, phosphorus, potassium, sodium, total proteins and carbohydrates in leaves were determined in both test and control plant leaves (Table 5). There is not much variation in the total nitrogen of

Table 4 : Changes in pigment concentrations of plant species. (Values given are mean of three replications)

Parameter	Cow pea				Tomato			
(mg/g)	CC	CW-1	CW-2	CW-3	TC	TM-1	TM-2	TM-3
Chlorophyll –a	0.921	0.922	1.58	1.137	1.80	1.263	1.398	1.363
Chlorophyll -b	0.44	0.45	0.55	0.68	0.55	0.60	0.65	0.80
Total chlorophyll	1.36	1.39	1.70	1.85	1.73	1.86	2.04	2.16
Carotenoid	0.071	0.074	0.087	0.096	0.095	0.093	0.099	0.107

Table 5 : Biochemical characteristics in the leaves of mature plants grown in sediment amended soils (Values given are mean of three replications)

Parameters	Cow pea				Tomato			
(mg/g)	CC	CW-1	CW-2	CW-3	TC	TM-1	TM-2	TM-3
Total Nitrogen	1.12	1.12	1.12	1.68	0.56	0.56	0.56	0.56
Phosphorus	0.302	0.290	0.584	0.302	0.457	0.662	0.671	0.681
Potassium	15.0	15.5	17.5	24.5	14.0	20.5	22.5	24.5
Sodium	0.05	0.10	0.55	0.65	0.20	0.30	0.30	0.30
Total proteins	1.76	2.62	2.76	3.12	2.02	2.10	2.78	3.02
Total carbohydrates (mg/100mg)	1.5	1.8	1.8	2.2	1.2	1.3	2.0	2.3

leaves in control and test plants. Phosphorus value showed marked changes in the test groups. Sodium, potassium content and biomolecular contents were high in both test plants studied compared to that of the control plants, since the test plants were grown in moderately higher nutrient concentration present in the amended sediments. Rammohan *et al.*, (2002) reported that organic matter serves as slow release source of nitrogen, phosphorus and sulphur for plant nutrition. High concentration of proteins and carbohydrate reported in the leaves of test plants may also be due to the availability of nutrients and organic carbon for the synthesis of biomolecules from the amended soils.

The comparison of important biochemical constituents (chlorophyll, carbohydrates and proteins) in cowpea and tomato plants are given in Fig. 1(a) and 1(b), respectively. The enrichment of the garden soil with aquaculture pond sediments accelerated the growth potentials of the studied plants and also helped the plants to increase the concentration of biomolecules. Similar studies by Muendo (2006) also reported the utility of pond sediments to fertilize crops.

A comparison of physico-chemical characteristics of garden soil (sandy loam), sediment and soils collected after the experimental period was also done (Table 2). Organic matter and organic carbon was very high in amended soil compared to the other two. This may be due to the addition of aquaculture pond sediment to test plant groups. Shuxin *et al.*, (1991) reported that by manure application the organic carbon in red arid soil increased from 0.5% to 0.6%. The high value of nitrogen in sediment may be due to high organic matter content in the fish pond. The low value of total nitrogen and potassium in amended soil (after 60 days) may be due to the utilization of nitrogen by plants for their growth and development. It was recognized that organic phase of the soil virtually controls the exchange behaviour, nutrient status and the general health of soil ecosystem as a whole. Small application of manure exerts a much more favorable influence on plant growth.

The studies showed that the plants grown in sediment amended soils showed improved growth compared to that grown in garden soil. The study also throws light on the

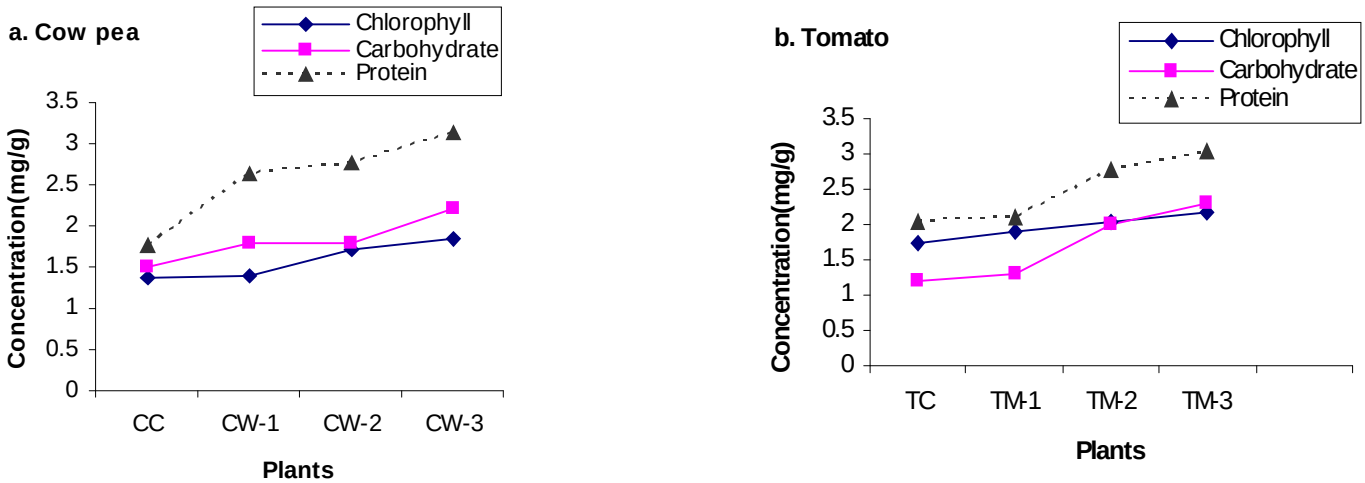

Fig. 1: Comparison of important bio- chemical constituents

improvement of nutrient quality of sandy loam soil (red soil) with low nutrient by the addition of aquaculture pond sediments rich in nitrogen, potassium and organic carbon. Pond sediments are commonly used to improve the chemical and physical properties of soils used for rice cultivation (Matsushima, 1980). So the present study discloses the fish culture pond sediments can be subsequently used at any time as an on-farm crop fertilizer and soil conditioner. Therefore, the sediment in fish ponds are not a menace for environment if it is utilized intelligently.

ACKNOWLEDGEMENT

The authors thank Dr. Roy Stephen, College of Agriculture, Vellayani, Thiruvananthapuram for his valuable suggestions to carry out this work.

Authors' affiliations

SEENA RADHAKRISHNAN, Department of Environmental Science, University of Kerala, Kariavattom P.O. THIRUVANANTHAPURAM (KERALA) INDIA

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