



Potential of Amended Silt as Nutrient Input in Agriculture - A Chemical Composition Analysis

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Accumulation of silt in channels and ponds has necessitated its removal, and its proper utilization has become pertinent for effective disposal. The present investigation aimed to explore the potential of using silt as a nutrient input and amending it with aquatic weeds paving the way to address the aquatic weed menace. The experiment was conducted at the Regional Agricultural Research Station, Kumarakom, Kottayam, during September to November 2022. The nutrient composition of silt was assessed and was amended in a 2:1 ratio (v/v) with various organic inputs, namely, FYM, *Gliricidia* leaves, *Salvinia*, *Salvinia* + *Gliricidia* leaves, *Eichhornia* + *Gliricidia* leaves, vermicomposted *Eichhornia*, and coir pith compost. Additionally, dolomite was added based on the initial pH of the silt to adjust it to pH 7. The results indicated an enhancement in the nutrient status of silt following amendment. The amended silt had higher nutrient contents and lower C:N ratio compared to the raw materials and unamended silt. Among the treatments, silt amended with *Gliricidia* leaves and *Salvinia* was found to be the most suitable option owing to its higher overall nutrient composition.

(**Key words:** Amendment, C:N ratio, *Eichhornia*, Nutrient, *Salvinia*, Sediments)

Silt deposition in ponds and channels is a natural phenomenon that must be managed to ensure the sustainability of these water bodies. Besides the soil fractions, fish wastes, unconsumed fish feed and decomposing organic materials are the major constituents of the bottom sediments. Modern agriculture, with its increasing focus on safe food production, calls for suitable alternatives to agrochemicals, including fertilizers. The silt removed from ponds has been reported to be rich in nutrients (KAU, 2017) and hence holds promise as a potential nutrient input in crop production. Kadam *et al.* (2016) reported the positive response of okra to a combination of silt and farm yard manure (FYM), supporting the idea that recycling of silt could simultaneously address the environmental problems of silt accumulation and reduce dependence on chemical fertilizers. However, Rahman *et al.* (2004) noted that while pond sediments are rich sources of mineral elements, they may also contain compounds that could undergo rapid degradation, which can result in unpleasant odours and pose environmental risks. Therefore, the agricultural reuse of the bottom sediments

necessitates appropriate treatments to offset these disadvantages. Processing the silt through techniques such as composting or the addition of organic materials (Drozd *et al.*, 2020) can enrich the nutrient content of the silt and improve its effectiveness as a fertilizer.

The Kuttanad wetlands, located in the coastal plains agroecological zone of Kerala, is unique with their below mean sea level farming systems. The wetlands support a distinctive agricultural practice that accommodates seasonal flooding and salinity intrusion to grow rice in the wetlands and garden crops on the bunds, often in rotation or simultaneously with fish farming. Being adjacent to water bodies, the use of agrochemicals in crop production should be advocated with extra caution. Silt accumulation is a common feature in the region and requires careful management in terms of both removal and disposal. The Kuttanad ecosystem thus offers a natural resource base that can support eco-friendly agricultural practices. In this background, a study was conducted to assess the nutrient composition of

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bottom sediments collected from the channels and enhance their properties through amendment with locally available organic materials for reuse in coastal agricultural systems. Aquatic weeds such as *Salvinia molesta* and *Eichhornia crassipes*, considered a menace in the wetland ecosystems, were included as amendment materials in the study, aiming to provide an effective means for utilisation of this biomass.

The experiment was conducted at the Regional Agricultural Research Station, Kumarakom, Kottayam (located at 9°37' N latitude and 76°25' E longitude and an altitude of 0.6 m below mean sea level) from September to November 2022. The site, falling under the Agroecological Unit 4 (Kuttanad) and the agroecological zone of coastal plains of Kerala state, experiences a tropical humid monsoon climate with an average annual rainfall of 2746.1 mm. The experiment was laid out in a Completely Randomised Design (CRD) with nine treatments, each replicated thrice. The treatments included, S₁: silt + farmyard manure (FYM); S₂: silt + *Gliricidia* leaves; S₃: silt + *Salvinia*; S₄: silt + *Salvinia* + *Gliricidia* leaves; S₅: silt + *Eichhornia* + *Gliricidia* leaves; S₆: silt + vermicomposted *Eichhornia*; S₇: silt + coir pith compost; S₈: silt + dolomite and S₉: silt alone (control). Vermicomposted *Eichhornia* was prepared by composting the plant material with earthworms (*Eudrilus eugeniae*). For this, the collected *Eichhornia* plants were chopped into small pieces, mixed with fresh cow dung in 8:1 ratio, and filled into cement rings. The mixture was allowed to wilt for 10 days and earthworms (@ 1000 kg⁻¹ material) were introduced. The material was turned at regular intervals, kept moistened throughout the composting period and was ready for use after 50 days.

The silt collected from the channels was mixed with organic materials in a 2:1 ratio (v/v) for treatments S₁ to S₇, and with dolomite in S₈. The quantity of dolomite used (2.29 g kg⁻¹) was arrived at by computing the amount of the liming material required to raise the pH of silt from 5.57 to 7. Samples of silt were kept apart for analysis of physical, chemical and biological properties as per the standard procedures. These included the Bouyoucos

hydrometer method for texture (Bouyoucos, 1962), undisturbed core sampling for bulk density (Black *et al.*, 1965), Keen Raczowski box for water holding capacity (Piper, 1967), and determination of pH and electrical conductivity using a 1:2.5 soil-to-water ratio (Jackson, 1973). Nutrient analyses were carried out using the alkaline permanganate method for nitrogen (Subbaiah and Asija, 1956), Bray No.1 extraction for phosphorus, flame photometry for potassium (Jackson, 1973), and the rapid titration method for organic carbon (Walkley and Black, 1934). Calcium and magnesium were extracted using neutral normal ammonium acetate and estimated by the EDTA titration method (Jackson, 1973). Micronutrients including zinc, iron, and manganese were determined using 0.1 N HCl extraction and atomic absorption spectrophotometry (Sims and Johnson, 1991), while boron was estimated as hot water extractable using the azomethine-H spectrophotometric method (Gupta, 1967). Dehydrogenase activity was assessed colorimetrically using 2,3,5-triphenyl formazan (Casida, 1977).

After two weeks of decomposition, the amended silt was analyzed for chemical constituents. Total nitrogen was estimated using the Micro-Kjeldahl method, phosphorus by spectrophotometry using the vanadomolybdo phosphoric yellow colour method and potassium was measured using flame photometry (Jackson, 1973). Calcium and magnesium were estimated following nitric-perchloric acid (9:4) digestion and titration (Piper, 1967). Iron, zinc, and manganese were extracted by the same acid digestion method and estimated using atomic absorption spectrophotometry (Jackson, 1973). Boron was estimated by spectrophotometry using the azomethine-H method (Gupta, 1967), and total carbon was determined using the weight loss on ignition method (FAI, 2017).

The data were then tabulated and subjected to statistical analysis using the General R-shiny based Analysis Platform Empowered by Statistics (GRAPES), designed by Gopinath *et al.* (2020), Department of Statistics, College of Agriculture, Kerala Agricultural University, Vellayani, Kerala. Wherever the F value was significant, critical

differences were computed for statistical comparison.

The properties of the silt are detailed in Table 1. A perusal of the data revealed that the channel sediments had a sandy clay texture, with a bulk density of 0.69 g cm⁻³ and a water holding capacity of 51.85%. Due to its fine particle size, silt possesses a large surface area, which facilitates greater water retention and thereby enhancing its water holding capacity (Kharche *et al.*, 2017). The chemical properties indicated that the silt was moderately acidic (pH 5.57) with an electrical conductivity of 1.00 dS m⁻¹. The acidic pH may be attributed to the accumulation of organic matter, which can lead to the generation of organic acids. The silt had an organic carbon content of 1.82%, corresponding to an estimated organic matter content of 3.13%. This organic matter likely originated from decomposed aquatic weed residues, metabolic by-products, and uneaten fish feed. The channels from which the silt was collected were used for fish rearing, which may have increased microbial activity in the sediments. This is supported by the measured dehydrogenase activity, suggesting elevated microbial density that likely accelerated organic matter decomposition,

leading to the formation of organic acids.

The initial chemical properties of channel silt and the raw materials used for amendment are presented in Table 2. Among the raw materials used, *Gliricidia* leaves had the highest N (3.48 %) and K (2.42 %) contents. Vermicomposted *Eichhornia* had the highest P content (2.19%), which was twice than that of raw *Eichhornia* (1.09%). The elevated P content may be attributed to the mineralization and mobilization of P through bacterial decomposition of organic matter and the enhanced phosphatase activity in earthworm casts (Vinotha *et al.*, 2000). Calcium (29.31 %) and Mg (17.89 %) contents were the highest in dolomite, an anhydrous mineral composed of carbonates of Ca and Mg. Among the raw materials tested, silt had the lowest nutrient contents (0.15% N, 0.07% P, 0.09% K, 0.06% Ca and 0.04% Mg).

The total C content was the highest in *Gliricidia* leaves (51.99 %) and the lowest in silt (2.50%). The C:N ratio followed the order, vermicomposted *Eichhornia* < *Gliricidia* < silt < *Eichhornia* < coir pith compost < *Salvinia* < FYM. Vermicomposted

Table 1. Physical, chemical and biological properties of silt

S. No.	Parameters	Value/Content
Physical		
1.	Texture	
	Sand (%)	48.40
	Silt (%)	10.00
	Clay (%)	41.60
	Textural class: Sandy clay	
2.	Bulk density (Mg m ⁻³)	0.69
3.	Water holding capacity (%)	51.85
Chemical		
4.	pH	5.57
5.	Electrical conductivity (dS m ⁻¹)	1.00
6.	Nitrogen (mg kg ⁻¹)	1466.67
7.	Phosphorus (mg kg ⁻¹)	701.12
8.	Potassium (mg kg ⁻¹)	933.33
9.	Organic carbon (%)	1.82
10.	Calcium (mg kg ⁻¹)	566.67
11.	Magnesium (mg kg ⁻¹)	434.33
12.	Zinc (mg kg ⁻¹)	5.19
13.	Iron (mg kg ⁻¹)	128.30
14.	Boron (mg kg ⁻¹)	0.13
15.	Manganese (mg kg ⁻¹)	15.84
Biological		
16.	Dehydrogenase activity (µg TPF g ⁻¹ h ⁻¹)	50.10

Table 2. Chemical characteristics of silt and materials used for amendment

Raw materials	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Total C (%)	C: N ratio
Silt	0.15	0.07	0.09	0.06	0.04	2.50	17.0
FYM	0.51	0.29	0.47	1.17	0.27	17.46	34.6
<i>Gliricidia</i> leaves	3.48	0.26	2.42	2.28	0.49	51.99	14.9
<i>Salvinia</i>	1.89	0.41	0.51	0.17	0.17	49.19	25.9
<i>Eichhornia</i>	1.65	1.09	1.31	0.34	0.28	40.10	24.3
Vermicomposted <i>Eichhornia</i>	2.61	2.19	2.26	0.37	0.32	18.22	7.0
Coir pith compost	1.18	0.12	1.11	0.54	0.37	28.73	24.4
Dolomite	-	-	-	29.31	17.89	11.73	-

Eichhornia had the lowest C:N ratio (7.0:1) owing to its relatively high N content (2.61%) and moderate C content (18.22%). In contrast, silt exhibited a wider ratio (17.0:1), despite its low C content, due to its extremely low N content (0.15%). FYM had the highest C:N ratio (34.6:1), which can be attributed to its low N and comparatively high C content.

Amending the silt with the organic raw materials in 2:1 ratio from S₁ to S₇ and with dolomite in S₈ (based on the pH of silt) resulted in significant variations in the nutrient contents. In general, nutrient contents increased while total C and C:N ratios decreased (Table 3). Silt amended with *Salvinia* + *Gliricidia* leaves (S₄) recorded the highest N (3.92%) and K (2.65%) contents. This could be attributed to the higher nutrient status of the constituent raw materials, particularly *Gliricidia* leaves. In addition, the microbial population in silt may have facilitated the mineralization of nutrients entrapped within plant tissues through decomposition (Bai *et al.*, 2022). The P content was found to be highest in silt amended with vermicomposted *Eichhornia* (S₆), followed by silt amended with *Eichhornia* and *Gliricidia* leaves (S₅). It is assumed that the high P content in silt amended with vermicomposted *Eichhornia* (2.19%) might have resulted in increased P levels (2.37%) in S₆, an increase of approximately 8.22% over vermicomposted *Eichhornia* alone. In S₅, the increase in phosphorus content was by 14.68%.

The highest Ca (31.42 %) and Mg (18.10 %)

contents were observed when silt was amended with dolomite (S₈), which can be ascribed to the high Ca and Mg levels present in the dolomite. The increase in Ca and Mg contents in S₈ over the raw material dolomite were 7.20 and 1.12%, respectively.

Micronutrient contents in the amended silt also exhibited significant variations (Table 3). The highest Zn content (19.63 mg kg⁻¹) was recorded in S₄ (silt + *Salvinia* + *Gliricidia* leaves) followed by S₁ (silt + FYM, 18.70 mg kg⁻¹). The highest Fe content (222.77 mg kg⁻¹) was observed in S₅ (silt + *Eichhornia* + *Gliricidia* leaves) followed by S₄ (217.72 mg kg⁻¹). The B content was highest in S₇ (silt + coir pith compost, 0.22 mg kg⁻¹) followed by S₄ (0.20 mg kg⁻¹), while Mn content was highest in S₄ (23.00 mg kg⁻¹) followed by S₅ (20.58 mg kg⁻¹). The results indicate that the organic amendments, being organic in nature contributed additional micronutrients to the silt which also inherently contains micronutrients (Table 1). Pond sediments are reported to be rich in N, P, K, and other macro and micronutrients (Rahman *et al.*, 2004). The overall increase in the micronutrient levels with amendments might be due to the synergistic effect of mixing of organic materials and enhanced microbial activity.

Total C was significantly higher in S₄ (11.69 %) followed by S₇ (9.84%). The C:N ratio of the amended silt was narrowest in S₂ (1.7:1) and widest in S₈ (5.9:1). The C:N ratio followed the order: silt + *Gliricidia* leaves (S₂) < silt + *Eichhornia* +

Table 3. Chemical characteristics of amended-silt

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (mg kg ⁻¹)	Fe (mg kg ⁻¹)	B (mg kg ⁻¹)	Mn (mg kg ⁻¹)	Total carbon (%)	C:N ratio
S ₁ : silt + FYM	1.09	0.55	0.86	1.43	0.55	18.70	187.40	0.18	13.67	5.97	5.6
S ₂ : silt + <i>Gliricidia</i> leaves	3.67	0.36	2.63	2.33	0.53	14.66	201.33	0.13	15.92	6.18	1.7
S ₃ : silt + <i>Salvinia</i>	2.17	0.60	0.67	0.35	0.27	13.68	194.55	0.12	14.00	9.70	4.5
S ₄ : silt + <i>Salvinia</i> + <i>Gliricidia</i> leaves	3.92	0.84	2.65	2.46	0.57	19.63	217.72	0.20	23.00	11.69	3.0
S ₅ : silt + <i>Eichhornia</i> + <i>Gliricidia</i> leaves	3.51	1.25	2.55	2.39	0.56	15.73	222.77	0.17	20.58	9.60	2.7
S ₆ : silt + vermicomposted <i>Eichhornia</i>	2.95	2.37	2.65	0.48	0.40	17.69	192.83	0.12	18.50	9.02	3.1
S ₇ : silt + coir pith compost	2.52	0.60	1.67	0.68	0.54	18.51	185.50	0.22	11.42	9.84	3.9
S ₈ : silt + dolomite	0.82	0.17	0.53	31.42	18.10	12.39	129.37	0.05	15.58	4.80	5.9
SEm(±)	0.03	0.01	0.01	0.03	0.13	0.14	0.58	0.01	0.30	0.04	0.2
CD(0.05)	0.090	0.037	0.045	0.092	0.384	0.420	1.748	0.021	0.901	0.112	0.54

Gliricidia leaves (S_5) < silt + *Salvinia* + *Gliricidia* leaves (S_4) < silt + vermicomposted *Eichhornia* (S_6) < silt + coir pith compost (S_7) < silt + *Salvinia* (S_3) < silt + FYM (S_1) < silt + dolomite (S_8). The C:N ratio decreased with composting and the changes in the C and N contents of the material governed the final C:N ratio of the amended material. During composting, microorganisms breakdown C sources to procure energy and nutrients to sustain their growth. This leads to a reduction in the C and N contents and consequently a narrowing of the C:N ratio. The lowest C:N ratio in S_2 (1.7:1) could be due to the relatively higher N and lower C content of the mixture. A decrease in C:N ratio during composting is a key indicator of improved mineralization and stabilisation of organic matter.

The study highlights the potential benefits of amending silt to enhance its nutrient quality. The nutrient enrichment was more pronounced in silt amended with *Gliricidia* in combination with *Salvinia* or *Eichhornia*. Such amendments offer a sustainable solution, in the context of organic farming, which promotes the use of alternatives to chemical fertilizers, as the latter is regarded as the root cause of eutrophication and water contamination in coastal agriculture. Furthermore, sediment accumulation in water bodies necessitates regular dredging and safe disposal for the long-term sustainability of the aquatic ecosystems. The possibility of amending silt with aquatic weeds, *Salvinia* and *Eichhornia*, the two most invasive and problematic species in aquatic environments not only provides a method for their effective utilization but also offers a cost-effective nutrient management strategy in wetland ecosystems such as the Kuttanad.

CONFLICTS OF INTEREST

There is no conflict of interest with regard to the content of the paper.

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