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Quantification of Nutrients Recycled by Tank Silt and its Impact on Soil and Crop

A Pilot Study in Warangal District of Andhra Pradesh

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International Crops Research Institute for the Semi-Arid Tropics

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Abstract

Tanks were an integral part of rural life in India traditionally. However, with decreasing collective action by the community inappropriate soil and water management practices adopted by the farmers, encroachments of tanks and waterway by the individuals resulted in neglect of the tanks in villages. Good practices such as desilting and application of silt to agricultural fields were abandoned. Continued mining by crops and reduced application of organic manures have resulted in deficiency of several nutrients particularly that of micronutrients. ICRISAT in association with Modern Architects of Rural India (MARI), an NGO conducted a pilot project and quantified major and micro-nutrients present in the tank silt and also its impact on soil health and crop yields.

The depth of silt in 12 tanks de-silted ranged from 1.2 m to 3.0 m. The pH of the tank silt ranged from 6.5 to 8.5, while the organic carbon content was found to be low (0.5% to 0.8%). The available N content of tank silt ranged from 328 mg kg^{-1} to 748 mg kg^{-1}, available P 5 to 35 mg kg^{-1} and K 271 to 522 mg kg^{-1} silt. Similarly, available S ranged from 12 mg kg^{-1} to 30 mg kg^{-1} zinc from1.2 mg kg^{-1} to 5.6 mg kg^{-1} and boron 0.4 to 0.8 mg kg^{-1} silt. Microbial population was found to be low and it could be due to excessive use of pesticides for cash crops like cotton and chilli grown in the catchment area. Textural analysis indicated 70 to 80% clay, while the silt ranged from 15 to 25%. Addition of tank silt at 50, 100, 150 and 375 tractor loads per hectare improved the available water content by 0.002, 0.007, 0.012 and 0.032 g g^{-1} of soil, respectively in the plough layer and enhanced the tolerance of rain-fed crops to moisture stress by three to five days. The farmers could recover the investment made on transport of the silt through increased net profit in cotton and chilli compared to turmeric and maize. Further, the saving on pesticides alone was to the tune of Rs. 2500 ha^{-1} in cotton and chilli crops, which has indirect beneficial impact on the ecosystem. De-silting was found to be an economically viable activity both in terms of farmers' and project's perspective to create more storage capacity as well as to return the silt back to the fields. De-silting activity needs greater support from the government and non-governmental agencies for achieving multiple outputs like employment generation for landless, rejuvenating of the tanks and for enhanced productivity of dryland crops.

Key words: tank silt, nutrient recycling, economic evaluation and impact assessment

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Contents

1.0 Introduction

In southern India, community tank systems are integral part of rural livelihoods for centuries. True to wetland ecosystem, the interactions between human, land and water are the highest in tanks and provides the highest productivity both in agriculture and ecosystem uses (DHAN, 2004). Tanks have multiple functions and several outputs like food (fish), fodder (tank bed) and fuel (bushes), ecosystem services like biodiversity (flora, fauna, avian), groundwater recharge and supporting services like washing, bathing, retting, etc., in addition to the main use as source of irrigation. Tanks serve as a common pool resource and have various stakeholders ranging from governmental agencies, local *panchayats,* farmers, rural rich and poor. The breakdown of traditional system has resulted in the encroachment, siltation, weed growth and poor inflows. Over exploitation of groundwater through bore wells have made these water bodies a neglected entity, truly as "tragedy of commons". Poor management practices of catchment have resulted in silting of most of these water bodies and significant reduction of storage capacity. Silt deposit has not only reduced the storage capacity but also groundwater recharge, eutrophication of tanks and most importantly, higher release of carbon into atmosphere through silt mediated anaerobic decomposition of organic carbon.

Though tanks are in existence across the country, they have not figured in any national programs. It is conspicuous that there are no countrywide programs as that of the Command Area Development Program (CADP) and Integrated Watershed Development Programs (DHAN, 2004). Tanks having more than 40 ha of command area are entrusted to *panchayats*, which are struggling for mobilization of funds and are loaded with too many activities. Most of the budget outlay goes to major and medium irrigation projects at national and state level, while the minor irrigation projects receive step-motherly treatment, which involves less investment and yields higher returns. Tanks and ponds provide water where people need it and support biodiversity. One of the advantages of tank restoration is the equity as they are evenly distributed over the landscape unlike canals, which follow the gradient and irrigate mostly the richly-endowed areas.

Green revolution has virtually transformed 'low external input' into 'high external input' agriculture. Soil is considered as pool of nutrients present in both available and reserve forms. Depletion occurs when nutrients don't get replenished from the reserve pool. Soil is not an eternal supplier of all the nutrients when exploited indiscriminately through excessive mining by crops or land degradation. Out of total 16 elements essential for plant growth, seven are required in much smaller quantities and are called micro-nutrients. They are namely, iron, manganese, boron, zinc, copper, molybdenum and chlorine. In most soils, the deficiency of boron and zinc is widely noticed (Rego et al. 2005, Sahrawat et al. 2008).

Nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) are considered as macro-nutrients as their requirement by plants is high, particularly the first three (N, P and K). It is estimated that there is an annual depletion of about 5.8 million tonnes of major nutrients due to agricultural production system, mostly P and K since most farmers apply these nutrients in much lesser amounts than needed (Rajendra Prasad, 2002). The normal application ratio of NPK is 4:2:1, but is now heavily biased towards N, resulting in nutrient imbalances.

2.0 Materials and Methods

The pilot study has been carried out in collaboration with Modern Architects of Rural India (MARI), an NGO active in Warangal district of Andhra Pradesh and was funded by World-Wide Fund for Nature (WWF). Warangal district lies between 17^0–19' and 18^0–36' North latitude and 78^0–49' and 80^0–43' East longitude. The elevation ranges from 266 m to 518 m MSL. On the north part of the district lies Karimnagar, West Medak and to South Nalgonda district and to East Khammam. The district falls in the catchment of both Krishna and Godavari rivers, two important rivers of Andhra Pradesh. The geographical area of the district is 12846 sq. km. About 41% of the total area is under cultivation, while 29% is under forest. Current and other fallow account for about 15% and the rest 15% is under miscellaneous category (non-agricultural, barren, grazing land, cultivable waste). All the mandals receive about 1000 mm rainfall, mainly through S-W monsoon. The study was carried in four mandals of the district, which have high percent of cropped area under irrigation, namely Nalabelli, Parkal, Shayampet and Regonda through tanks and open dug/bore wells.

Salivagu micro basin of Godavari river having 447 tanks spread over 878.35 sq km of catchment was selected for the study. Twelve tanks were identified in the Salivagu micro basin for de-silting on pilot basis during 2005-06. Name of the village, tank and the number assigned to the tank is set out in (Table 1).

Samples of tank silt were drawn using 5 cm core from four layers (0 to 30 cm, 30 to 60 cm, 60 to 90 cm and 90 to 120 cm) at various locations in the tank bed area proposed for de-silting. A composite sample for each depth was drawn using normal sampling procedure. Various chemical, physical and biological parameters of silt were assessed using standard methods (Table 2).

The valuation of nitrogen in the silt was based on the cost of urea while phosphorous on the basis of single super phosphate (SSP). Potassium was based on muriate of potash (MOP), zinc (zinc sulphate) and boron (Borax) at the existing rates. Value of tank silt was based on the content of N,P,K, zinc and boron and equated with cost of fertilizers. The benefit was calculated by summing the value of silt for different nutrients. Value of other nutrients was not estimated. The benefit-cost ratio calculated was the apparent value and indicated only the cost of de-silting operation borne by the project and the total value of the nutrients.

Table 1. Tank number, name of the village, tank and *mandal*.			
Tank number	**Name of the village**	**Name of the *mandal***	**Name of the tank**
T1	Koppula	Shayampet	Pedda Cheravu
T2	Relakunta	Nallabelli	Tummala Cheravu
T3	Rudragudem	Nallabelli	Yerra Cheravu
T4	Chinnakodepaka	Regonda	Pedda Cheravu
T5	Gorikothapalli	Regonda	Bokki Cheravu
T6	Gangirenigudem	Shayampet	Thimmanakunta
T7	Nizampally	Regonda	Reddy Cheravu
T8	Pathipaka	Shayampet	Moggula Cheravu
T9	Dammanapet	Regonda	Pedda Cheravu
T10	Rayaparthi	Parkal	Oora Cheravu
T11	Repaka	Regonda	Oora Cheravu
T12	Munchupla	Nallabelli	Venkatapalem Cheravu

Table 2. Methods of analysis for properties determined on air-dried soil samples.		
Property	**Test**	**Reference**
Total N	Modified Kjeldahl digestion	Dalal et al. 1984
Olsen P	Extracted by 0.5 M $NaHCO_3$	Olsen & Sommers 1982
Mineral biomass C	Chloroform fumigation and incubation	Jenkinson & Powlson 1976; Jenkinson 1988; Wani et al. 1994
Particle size texture analysis	Bouyoucos hydrometer method	Bouyoucos 1962
Organic carbon	Dry combustion method, Primacssc TOC analyzer, Skalar	Nelson & Sommers 1982
Microbial population	Serial dilution and spread plate method Bacteria-Nutrient Agar Fungi-Potato Dextrose A gar Actinomycetes – Nutrient Agar	Zuberer 1994; Parkinson 1994; Wellington & Toth 1994

3.0 Results

The depth of silt deposit in 12 tanks ranged from 1.2 m to 3.0 m. The depth was found to be the highest in Rayaparthi tank (T10) and the least in Repaka (T11).

3.1 Chemical Properties

pH and electrical conductivity (EC): The pH of the tank silt ranged from 6.5 to 8.5. pH of the tank silt varied with depth (Table 3). Except Relakunta (T-2) all the tanks recorded pH 7.0 and above, while Rudragudum (T-3) recorded the highest (8.5). pH has high relevance and some crops are very sensitive. If soils with high pH receive more tank silt having high pH, it might affect the crop productivity adversely. EC was found to be normal (<0.4 dS m^{-1}) and within safe limits for all the tanks.

Nitrogen and organic carbon content: Available N-content of tank silt ranged from 328 mg kg^{-1} to 748 mg kg^{-1} silt. The organic carbon content was found to be low and ranged from 0.5% to 0.8%. The highest value of organic carbon content of 1.5% was recorded in Munchupla at surface while it declined with depth (Table 3). The quality of Munchupla (T-12) was found to be superior compared to other tanks in terms of normal pH, high organic carbon and nitrogen contents.

Phosphorous and potassium content: The available phosphorous content ranged from 5 mg kg^{-1} to 35 mg kg^{-1} while exchangeable K from 271 mg kg^{-1} to 522 mg kg^{-1} silt.

Sulphur, zinc and boron: Available S (12 mg kg^{-1} to 30 mg kg^{-1}) zinc (1.2 mg kg^{-1} to 5.6 mg kg^{-1}) and boron (0.4 mg kg^{-1} to 0.8 mg kg^{-1}) were found to be highly variable.

3.2 Physical Properties

All the tanks had high clay content, followed by silt, fine sand and coarse sand irrespective of the depth, indicating tank silt richness in clay than silt. All the tanks except Rudragudum (T-3) had 70% to 80% clay while silt ranged from 15% to 25% (Table 4). Fine sand and coarse together amounted to less than 10% of the total in all the tanks except T-3. High clay content at all the depths was noticed in case of Repaka (T-11), while high silt content was found in Gorikothapalli (T-5) at all the depths, except surface level (0 to 30 cm). Depth-wise values of coarse sand, fine sand, silt and clay are indicated in Table 4.

Table 3. Chemical properties of tank silt samples at different depths.

Village name & tank number	Depth (cm)	pH	EC (dS m^{-1})	Org.C (%)	Kjheldahl N (mg kg^{-1})	Olsen P (mg kg^{-1})	Exchangable K (mg kg^{-1})	Available S (mg kg^{-1})	Available Zn (mg kg^{-1})	Available B (mg kg^{-1})
Koppula (T1)	0–30	8.0	0.1	0.4	431	12	446	5	0.8	0.4
	30–60	8.0	0.1	0.4	420	13	439	7	1.0	0.5
	60–90	7.9	0.1	0.4	398	13	422	5	1.0	0.4
	90–120	8.0	0.1	0.4	399	11	421	1	0.8	0.5
	Average	8.0	0.1	0.4	412.0	12.3	431.7	4.6	0.9	0.5
Relakunta (T2)	0–30	6.5	0.5	0.8	999	31	594	75	3.6	0.6
	30–60	6.8	0.2	0.5	596	22	518	16	8.1	0.5
	60–90	6.4	0.2	0.4	633	31	524	15	3.9	0.2
	90–120	6.3	0.2	0.4	552	26	453	15	4.9	0.3
	Average	6.5	0.3	0.5	695.0	27.5	522.0	30.1	5.1	0.4
Rudragudum (T3)	0–30	7.2	0.4	0.6	680	22	518	29	2.2	0.7
	30–60	8.7	0.3	0.2	221	3	214	6	0.5	0.8
	60–90	9.0	0.5	0.2	218	1	191	8	1.0	1.2
	90–120	9.0	0.6	0.2	192	2	161	5	1.1	0.3
	Average	8.5	0.4	0.3	327.8	7.0	271.1	11.9	1.2	0.8
Chinnakodepaka (T4)	0–30	8.2	0.2	0.5	531	7	449	49	1.0	0.8
	30–60	8.3	0.2	0.5	528	6	506	6	0.9	0.5
	60–90	8.2	0.3	0.5	588	6	524	7	1.0	0.2
	90–120	8.0	0.2	0.5	485	6	507	11	1.5	0.4
	Average	8.2	0.2	0.5	533.0	6.3	496.3	18.4	1.1	0.5
Gorikothpally (T5)	0–30	8.6	0.2	0.6	549	16	426	17	6.0	0.5
	30–60	7.7	0.2	0.6	537	10	373	14	5.7	0.4
	60–90	7.5	0.2	0.6	545	12	381	15	5.4	0.6
	90–120	7.3	0.2	0.5	432	13	405	16	5.2	0.5
	Average	7.8	0.2	0.6	515.8	12.8	395.9	15.4	5.6	0.5
Gangrirenigudum (T6)	0–30	8.3	0.4	0.7	719	19	533	15	0.9	0.7
	30–60	8.3	0.4	0.6	552	19	517	14	1.0	0.8
	60–90	8.3	0.3	0.5	450	15	457	37	1.1	0.7
	90–120	8.2	0.3	0.4	386	13	378	22	0.8	0.5
	Average	8.3	0.3	0.5	526.8	16.5	470.9	21.7	0.9	0.7

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Nizampally (T7)	0–30	7.5	0.1	0.6	498	6	343	6	2.3	0.0
	30–60	7.7	0.1	0.5	408	5	285	8	2.3	0.5
	60–90	8.0	0.1	0.5	380	4	266	5	2.1	0.5
	90–120	8.1	0.2	0.5	353	4	263	8	2.1	0.5
	Average	7.8	0.1	0.5	409.8	4.8	289.2	6.7	2.2	0.4
Pathipaka (T8)	0–30	8.0	0.4	0.4	488	11	519	36	0.7	0.5
	30–60	8.1	0.4	0.4	389	9	429	41	0.6	0.5
	60–90	8.0	0.4	0.4	410	7	424	52	0.5	0.4
	90–120	8.0	0.4	0.4	345	6	356	23	1.5	0.5
	Average	8.0	0.7	1.5	408.0	8.3	432.2	37.9	0.8	0.5
Dammanapeta (T9)	0–30	7.4	0.2	0.4	542	36	459	14	1.4	0.8
	30–60	7.4	0.2	0.5	536	29	453	14	3.3	0.6
	60–90	7.3	0.2	0.4	471	26	432	8	1.0	0.3
	90–120	7.4	0.2	0.4	473	26	441	10	0.8	0.5
	Average	7.4	0.2	0.4	505.5	29.3	445.9	11.2	1.6	0.5
Rayaparthi (T10)	0–30	7.5	0.2	0.4	462	25	409	12	0.7	0.4
	30–60	7.9	0.2	0.4	399	29	416	26	0.7	0.4
	60–90	7.9	0.1	0.3	371	38	409	5	0.7	0.4
	90–120	7.7	0.2	0.4	405	49	486	10	0.8	0.3
	Average	7.8	0.2	0.4	409.3	35.3	430.2	13.2	0.7	0.4
Repaka (T11)	0–30	8.0	0.3	0.5	566	13	513	12	0.8	0.6
	30–60	7.9	0.3	0.5	522	13	538	15	1.0	0.6
	60–90	7.9	0.2	0.5	530	12	519	12	0.9	0.5
	90–120	7.8	0.3	0.5	549	12	549	16	0.9	0.6
	Average	7.9	0.2	0.5	541.8	12.5	529.7	13.8	0.9	0.6
Munchupla (T12)	0–30	7.0	0.4	1.5	1335	19	545	75	2.5	1.0
	30–60	7.2	0.2	0.8	914	14	483	9	1.6	0.4
	60–90	6.9	0.1	0.4	407	14	343	8	1.6	0.3
	90–120	6.9	0.1	0.3	335	7	277	4	1.5	0.4
	Average	7.0	0.2	0.8	747.8	13.5	411.9	24.0	1.8	0.5

Table 4. Textural variation (%) in tank silt at different depths.

Tank number & village name	Coarse sand	Fine sand	Silt	Clay
		Depth (0–30 cm)		
T1 - Koppula	1.59	10.85	14.82	72.74
T2 - Relakunta	0.35	8.36	15.88	75.41
T3 - Rudragudem	7.15	12.16	20.82	59.87
T4 - Chinnakodepaka	0.13	1.47	20.22	78.18
T5 - Gorikothpally	2.34	5.85	19.96	71.85
T6 - Gangrirenigudum	2.09	5.54	16.07	76.30
T7 - Nizampally	2.49	2.36	21.75	73.40
T8 - Pathipaka	8.09	7.81	14.92	69.18
T9 - Dammanapeta	1.92	4.42	18.73	74.93
T10 - Rayaparthy	1.34	6.27	19.02	73.37
T11 - Repaka	0.24	2.47	15.07	82.22
T12 - Munchupla	1.18	2.48	18.73	77.61
Average	2.41	5.84	18.00	73.76
		Depth (30–60 cm)		
T1 - Koppula	3.20	7.46	14.89	74.45
T2 - Relakunta	0.56	9.16	17.26	73.02
T3 - Rudragudem	15.65	33.02	17.97	33.36
T4 - Chinnakodepaka	0.17	0.69	16.07	83.07
T5 - Gorikothpally	0.48	2.32	25.30	71.90
T6 - Gangrirenigudum	3.41	6.22	22.59	67.78
T7 - Nizampally	6.30	5.14	21.47	67.09
T8 - Pathipaka	0.32	1.28	19.13	79.27
T9 - Dammanapeta	1.15	3.78	20.09	74.98
T10- Rayaparthy	1.25	3.38	21.80	73.57
T11 - Repaka	0.17	3.28	14.96	81.59
T12 - Munchupla	0.90	6.34	17.48	75.28
Average	2.80	6.84	19.08	71.28
		Depth (60–90 cm)		
T1 – Koppula	2.02	0.07	22.80	75.11
T2 – Relakunta	3.50	9.38	18.48	68.64
T3 – Rudragudem	11.92	31.52	21.85	34.71
T4 – Chinnakodepaka	0.12	2.66	16.20	81.02
T5 – Gorikothpally	0.15	4.94	24.06	70.85
T6 - Gangrirenigudum	4.22	6.98	19.88	68.92
T7 - Nizampally	4.21	7.10	18.81	69.88
T8 - Pathipaka	0.27	3.08	16.57	80.08
T9 - Dammanapeta	1.57	0.66	22.77	75.00

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Table 4. Textural variation (%) in tank silt at different depths.

Tank number & village name	Coarse sand	Fine sand	Silt	Clay
T10 - Rayaparthy	3.76	7.23	17.80	71.21
T11 - Repaka	0.32	2.68	15.03	81.97
T12 - Munchupla	6.44	16.93	18.50	58.13
Average	3.21	7.77	19.40	69.63
		Depth (90–120 cm)		
T1 - Koppula	8.05	5.70	16.17	70.08
T2 - Relakunta	3.50	10.45	17.21	68.84
T3 - Rudragudem	15.95	38.01	12.79	33.25
T4 - Chinnakodepaka	2.11	0.85	16.17	80.87
T5 - Gorikothpally	0.22	5.69	21.51	72.58
T6 - Gangrirenigudum	7.49	11.16	20.00	61.35
T7 - Nizampally	5.00	9.50	21.37	64.13
T8 - Pathipaka	0.22	5.83	13.82	80.13
T9 - Dammanapeta	3.81	7.58	18.80	69.81
T10 - Rayaparthi	9.33	5.40	17.60	67.67
T11 - Repaka	0.36	2.73	15.01	81.90
T12 - Munchupla	4.69	21.07	15.91	58.33
Average	5.06	10.33	17.20	67.41

3.3 Biological Properties

Microbial population (bacteria, fungi and actinomycetes) was found to be low due to crops like cotton and chilli in the catchment consuming large amount of pesticides. The bacterial population of tanks in Medak varied from 200 x 10^3 CFU g^{-1} to 300 x 10^3 CFU g^{-1} (Padmaja et al. 2003) when compared to low counts of 0.2 x 10^3 CFU g^{-1} and high counts of 92 x 10^3 CFU g^{-1} for tanks in Warangal district (Fig. 1). Microbial biomass C ranged from 204 to 383 µg C g^{-1} soil, while the microbial biomass N ranged from 19 to 31 µg M g^{-1} soil.

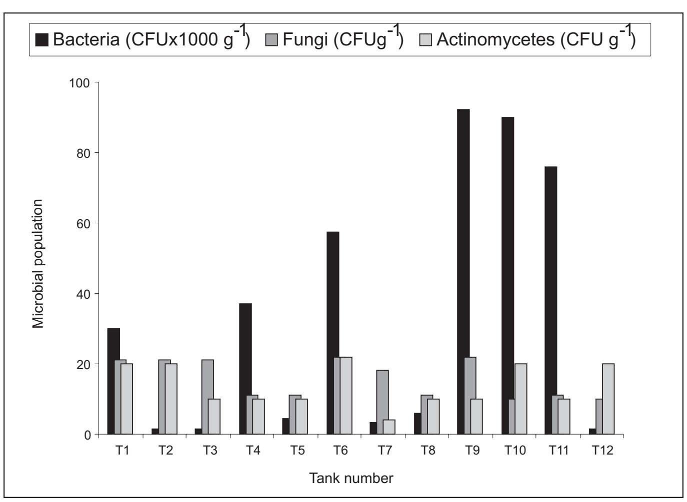

Figure. 1 Microbial population of different tanks

4.0 Impact on Soil

The clay content of the tank silt ranged from 60 to 80%, while its application to the field reduced the bulk density of the soil from 1.5 to 1.25 g cc^{-1}. Addition of tank silt at the rate of 50, 100, 150 and 375 tractor loads per hectare improved the available water content by 0.002, 0.007, 0.012 and 0.032 g g^{-1} soil, respectively. All the farmers were in agreement that the moisture retention had gone up by 4 to 7 days, which plays an important role during the period of prolonged dry spells. This was confirmed through gravimetric studies that the available water content in the root zone increased by one per cent, i.e., from a normal 6% to 7% with addition of 100 tractor loads per hectare. Farmers believe that once applied, the impact on crop yield will remain for three years, but the invisible aspect is the permanent change in physical and chemical properties of soil. A change in the clay percent was noticed from 20 to 40 in the root zone, while there was no change in the silt content. A decrease in coarse sand and fine sand was noticed. No change in pH, EC and organic carbon was noticed, while an appreciable change was observed in available N, P and K and moderate reduction in sulphur. Improvement in clay content will not only retain higher moisture but will also reduce the losses of nutrients through leaching because of improved cation exchange capacity (CEC).

5.0 Impact on Crop Growth and Yield

In an observation made on plant population and growth of *rabi* maize 45 days after sowing (DAS), indicated that not only silt-received-plot had higher plant population but also higher plant height (Table 5). Most of the farmers interviewed reported savings on fertilizers ranging from Rs. 2500 to Rs. 3750 per hectare in case of cotton, which is a major crop grown in this area. The increase in the yield of cotton was to the tune of 1000 kg ha^{-1}. Farmers could achieve this kind of response with the application of 100 tractor loads per ha. Farmers paid Rs. 50-60 for each trip of tractor depending upon the distance plus Rs. 10 towards contribution. A farmer for 100 tractor loads paid Rs. 6000 towards transport and contribution while the project borne the rest of Rs. 6000. The maximum benefit was obtained in chillies and cotton and the gain was negligible in turmeric and no gain was observed for maize (Fig. 2). A detailed cost of cultivation with and without application of silt for different crops is set out in Annex-I. An additional environmental benefit was obtained through less use of pesticides through application of tank silt. Farmers reported less number of sprays in various crops that received tank silt (Fig. 3). The number of sprays reduced by two compared to the normal, which resulted in saving of Rs. 2500 ha^{-1} in cotton, chilli and turmeric, respectively while Rs. 1750 ha^{-1} in maize.

Table 5. Plant population and plant height of maize as influenced by application of tank sediment in Nizampally, Warangal district.

Tank sediment	Plant population (m^2)	Plant height (cm)
With	9.6	38.0
Without	7.4	26.0

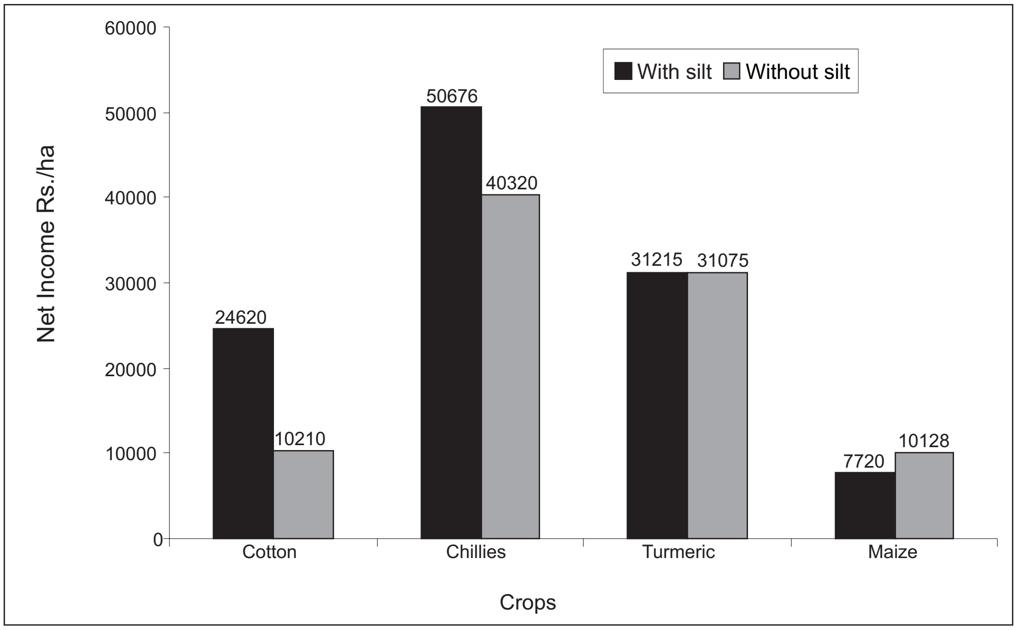

Figure. 2. Net income with and without application of tank silt obtained for various crops by farmers in Warangal district of Andhra Pradesh.

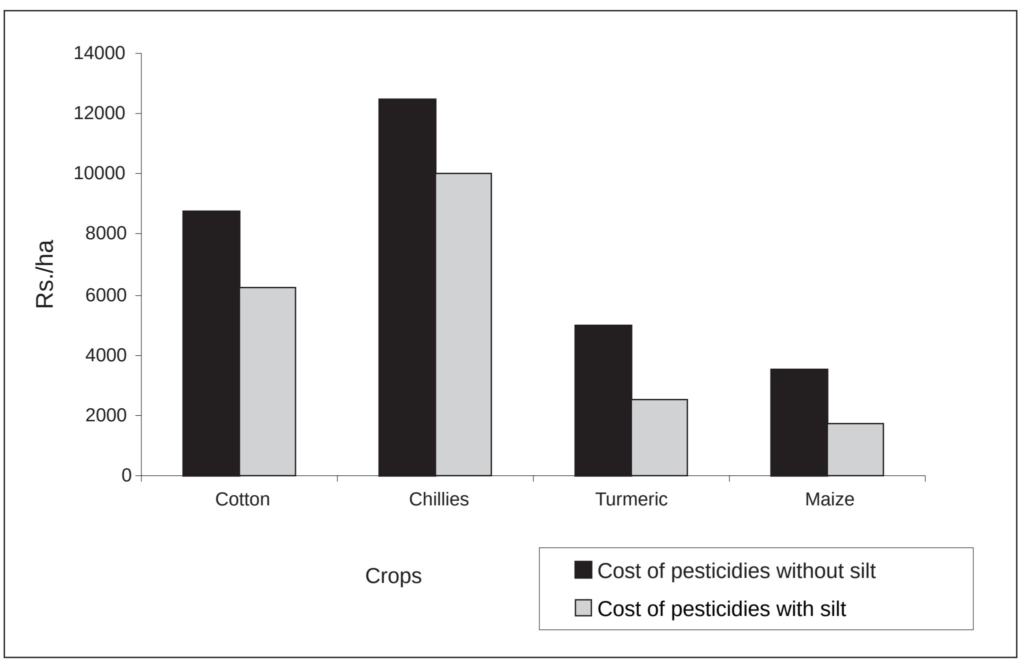

Figure. 3. Savings on pesticides with application of tank silt in various crops.

6.0 Economic Evaluation

The economic feasibility of the removal of silt was estimated. The quantity of silt removed from different tanks amounted to 76393 tons. The total cost incurred in the removal of silt amounted to Rs. 11,33,190. The value of silt was quantified in terms of fertilizer equivalent costs for different nutrients. The nutrients retrieved from silt were considered to be beneficial as against the expenditure (cost) incurred in removing the silt from the tanks. The value for various nutrients is presented in Table 6. Additionally, the process of silt application to farm lands that is rich in organic C resulted in C mineralisation and higher nutrient availability, thereby helping plant growth and greater fixation of C through photosynthesis.

The benefit-cost ratio was found to be highly variable and ranged from 0.44 to 1.11, which is lower than the B:C ratio reported earlier for tank de-silting in Medak district (Padmaja et al. 2008). Average benefit-cost ratio of 0.72 is not reflecting the true picture as physical and other ecosystem benefits are not accounted. It is worth noting that fertilizers are supplied at 50% of the production cost and the government meets the rest as subsidy. If subsidy is accounted, the average B:C ratio will become 1.44 and recycling of silt back to the farm lands will become highly economical proposition. Indirect benefits are many and difficult to account in rupee terms. Application of the silt back to the agricultural fields forms an improved agricultural management practice that enhances and protects the soil quality, resulting in improved production capacity of the soil and reverses the process of land degradation. The impacts of recycling will be long lasting and need to be studied for longer period.

Table 6. Economic valuation of tank sediment in terms of plant nutrients returned to farm and benefit-cost analysis of de-silting operation.

Name of village and tank	Quantity of sediment (tons)	Amount spent (Rs.)	Nutrients in terms of Rupee equivalent						B:C ratio
			N	P	K	Zinc	Boron	Total	
Koppula	4478	59700	20903	2712	17932	480	802	42828	0.72
Relakunta	7034	93780	55388	9524	34059	4269	1007	104247	1.11
Rudragudem	14184	189120	52679	4888	35669	2025	4062	99323	0.53
Chinnakodepaka	7853	104700	47423	2436	36153	1028	1406	88446	0.84
Gorikothpally	11356	151410	66365	7157	41703	7568	2033	124826	0.82
Gangrirenigudum	1355	18060	8087	1101	5919	145	340	15592	0.86
Nizampally	7538	100500	34999	1781	20222	1973	1079	60054	0.60
Pathipaka	4084	54450	18879	1669	16377	389	731	38044	0.70
Dammanapeta	2100	50400	12027	3029	8686	400	376	24518	0.49
Rayaparthy	3713	89100	17219	6453	14817	309	532	39330	0.44
Repaka	4938	118500	30312	3039	24263	529	1061	59204	0.50
Munchupla	7760	103470	65747	5158	29649	1662	1389	103605	1.00
Average									**0.72**

Estimation of silt requirement based on silt quality and crop need

A simple formula has been devised to meet the crop nutrient requirement in terms of nitrogen equivalent. In general, tractors are used for transport of tank silt, therefore, estimation need to be made in terms number of tractor loads required to meet the need of a particular crop. The impact will be there on the successive crops too. An example of cotton is given below which has a recommended dose of 120 kg N ha^{-1}. About 117 tractor loads are needed to meet N requirement of cotton using Koppula tank silt, having 0.0412% available N. Any increase in N content of tank silt will reduce the number of tractor loads needed per unit area. Therefore, preference may be given for de-silting of tanks having high fertility.

$$N = \frac{X}{25Y}$$

N = Number of tractor loads required for one hectare area

X = Nutrient required by the crop (kg ha^{-1})

Y = Nutrient content of tank silt in %

$$N = \frac{120}{25 \times 0.0412} = 117$$

7.0 Policy Implications

The past experiences of de-silting in Medak and Warangal indicate the presence of all the valuable nutrients required for plant growth in adequate quantities. Recycling of tank silt will overcome the deficiency of nutrients observed in many soils, particularly that of zinc, boron and sulphur and will also improve organic carbon content of soil, resulting in improved soil physical properties. The following interventions should be planned and implemented in view of economic viability, social acceptability and eco-friendliness of tank de-silting.

- Tank silt to be considered as a substitute for the fertilizer and a part of subsidy given to fertilizers need to be diverted for tank de-silting and recycling of nutrients to farm lands. Fertilizers provide one or two nutrients, while silt provides all the nutrients in adequate quantities and also improves soil health and water-holding capacity essential for drought-proofing in rain-fed areas.
- De-silting operations of the existing tanks could be included in the National Food for Work Programme, which creates employment as well as restores the asset for harvesting rainwater.
- Provide soft credit line to farmer to apply tank silt to the fields and credit support to various government programs/*panchayats* for undertaking de-silting operation.

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Annexure – I

Cost of cultivation as influenced by application of tank silt

Cotton

Cost of inputs, yield and income	With silt	Without silt
Cost of silt (100 tractor loads ha^{-1})	12000	-
Cost of FYM (25 cart loads ha^{-1})	-	2500
Cost of DAP	3637	6062
Cost of urea	1912	3187
Cost of potash	580	290
Cost of pesticides	6250	8750
Cost of inputs	24380	20790
Cost of cultivation, seed, seeding, harvest and other miscellaneous	5000	5000
Total cost (Rs.)	**29380**	**25790**
No. of bolls per plant	80	60
Yield (kg ha^{-1})	3000	2000
Gross income (Rs. ha^{-1})	54000	36000
Net income (Rs. ha^{-1})	24620	10210

Note: Varieties: RCH-2, Bollguard, Price: Rs. 18.0 kg^{-1}

Cost of urea Rs. 255 per 50 kg, DAP Rs. 485 per 50 kg, MoP Rs. 232 per 50 kg

Chillies

Cost of inputs, yield and income	With silt	Without silt
Cost of silt (100 tractor loads ha^{-1})	12000	-
Cost of FYM (25 cart loads ha^{-1})	250	750
Cost of DAP	606	1212
Cost of urea	637	637
Cost of potash	580	580
Cost of plant protection (No. of sprays)	10000	12500
Cost of inputs	24074	15680
Cost of cultivation, seed, seeding, harvest and other miscellaneous	4000	4000
Total cost (Rs.)	**28074**	**19680**
No. of fruits per plant	100	75
Yield (kg ha^{-1})	3500	3000
Gross income (Rs.ha^{-1})	78750	60000
Net income (Rs. ha^{-1})	50676	40320

Note: Varieties grown: *Kaveri, Tulasi*

Cost of urea Rs. 255 per 50 kg, DAP Rs. 485 per 50 kg, MoP Rs. 232 per 50 kg

Turmeric

Cost of inputs, yield and income	With silt	Without silt
Cost of silt (100 tractor loads ha^{-1})	12000	--
Cost of FYM	--	2500
Cost of DAP	1212	2425
Cost of urea	1912	2550
Cost of potash	1160	1450
Cost of plant protection (No. of sprays)	2500	5000
Cost of inputs	18785	13925
Cost of cultivation, seed, seeding, harvest and other miscellaneous	5000	5000
Total cost (Rs.)	**23785**	**18925**
Yield (kg ha^{-1})	2750	2500
Gross income (Rs. ha^{-1})	55000	50000
Net income (Rs. ha^{-1})	31215	31075

Note: Price: Rs. 20.0 kg^{-1}

Cost of urea Rs. 255 per 50 kg, DAP Rs. 485 per 50 kg, MoP Rs. 232 per 50 kg

Maize

Inputs, yield and income	With silt	Without silt
Cost of silt (100 tractor loads ha^{-1})	12000	-
Cost of FYM	-	500
Cost of DAP	1213	1213
Cost of urea	1912	2550
Cost of potash	580	1160
Cost of plant protection (No. of sprays)	1750	3500
Cost of inputs	17455	8923
Cost of cultivation, seed, seeding, harvest and other miscellaneous	3000	3000
Total cost (Rs.)	**20455**	**11923**
No. of crops/plant	1–2	1
Yield (kg ha^{-1})	5750	4500
Gross income (Rs. ha^{-1})	28175	22050
Net income (Rs. ha^{-1})	7720	10128

Note: Varieties grown: Bioseed, Kargil, Monsanto double, Price Rs. 4.90 kg^{-1}

Cost of urea Rs. 255 per 50 kg, DAP Rs. 485 per 50 kg, MoP Rs. 232 per 50 kg

About ICRISAT

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The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT is supported by the Consultative Group on International Agricultural Research (CGIAR).

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