Global Theme 3: Water, Soil and Agrodiversity Management for Ecosystem Resilience

Report no. 4

Economic assessment of desilted sediment in terms of plant nutrients equivalent: A case study in the Medak district of Andhra Pradesh

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Abstract

Water harvesting, storage and reutilization for crop production is an important component of research for sustainable agricultural development in the dry regions. Traditionally in southern India, water storage tanks are an integral part of villages and the water is used for recharging groundwater and irrigating fields. Over the years, the storage capacity of tanks gets reduced due to sediment deposits from erosion and runoff processes. During 2001, the Government of Andhra Pradesh undertook the 'Neeru-Meeru' (Water and You) initiative in Medak district, for desiltation of tanks during the dry season. We assessed the viability of desilting operations and economic value of potential utilization of sediments desilted from tanks for its nutrient value. The sediment samples collected from 21 tanks spread out in 11 mandals of the Medak district were analyzed for their plant nutrient content and microbiological properties. On an average, the sediment samples contained 720 mg nitrogen (N) and 320 mg phosphorus (P) per kg of sediment. The organic carbon (C) content of sediment varied from 5.3 g kg^{-1} to 27.2 g kg^{-1}, with a mean value of 10.7 g C kg^{-1} of sediment. The application of 48,777 tons of sediments to agricultural lands returned 520 tons of C to fields, thereby enhancing the nutrient availability for crop production. The microbiological assays indicated that the sediment samples had higher counts of bacteria (20-30 $\times$ 10^4 colony forming units [CFU] g^{-1} of sediment) and actinomycetes followed by fungi. The benefit-cost (B/C) ratio of desilting operation and its utilization as plant nutrient source of N and P varied from 0.62 to 3.44 with an average ratio of 1.17. This suggests economic feasibility for the application of tank sediment to agricultural fields for crop production in addition to increased water storage capacity, groundwater recharge and availability of more irrigation water. The data obtained from 21 tanks was used for extrapolating results to the entire district in which a total of 78 tanks were desilted. The approach used for extrapolation utilized the N and P composition of sediments from the nearest available sediment value to compute for rest of the tanks in the district. The overall mean N, P and organic C content in the sediments was calculated to be 730 mg kg^{-1} sediment, 357 mg kg^{-1} sediment and 11.64 g C kg^{-1} sediment respectively. In the district, a total of 246831 tons of sediments from 78 tanks were desilted and addition of these sediments back to farms would return 183 tons of N, 86 tons of P and 2873 tons of organic carbon. On an average, the B/C ratio for desilting operations from water tanks based on the economic plant nutrient value (N and P content) of the district was calculated to be 1.23 which reflects a positive benefit for the cost incurred in the 'Neeru-Meeru' program.

Keywords: Desilted tank sediments, nitrogen and phosphorus, organic carbon, nutrients, microorganisms, microbiological properties, benefit-cost ratio, economic analysis.

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Contents

Executive Summary

In southern India, water tanks are an integral part of village settlements. These tanks take care of villagers' needs of water for domestic and agricultural purposes. Over the years, with sediment deposition the water storage capacity of these tanks has been considerably reduced. During 2001, the Government of Andhra Pradesh initiated 'Neeru-Meeru' (Water and You) program under the Water Conservation Mission. Under the program, desilting of over thousand village tanks in various districts was undertaken. In one such exercise, a study was taken up in Medak district to assess the economic feasibility of such a massive scale desilting operation and the quality of the sediment material which was used for adding to the fields.

The study showed that the tank sediment contained 30% to 71% silt and clay. The organic carbon (C) content varied from 5.4 g C kg^{-1} to 27.2 g C kg^{-1} suggesting large variation in the eroded material. The nitrogen (N) and phosphorus (P) content of the sediment samples varied from tank to tank and also with the depth of sampling indicating the variation in the management practices not only in different catchments but also over the time in a given catchment. The N content in the sediment samples varied from 340 mg N kg^{-1} to 1760 mg N kg^{-1} sediment with an average N content of 719 mg N kg^{-1} sediment. This value is almost double of the soil N content in the nearby fields. Similarly, the P content, microbial counts, organic C and microbial biomass C of the sediment varied across the tanks.

Based on the economic value of N and P plant nutrients returned to the fields, the average benefit-cost (B/C) ratio of desilting works was calculated to be 1.17. This is in addition to other primary benefits such as increased rainwater storage, groundwater recharge, water availability, restoration of biological activity and return of high value organic C to fields for improving crop productivity. Addition of sediments back to the agricultural lands not only returns back the nutrient-rich fine fractions with high C values but also restores the soil microbial biodiversity in the system.

The data obtained from 21 tanks was used for extrapolating results to the entire district in which a total of 78 tanks were desilted in the 'Neeru-Meeru' initiative. The approach used for extrapolation utilised the N and P composition of sediments from the nearest available sediment value. An average value of sediment analysis from 2 to 3 nearest tanks was used to compute for other tanks in the district. The overall mean N, P and organic C content in the sediments was calculated to be 730 mg kg^{-1} sediment, 357 mg kg^{-1} sediment and 11.64 g C kg^{-1} sediment respectively. In the district, a total of 246831 tons of sediments from 78 tanks were desilted and addition of these sediments back to farms would return 183 tons of N, 86 tons of P and 2873 tons of organic carbon. On an average, the B/C ratio for the desilting operations from water tanks based on the economic plant nutrient value (N and P content) of the district was calculated to be 1.23 which reflects a positive benefit for the cost incurred in the 'Neeru-Meeru' program.

Application of sediment desilted from the water tanks to agricultural fields appears to be a economically viable option for returning N, P nutrients along with organic C back to the soil. The methodology used for extrapolation could be upscaled and used for computing sediment yield, nutrient content and their economic value. Scientific studies along these lines provide an insight for land managers and policy makers to evaluate the existing management strategies and take appropriate decisions.

Introduction

Soil, water and vegetation are basic resources of life. With an increase in population, these land-based resources are being exploited with inappropriate technologies. There has been an increase in activities that are not consistent with sustainable development. Therefore, this has led to problems like soil erosion, excessive water runoff, loss of plant nutrients, water scarcity and downstream flooding. These in turn have led to decline in crop yields and food security.

Sustainable agricultural productivity depends on soil and water, which are the most important natural resources. Water is a limiting natural resource in the semi-arid tropics (SAT), which is characterized by low and erratic rainfall patterns. Rainfall occurs as torrential downpours and is highly erratic in the dry ecoregions. Soil erosion is common during the heavy downpour. As 70 per cent of agriculture is rainfed in dry areas, conservation of rainwater is essential to meet the growing demand for food, feed and fiber on a sustainable basis.

Runoff occurs in situations where the intensity of rainfall exceeds the infiltration rate which leads to surface flow and ponding of water. This problem is common in Vertisols and other soils with high clay content. Runoff can also take place when the intensity of rainfall exceeds the percolation rate and when soil surface is saturated with water. Runoff from the agricultural lands leaves the land unproductive and promotes land degradation.

Modern agricultural practices depend on commercial fertilisers to supply plant nutrients. Non-point source pollution of surface and groundwater has been linked to agricultural practices. During surveys, the inputs used in farming have been detected in both surface and ground waters. With an environmental dimension added to sustainable productivity in the semi-arid ecoregions, assessing the quality of runoff is of high priority because runoff water can cause chemical pollution. This is further burgeoned with sedimentation, which causes interference with drainage, land use, irrigation and decreases the water storage capacity of tanks.

With conventional assessments of soil loss measurements, it is hard to link soil losses with yield decline. The use of qualitative studies of the lost soil, which gets deposited as sediments in the tanks, may be another approach for this purpose. The approach to soil loss and its impact on productivity is different for agronomists and hydrologists. Analysis and interpretation of results from such studies in isolation does not provide plausible solutions to the problems of sustainability. An environmental approach with integration of different processes in the ecosystem needs to be studied. Qualitative assessment followed by quantification of parameters together help to understand the effects of land use on its degradation.

Runoff water carries along nutrients and fine organic matter particulates from agricultural lands. Often the sources and pathways of nutrients moved by sediments in the runoff are difficult to fully identify. For rainfed farming system there is a need to capture significant amount of rainwater, which is generally lost as runoff and deep drainage. This stored water can be used for supplemental irrigation, increasing crop productivity and resource-use efficiency. However, deposition of sediment in tanks reduces its capacity and also hampers the additional water storage in the rainfed areas. Hence, removal of sediments from tanks is a relevant approach for rainfed farming systems.

Background

The Andhra Pradesh government's Water Conservation Mission during 2001 adopted an approach to bring together watershed experts, policy makers and various government departments associated with water conservation. Following the meet, the government officials with technical backstopping from ICRISAT scientists selected Medak district in Andhra Pradesh, India, on a pilot basis.

The water conservation mission's 'Neeru-Meeru' (Water and You) program took up desilting of village tanks during the dry season for increasing water storage capacity. In the process, the tanks were cleared off the sediment deposited and large amounts of desilted materials were available for farm use. Under this program, the Andhra Pradesh government provided mechanical diggers to the villages for removal of sediment. Farmers transported the sediment to their fields on their own, bearing the transportation and labour cost for application. The sequence of events during the desilting operation and application of tank sediment are shown in figures 1, 2, 3, 4 and 5. There is enough information on effect of sediment application on crop yields and improved soil properties. However, economic valuation of such a massive scale of desilting operation is not available. In order to assess the economic feasibility of desilting operation under 'Neeru Meeru' program, this study was taken up with the following objectives.

Objectives

The overall goal of the present study was to assess the economic feasibility of desilting operation by quantifying the amount of plant nutrients returned to agricultural fields through sediment application. The specific objectives were:

- To quantify the amounts of nitrogen (N), phosphorus (P) and organic carbon (C) returned to agricultural fields and economic valuation of sediment in terms of cost of N and P nutrients
- To assess the differences in quality and terms of physical, chemical and biological parameters of sediment from different water storage tanks in Medak district of Andhra Pradesh.

Fig 1. ***Desilting work at Reddykunta tank, Wargal mandal, Medak district.***

Fig 2. ***Manual removal of sediments by farmers in Lakdaram village, Patancheru mandal, Medak district.***

Fig 3. ***Transportation of sediment by farmers in Kotha Kunta tank, Raikode mandal, Medak district.***

Fig 4. ***Desilting work by digger at Peddacheruvu tank, Narsapur mandal, Medak district.***

Fig 5. ***Application and spreading of tank sediment in the field by a farmer.***

Methodology

Medak district located at longitude 78.25^0 E and latitude 17.75^0 N at 500 m MSL in Andhra Pradesh, India, was selected for the study. The soils in Medak district are mostly sandy and gravely shallow type of red soils (Alfisols), while black soils (Vertisols and associated soils) are found in small patches in depression areas of the district. Dominant soil types are sandy loam and clay loam in the 11 mandals of Medak district under study (Table 1). A district scale effort began where sediment samples were collected during March 2001-May 2001 from 21 tanks spread out in 11 mandals in the district (Fig 6). Seventy-seven sediment samples up to 90-cm depth in these tanks were collected. The details of the tanks and their location are given in Table 1. These sediment samples were air-dried and processed at the ICRISAT, Patancheru for analysis. The samples were analyzed for physico-chemical and biological properties by following the standard methods (Table 2).

Apparent benefit-cost ratio: The valuation of nitrogen in the sediment is based on the cost of urea fertilizer and fertilizer equivalent value of phosphorus is based on the cost of diammonium phosphate (DAP) fertilizer at the existing rates. The benefit-cost ratio calculated is the apparent value and indicates only cost of desilting operation and value of silt as source of N and P nutrients.

Table 1. Location of water tanks, rainfall and distribution of soil types in Medak district.

Tank No.	Mandal	Village	Name of the Tank	Annual rainfall (mm) during 2001	Soil type
1	Sangareddy	Goudicherla	Kudi Cheruvu	752	Sandy loam
2	Sangareddy	Yeranoor	Edula Kunta	752	Sandy loam
3	Kondapur	Merepally	Kotha Kunta	650	Clay loam
4	Sadasivapet	Atmakur	Rahul Cheruvu	639	Clay loam
5	Sadasivapet	Veltoor	Pedda Cheruvu	639	Clay loam
6	Sadasivapet	Enekepally	Kotha Cheruvu	639	Clay loam
7	Alladurg	Muslapur	Nadayani Kunta	683	Clay loam
8	Alladurg	Marvelly	Regode Cheruvu	683	Clay loam
9	Alladurg	Chilver	Komantlavani Kunta	683	Clay loam
10	Alladurg	G.Peddapur	Gollai Kunta	683	Clay loam
11	Andole	Masaipally	Govram Cheruvu	816	Sandy loam
12	Kalher	Krishnapur	Krishnapur Tank	782	Sandy loam
13	Kulcharam	Pothereddypally	Chandra Kunta	465	Sandy loam
14	Kulcharam	Yenigandla	Damara Cheruvu	465	Sandy loam
15	Narsapur	Lingapur	Komati Kunta	794	Sandy loam
16	Narsapur	Chipal thruthy	Pathi Kunta	794	Sandy loam
17	Narsapur	Thirmalapur	Damara Cheruvu	794	Sandy loam
18	Yeldurthy	Edulapally	Pedda Cheruvu	567	Sandy loam
19	Shankarampet	Dharpally	Bathkamma Cheruvu	623	Sandy loam
20	Shankarampet	Kaslapur	Chintala Cheruvu	623	Sandy loam
21	Alladurg	G.Peddapur	Thimmana Cheruvu	683	Clay loam

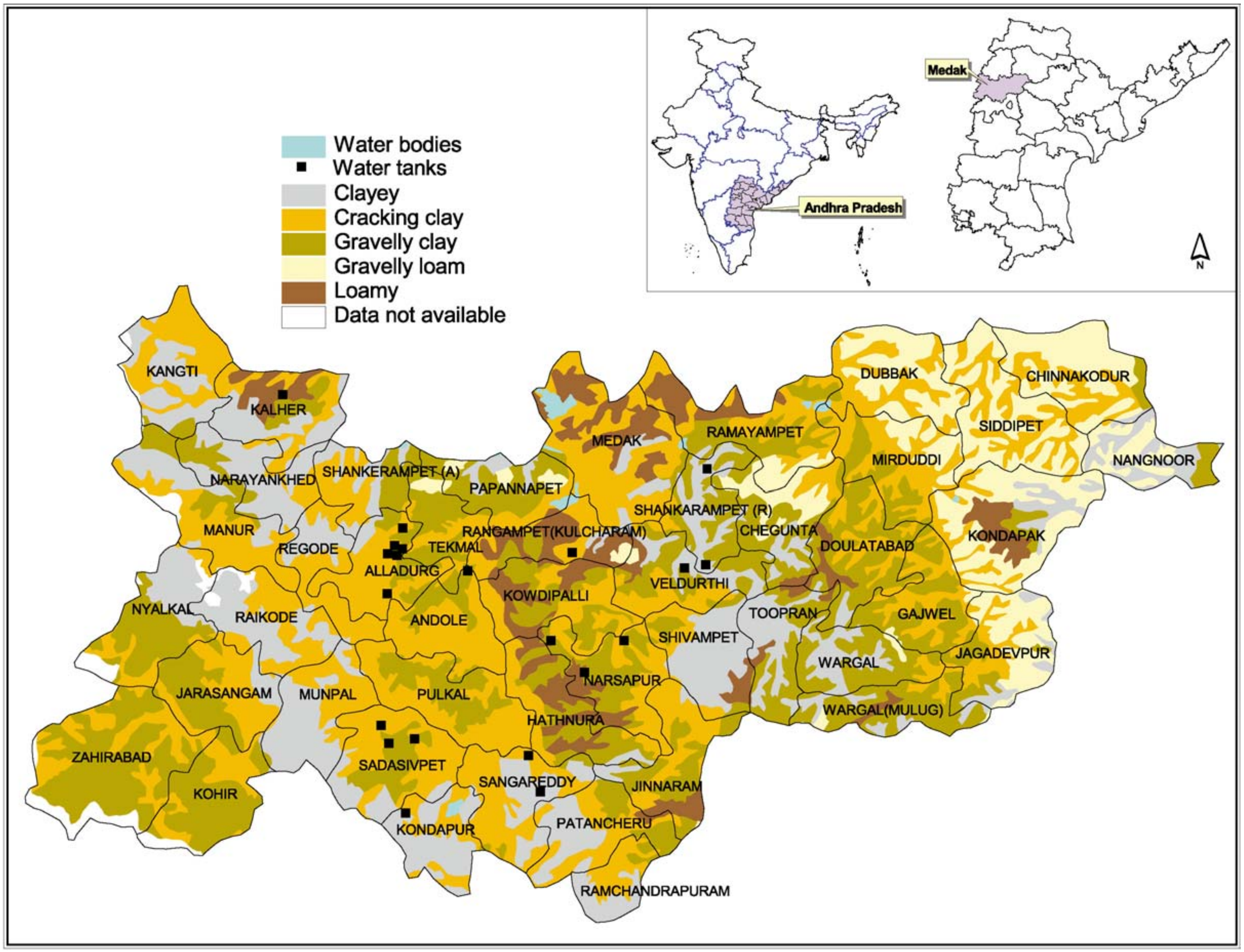

Fig 6. ***Location of different tanks in 11 mandals of Medak district, Andhra Pradesh, India.***

Table 2. Methods of analysis for properties determined on air-dried soil samples passed through 2-mm sieve.

Property	Test	Reference
Total N	Modified Kjeldahl digestion	Dalal *et al.* 1984
Total P	Perchloric acid digestion method	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 C	Dry Combustion Method Primacs^{sc} TOC Analyser, Skalar	Nelson & Sommers, 1982
Microbial population	Serial dilution and Spread plate method 1. Bacteria- Nutrient Agar 2. Fungi – Potato Dextrose Aga 3. Actinomycetes – Nutrient Agar	Zuberer 1994; Parkinson 1994; Wellington & Toth 1994

Rainfall

The average annual rainfall received in the Medak district is 873 mm. However, during 2001 the district received a total rainfall of 679 mm. Highest rainfall of 816 mm (Table 1) was recorded in Andole mandal where Govram Cheruvu is located and lowest rainfall of 465 mm was recorded in Kulcharam mandal where Chandra Kunta tank is located.

Crops grown

Sorghum, maize, pigeonpea, cotton, castor, blackgram, greengram, paddy and sugarcane are the principal crops grown during the rainy season (*Kharif*) in the district. During the postrainy season (*Rabi*), jowar, maize, groundnut, blackgram and greengram are grown on stored soil moisture on Vertisols or with supplemental irrigation.

Fertilizer inputs

The chemical fertilizers commonly used are urea and diammonium phosphate (DAP) for supplying nitrogen and phosphorus nutrients to crops. On an average for agricultural crops, the farmers apply 50 kg N and 60 kg P ha^{-1}. Depending on the availability of farmyard manure (FYM), the farmers apply FYM at a rate of 10 to 12 t ha^{-1} biannually. When FYM is available, the amount of chemical fertilizer application is accordingly reduced and additional amount of N is applied through urea.

Results

Sediment samples from tanks were analyzed for particle size composition, organic carbon, total N, total P and microbial population enumeration following standard methods (Table 2).

Texture of the sediment

Texture analysis of sediment samples provide an estimate on the relative fraction size in the sediment from the surrounding areas where the finer fractions of soil eroded are carried along runoff and deposited in the tanks. This texture analysis indicates the nature of areas from where the sediment originated. In this study, the fine sand in the samples ranged between 12 % and 53 %, while silt and clay amounts ranged between 30 % and 71 %. When the sediment comes from fine-grained soil such as alluvial clay or heavy textured soils, the sediment is mostly in the form of suspension. However, on the other hand when the velocity of the flow of water during runoff is higher the movement of the gravel pebbles and bigger fractions of the soil takes place. The texture analysis revealed that the composition of the sediment deposited in the tanks varied widely within the district reflecting on the soil type, topography, rainfall intensity, crop cover and organic matter content of the soils in the catchment area.

Organic carbon

Tank sediment samples from 0-15 cm depth were studied for the organic carbon levels whose values ranged from 5.4 g C kg^{-1} to 27.2 g C kg^{-1} sediment (Fig 7). Highest organic carbon value of 27.2 g C kg^{-1} sediment was recorded in Tank 3 (Kothakunta Tank of Merepally village, Kondapur mandal). Tank numbers 17, 7, 8 and 5 recorded organic carbon values lower than 6.5 g C kg^{-1} sediment. Lowest organic carbon value of 5.4 g C kg^{-1} sediment was recorded in Tank 17 (Nadayani Kunta Tank of Aldurg mandal).

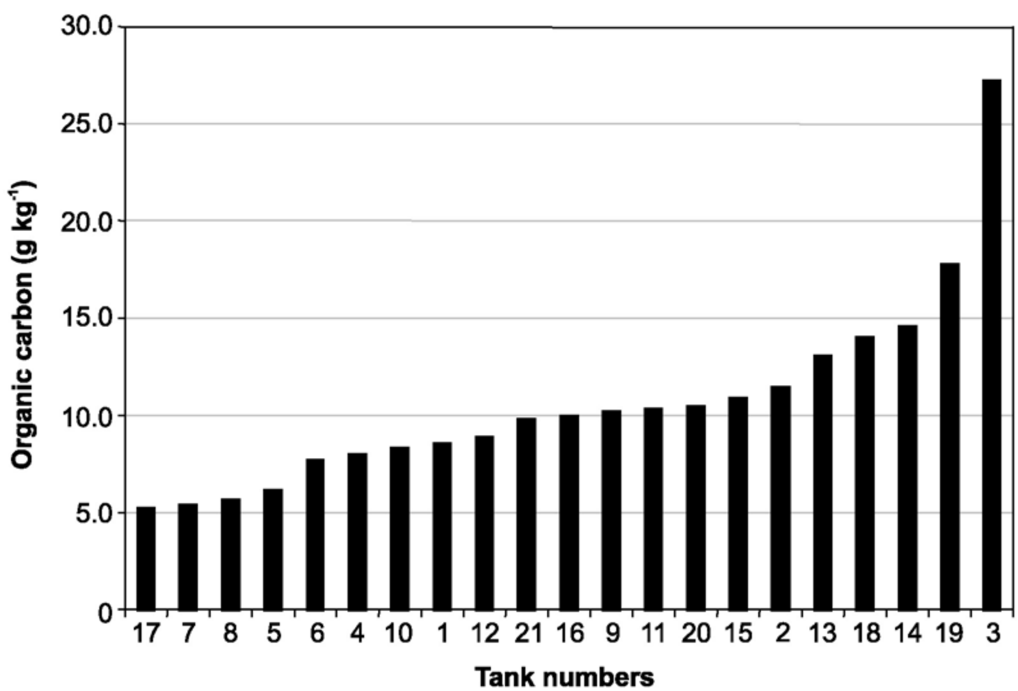

Fig 7. ***Organic carbon in Medak tank sediment.***

The overall mean organic C value for the 21 tank sediment samples studied was 10.7 g C kg^{-1} sediment, indicating that by desilting the tanks and adding the sediment to farms would return 520 tons of organic C. This will be recycled for increasing agricultural productivity through C mineralisation and the release of plant nutrients. The improved plant growth in turn would fix more C through increased photosynthesis resulting in increased productivity of farms and reduced CO_2 concentration in the atmosphere. This large amount of carbon in tank sediment would otherwise have been released to atmosphere, resulting in increased concentration of atmospheric CO_2. Organic C plays an important role in plant nutrition and the application of sediment with higher values would give increased benefits to the agricultural system by improving the soil quality and productivity.

Microbial population

The microbial activity is responsible for nutrient transformations and cycling. Their qualitative and quantitative data indicate the sediment quality. Hence, the tank sediment samples were quantified for fungi, bacteria and actinomycetes population. Surface samples of 0-15 cm of the deposited sediment were taken for the microbial population count estimation. Enumeration of microbial population was done by serial dilution using spread plate technique. Standard methods and media were used for the microbial population counts (Table 2).

Quantification of viable microorganisms in sediment recorded a higher and diversified population of the microflora, indicating qualitative and quantitative differences in the sediment. These results also indicate indirectly the quantified differences in the locations from where the sediment originated. A perusal of the results obtained for microbial population in general revealed that among the microflora, the bacteria were in highest number, followed by actinomycetes and fungi which were lowest in population (Fig 8). The actinomycetes and fungi population recorded as colony forming units (CFU) ($< 5 \times 10^4$ CFU g^{-1}) was similar in all the 21 tank samples under study. However, the bacterial population was found to be quite variable among the different sediment samples. In the agricultural system, a broad range of conditions like soil reaction, temperature, organic carbon levels and nutrient availability influence the microbial communities. The bacterial population on an average varied between 20×10^4 CFU g^{-1} and 30×10^4 CFU g^{-1} of tank sediment. A comparatively low population counts were found in sediment samples from tank 7, 10, 11, 12 and 17. In contrast, a high microbial population was recorded in sediment sample from the Tank 21, which is surrounded by clayey soils. In general, higher microbial counts were recorded from the sediment collected from tanks surrounded by soils with clay texture.

A higher microbial population gives an indirect inference of higher moisture retention capacity in the substrate sediment as well as better nutrient availability. Maximum microbial population is found in region where soils have high moisture retention capacity, which is optimum for the microbial activity. This wide variability in microbial population could be attributed to the nutrient status of tank sediment, farm cropping and soil history which have a direct influence on the quality of the tank sediment. Loss of microbial diversity from fields is one of the important causes of land degradation through erosion. Returning of tank sediments rich in biological counts would help in improving the microbial diversity and biological activity in farm soils thereby improving soil quality and crop production.

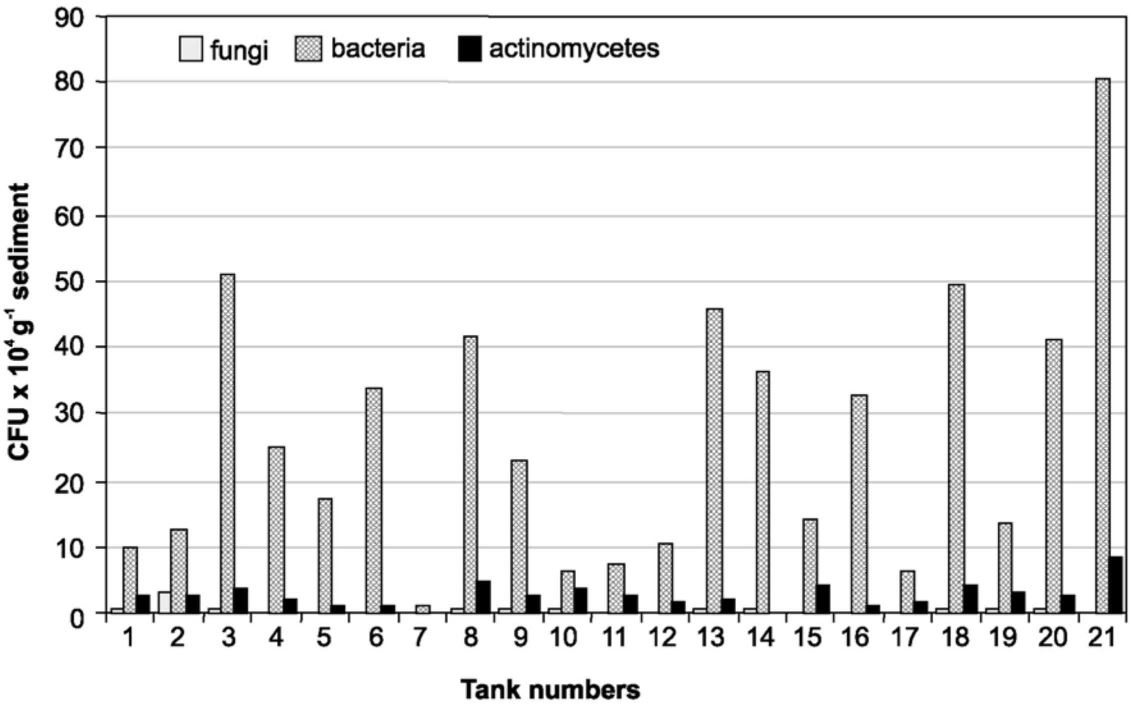

Fig 8. ***Microbial population in the tank sediment.***

Soil Microbial Biomass

Soil microbial biomass is an important component of the soil organic matter that regulates the transformation, cycling and storage of nutrients. Microbial biomass is a part of the organic matter in soil that constitutes living microorganisms smaller than 5-10 μm^3, generally expressed in milligrams of carbon per kilogram soil. Typically, biomass carbon ranges from 1% to 5% of soil organic carbon. The interest in estimating soil microbial biomass is related to its functions as a pool for subsequent delivery of nutrients, role in structure formation, stabilization of soil and an ecological quality indicator. Estimation of microbial biomass helps in monitoring the toxicity of pollutants and degradation of organic entities like pesticides and other agricultural chemicals.

The microbial biomass C in the sediment samples ranged between 140.5 mg C kg^{-1} and 393.1 mg C kg^{-1} of sediment (Fig 9). Samples from tank 12 recorded the highest microbial biomass C (393.1 mg C kg^{-1} of sediment) and microbial population. The sediment samples recorded an average of 273.5 mg of biomass C per kilogram of sediment, indicating a higher quality of the tank sediment. Of the 21 tank samples 33 % recorded less than the mean value (273.5 mg kg^{-1} of sediment). The influence of cropping systems, nutrient availability, soil reaction, and other physico-chemical parameters on microbial activity is reflected in the microbial biomass values. The biomass C as a proportion of organic C varied in tank sediment samples indicating the qualitative content differences in the sediment samples (Table 3). On an average, the proportion of microbial biomass C to organic C was recorded to be 2.89 per cent. The higher proportion values suggest that there will be greater and faster release of plant nutrients from the particular sediment samples.

Table 3. Organic Carbon (OC), microbial biomass Carbon (MBC) and microbial C as proportion of organic C content of sediment samples collected from Medak district

Tank No.	Name of Tank	Village	Mandal	Organic Carbon (g kg^{-1} sediment)	Amount of sediment (tons)	Amount of Carbon (tons)	Microbial Biomass C (mg kg^{-1} sediment)	Proportion of MBC to OC (%)
1	Kudicheruvu	Goudicherla	Sangareddy	8.6	2460.0	21.1	272.4	3.18
2	Edulakunta	Yerdanoor	Sangareddy	11.5	745.2	8.6	257.8	2.25
3	Kuthakunta	Merepally	Kondapur	27.2	1974.0	53.7	228.9	0.84
4	Rahul Cheruvu	Atmakur	Sadasivapet	8.0	4276.8	34.4	323.4	4.02
5	Peddacheruvu	Veltoor	Sadasivapet	6.2	5220.0	32.1	203.6	3.31
6	Kotha cheruvu	Enekepally	Sadasivapet	7.7	729.6	5.6	343.8	4.46
7	Nadayanikunta	Muslapur	Alladurg	5.4	1445.2	7.8	166.0	3.08
8	Regode cheruvu	Marvelly	Alladurg	5.7	1146.2	6.5	165.0	2.91
9	Komantlawaly kunta	Chilver	Alladurg	10.2	2970.0	30.4	224.6	2.20
10	Gollai kunta	G.Peddapur	Alladurg	8.4	2785.1	23.3	140.5	1.68
11	Govram cheruvu	Masaipally	Andole	10.4	5583.6	57.9	175.1	1.69
12	Krishnapur tank	Krishnapur	Kalher	8.9	2270.4	20.3	393.1	4.41
13	Chandra kunta	Pothereddypally	Kulcharam	13.1	2166.0	28.3	296.3	2.27
14	Damara Cheruvu	Yendgandla	Kulcharam	14.6	1928.1	28.2	339.1	2.32
15	Komati kunta	Lingapur	Narsapur	10.9	3001.4	32.8	333.0	3.05
16	Pathi kunta	Chipal thruthy	Narsapur	10.0	2662.7	26.6	309.6	3.09
17	Damara Cheruvu	Thirmalapur	Narsapur	5.3	3016.3	15.9	290.2	5.51
18	Pedda cheruvu	Edulapally	Yeldurthy	14.0	1218.7	17.1	330.9	2.36
19	Bathkamma cheruvu	Dharpally	Shankarampet	17.8	1298.4	23.1	316.7	1.78
20	Chintala cheruvu	Kaslapur	Shankarampet	10.5	468.0	4.9	341.1	3.24
21	Thimmana cheruvu	G.Peddapur	Alladurg	9.8	1411.5	13.9	293.2	2.98
	Total/Average			**10.7****	**48777.2***	**520.7***	**273.5****	**2.89****

* Total value
** Average value

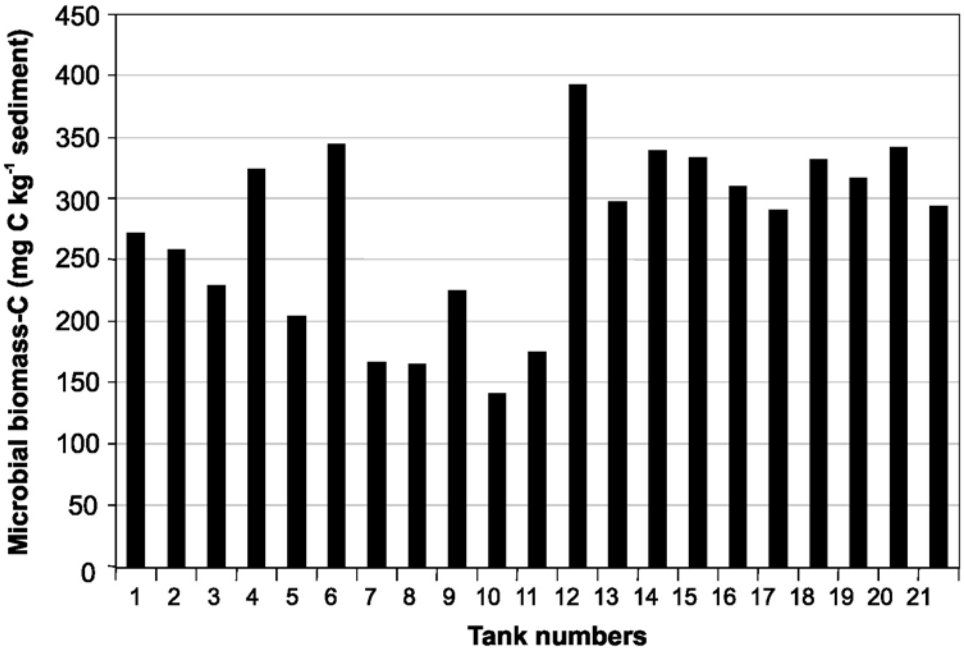

Fig 9. ***Variability of microbial biomass C in the tank sediment.***

Nitrogen and phosphorus content in the sediment

Fertilizer usage details provided by the state district officials reveal that mostly nitrogen (N) and phosphorus (P) are applied through diammonium phosphate (DAP) fertilizer and only nitrogen was applied through urea fertilizer. Nitrogen and P are the most important nutrients that contribute towards higher crop yields. The sediment samples were analysed for N and P contents.

The total N content in the tank sediment samples varied from 340 mg kg^{-1} to 1760 mg kg^{-1} sediment with an average N content of 719 mg kg^{-1} which is two times more than the normal soil N content of the cultivated fields in the region. Highest N content was recorded in sediment samples from tank number 3 (Fig10). Sediment samples from tank 2,13,19,11 and 3 recorded total N values greater than 1000 mg N kg^{-1} of sediment, reflecting greater economic feasibility in replacing the sediment back to agricultural fields.

The total P per cent in the sediment samples of different tanks ranged between 80 mg P kg^{-1} and 1120 mg P kg^{-1} of sediment, with an average of 321 mg of total P kg^{-1} sediment (Fig 10). It was observed that 50 per cent of the tank sediment samples had total P values higher than the mean value of 321 mg kg^{-1}. Results show that nutrient (N and P) losses from the agricultural land were higher as reflected in the sediment N and P composition. In total, 48,777 tons of sediment contained 34 tons of nitrogen and 15 tons of phosphorus .

Relationship between nutrients and microbial population

Nutrients such as N and P are required for synthesis of amino acids, proteins, purine, pyrimidine nucleotides and certain vitamins, which are important for microbial growth. The nitrogen occurs in

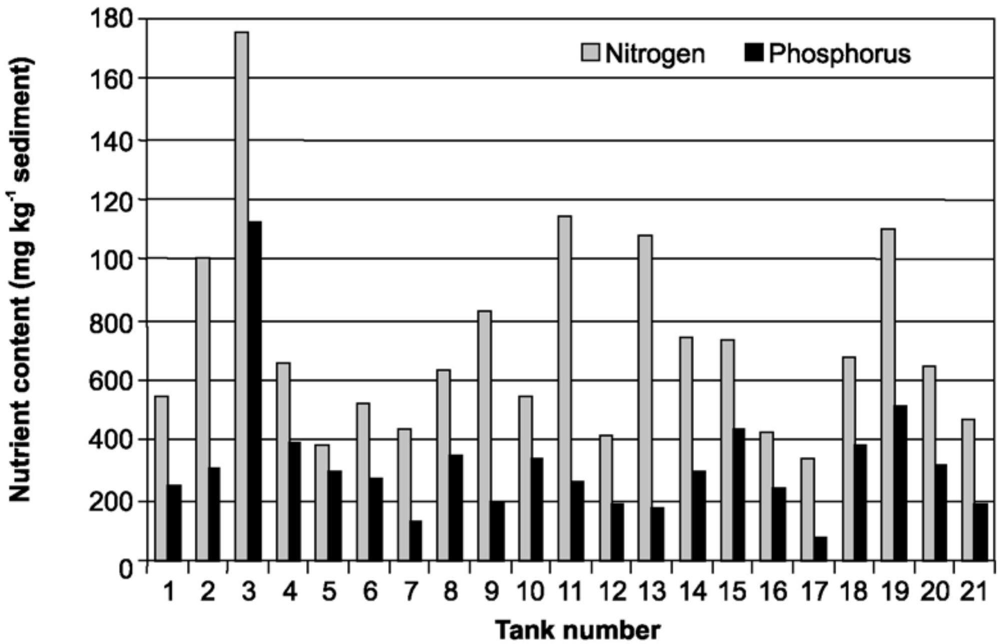

Fig 10. ***Nitrogen and phosphorus content (mg kg^{-1}) in the sediment deposited in different tanks in Medak district.***

nature in a variety of oxidation states, each of which can be utilized by different microorganisms. It was found that sediment samples, which were high in N content, also had a higher microbial population. This trend can be seen from the analysis of sediment samples from tank 3.

Phosphorus occurs in living organisms chiefly as sugar phosphates in nucleotide and nucleic acids. Hence phosphorus, usually as inorganic phosphate, needs to be provided in considerable amount for the growth of microorganisms. A similar positive relationship was found between P content in the sediment and the microbial population. When a comparison of the bacterial population and N and P content in the sediment samples from tanks 20 and 21 were made, where the bacterial population was high, the N and P contents were low. This indicates that the nutrients could possibly be utilised for microbial assimilation or used for restoring the soil health. The nutrients in the tank sediment that were washed off from the fields are directly related to the agricultural practices adopted. Hence, a direct positive relationship can be established between microbial population and nutrient (N, P) content.

Economics of removal of sediment from the tanks

A direct positive correlation was found between amounts of sediment deposited in the tank to the rainfall received in the mandal. In Andole mandal, which received 816 mm of rainfall in 2001(highest in the district), Govram Cheruvu recorded 5583.6 tons of sediments. As the quantities of sediment deposited in the tanks were huge, an economic feasibility for the desiltation process was required to be undertaken. The volume of sediment removed in different tanks ranged from as low as 390 cu.m to

4653 cu m. The total quantity of sediment from all the 21 tanks amounted to 48,777 tons. The total cost incurred in removal of this sediment from tanks amounted to Rs 569, 041(Table 4).

Benefit-cost ratio

In order to check whether the task of sediment removal and their recommendations to apply to fields makes sense, the economic feasibility of such investment costs were estimated. The quantity of sediment removed from different tanks amounted to 48,777 tons. The total cost incurred in removal of this sediment amounted to Rs 5,69,041. The value of sediment was quantified in terms of fertiliser equivalent costs. The nutrient content in terms of N and P retrieved from the sediment was considered to be the profit (benefit) as against the expenditure (cost) incurred in removing the sediment from the tanks (Table 5). Additionally the process of sediment application to farm lands that is rich in organic C will result in C mineralisation and higher nutrient availability thereby helping plant growth and greater fixation of C through

Table 4. Cost incurred in removal of sediment from tanks of Medak district of Andhra Pradesh.

Tank No.	Mandal	Village	Name of the Tank	Volume desilted (cu.m)	Amount of sediment removed (tons)	Cost incurred (Rs)
1	Sangareddy	Goudicherla	Kudi Cheruvu	2050	2460	28700
2	Sangareddy	Yeranoor	Edula Kunta	621	745	8694
3	Kondapur	Merepally	Kotha Kunta	1645	1974	23030
4	Sadasivapet	Atmakur	Rahul Cheruvu	3564	4276	49896
5	Sadasivapet	Veltoor	Pedda Cheruvu	4350	5220	60900
6	Sadasivapet	Enekepally	Kotha Cheruvu	608	729	8512
7	Alladurg	Muslapur	Nadayani Kunta	1204	1445	16856
8	Alladurg	Marvelly	Regode Cheruvu	955	1146	13372
9	Alladurg	Chilver	Komantlavani Kunta	2475	2970	34650
10	Alladurg	G.Peddapur	Gollai Kunta	2320	2785	32480
11	Andole	Masaipally	Govram Cheruvu	4653	5583	65142
12	Kalher	Krishnapur	Krishnapur Cheruvu	1891	2270	26488
13	Kulcharam	Pothereddypally	Chandra Kunta	1804	2165	25269
14	Kulcharam	Yenigandla	Damara Cheruvu	1606	1928	22489
15	Narsapur	Lingapur	Komati Kunta	2501	3001	35017
16	Narsapur	Chipal thruthy	Pathi Kunta	2218	2662	31063
17	Narsapur	Thirmalapur	Damara Cheruvu	2513	3016	35190
18	Yeldurthy	Edulapally	Pedda Cheruvu	1015	1218	14218
19	Shankarampet	Dharpally	Bathkamma Cheruvu	1082	1298	15148
20	Shankarampet	Kaslapur	Chintala Cheruvu	390	468	5460
21	Alladurg	G.Peddapur	Thimmana Cheruvu	1176	1411	16467
			Total	**40648**	**48777**	**569041**

Table 5. Economic valuation of tank sediment in terms of plant nutrients returned to farms and benefit cost analysis of desilting operations.

Tank No.	Mandal	Village	Tank	N %	P %	Amount of sediment (tons)	N in sediment (tons)	P in sediment (tons)	N fertilizer equivalent (Rs)	P fertilizer equivalent (Rs)	B/C ratio
1	Sangareddy	Goudicherla	Kudi Cheruvu	0.06	0.03	2460	1.35	0.62	14707	11531	0.91
2	Sangareddy	Yerdanoor	Edula Kunta	0.1	0.03	745.2	0.75	0.23	8100	4332	1.43
3	Kondapur	Merepally	Kutha Kunta	0.18	0.11	1974	3.47	2.21	37764	41454	3.44
4	Sadasivapet	Atmakur	Rahul Cheruvu	0.07	0.04	4276.8	2.78	1.67	30217	31274	1.23
5	Sadasivapet	Veltoor	Pedda Cheruvu	0.04	0.03	5220	1.98	1.57	21561	29363	0.84
6	Sadasivapet	Enekepally	Kotha Cheruvu	0.05	0.03	729.6	0.38	0.2	4124	3707	0.92
7	Alladurg	Muslapur	Nadayani Kunta	0.04	0.01	1445.2	0.64	0.19	6912	3523	0.62
8	Alladurg	Marvelly	Regode Cheruvu	0.06	0.04	1146.2	0.72	0.4	7849	7522	1.15
9	Alladurg	Chilver	Komantlawaly Kunta	0.08	0.02	2970	2.47	0.59	2695	11138	1.09
10	Alladurg	G.Peddapur	Gollai Kunta	0.06	0.03	2785.1	1.53	0.95	16650	17755	1.06
11	Andole	Masaipally	Govram Cheruvu	0.12	0.03	5583.6	6.42	1.47	69795	27534	1.49
12	Kalher	Krishnapur	Krishnapur Cheruvu	0.04	0.02	2270.4	0.95	0.43	10365	8088	0.70
13	Kulcharam	Pothereddypally	Chandra Kunta	0.11	0.02	2166	2.34	0.37	25427	6904	1.28
14	Kulcharam	Yendgandla	Damara Cheruvu	0.07	0.03	1928.1	1.43	0.58	15509	10846	1.17
15	Narsapur	Lingapur	Komati Kunta	0.07	0.04	3001.4	2.19	1.32	23816	24762	1.39
16	Narsapur	Chipal thruthy	Pathi Kunta	0.04	0.02	2662.7	1.14	0.64	12445	11982	0.79
17	Narsapur	Thirmalapur	Damara Cheruvu	0.03	0.01	3016.3	1.03	0.24	11147	4524	0.45
18	Yeldurthy	Edulapally	Pedda Cheruvu	0.07	0.04	1218.7	0.83	0.46	9008	8684	1.24
19	Shankarampet	Dharpally	Bathkamma Cheruvu	0.11	0.05	1298.4	1.43	0.66	15524	12416	1.84
20	Shankarampet	Kaslapur	Chintala Cheruvu	0.06	0.03	468	0.3	0.15	3271	2808	1.11
21	Alladurg	G.Peddapur	Thimmana Cheruvu	0.05	0.02	1411.5	0.67	0.27	7257	5029	0.75
	Total/Average					**48777.2***	**34.13***	**14.94***	**378240***	**285174***	**1.17****

* Total value
** Average value

photosynthesis. The benefit-cost (B/C) ratio ranged between 0.62 and 3.44 and in the case of 50 per cent of tank desilting operations the B/C ratio was greater than one. The benefit-cost ratio averaged to 1.17 for all the 21 tanks under study (Table 5).

Average benefit-cost ratio of 1.17 suggests that desilting operations are not only economically viable but also have additional benefits like environmental protection, increased soil microbial bio-diversity, improved soil quality and increased water storage. If indirect additional environmental benefits are also estimated in the benefit component then there would be compounded benefit. Application of sediment back to the agricultural fields forms an improved agricultural management system that enhances and protects the soil quality resulting in improved production capacity of soil and reversing the process of land degradation.

Extrapolation of results to the district

The enormous task of desilting the water tanks deposited with huge amounts of sediments under the 'Neeru-Meeru' initiative was assessed through benefit-cost analysis. For this exercise, data obtained from 21 tanks were extrapolated to the entire district in which a total of 78 tanks were desilted. The approach used for extrapolation utilized the N and P composition of sediments from the nearest available sediment value. Average values of sediment analysis from 2 to 3 nearest tanks were used to compute for rest of the tanks in the district (Table 6). The overall mean N content in the sediment samples was 730 mg kg^{-1} sediment and average P content was calculated to be 357 mg kg^{-1} sediment. The sediments of 78 tanks had an average organic C value of 11.64 g C kg^{-1} sediment. In the district, a total of 246831 tons of sediments from 78 tanks were desilted and addition of these sediments back to farms would return 183 tons of N, 86 tons of P and 2873 tons of organic carbon. On an average, the B/C ratio for the desilting operations from water tanks based on the economic plant nutrient value (N and P content) of the district was calculated to be 1.23, which reflects a positive benefit for the cost incurred in the 'Neeru-Meeru' program.

Conclusion

Application of sediment desilted from the water tanks to agricultural fields appears to be a economically viable option for returning N, P nutrients along with organic C to the soil for increasing nutrient availability and enhancing crop production. The methodology used for extrapoltion could be adopted for computing the sediment yield, nutrient content and for assessing their economic value. Scientific studies along these lines provide an insight for land managers and policy makers to evaluate the existing management strategies and take appropriate decisions.

Future research

Depending on the availability of tank sediment and their nutrient content there is a case made for its proper utilisation through application to farm lands for increasing productivity and improving soil quality. However, there is a need for more complete elemental analysis of sediments for micro elements as well as likely pollutants (for e.g., pesticides).

Table 6. Economic valuation of tank sediment in terms of plant nutrients returned to farms and benefit cost analysis of desilting operations in Medak district

Tank No	Mandal	Village	Name of tank	Cost incurred (Rs)	Amount of sediment (tons)	Nitrogen in sediment (%)	Phosphorus in sediment (%)	N in sediment (tons)	P in sediment (tons)	B/C ratio
1	Alladurg	Gadipeddapur	Tirmancheru	21770	1865	0.06	0.03	1.03	0.63	1.06
2	Andole	Erraram	Peddacheru	95400	8175	0.12	0.03	9.40	2.13	1.49
3	Andole	Masanpally	Gouravanikunta	96500	8269	0.12	0.03	9.51	2.15	1.49
4	Chegunta	Bonal	Brahmandlacheru	46800	4010	0.08	0.04	3.25	1.60	1.40
5	Chinnakodur	Alipur	JalCheru	60327	5169	0.08	0.04	4.19	2.07	1.40
6	Chinnakodur	Gurralagondi	Peddarajcheru	16800	1440	0.08	0.04	1.17	0.58	1.40
7	Chinnakodur	Ramancha	Mysammacheru	14400	1234	0.08	0.04	1.00	0.49	1.40
8	Dubbak	Dubbak	Peddacheru	85680	7342	0.08	0.04	5.95	2.94	1.40
9	Dubbak	Gambheerpur	Peddacheru	41674	3571	0.08	0.04	2.89	1.43	1.40
10	Dubbak	Peddagundavelly	Chowdaricheru	13758	1179	0.08	0.04	0.95	0.47	1.40
11	Dubbak	Gosanpally	Bandamcheru	11014	944	0.08	0.04	0.76	0.38	1.40
12	Gajwel	Dharmareddipally	Pathacheruvu	13839	1186	0.07	0.03	0.78	0.39	1.14
13	Gajwel	Gajwel	Pandavulacheru	85710	7344	0.07	0.03	4.85	2.42	1.14
14	Jinnaram	Domadugu	Rajannacheru	50000	4284	0.08	0.03	3.34	1.20	1.18
15	Kalher	Kadpal	Somancheru	84000	7198	0.04	0.02	3.02	1.37	0.70
16	Kalher	Bibipet	Rameshwaramcheru	36000	3085	0.04	0.02	1.30	0.59	0.70
17	Kohir	Machireddipally	Nareducheru	27852	2387	0.08	0.05	1.98	1.24	1.61
18	Kohir	Venkatapur	Venkatapurkunta	10526	902	0.08	0.05	0.75	0.47	1.61
19	Kondapak	Marpadga	Peddacheru	37544	3217	0.08	0.05	2.61	1.67	1.59
20	Kondapak	Sirsingandla	Ooracheru	24945	2138	0.08	0.05	1.73	1.11	1.59
21	Kondapak	P. Masanpally	Peddacheru	22981	1969	0.08	0.05	1.60	1.02	1.59
22	Kondapak	Thogita	Peddacheru	26585	2278	0.08	0.05	1.85	1.18	1.59
23	Kondapak	JapthiNacharam	Nallacheru	35666	3056	0.08	0.05	2.48	1.59	1.59
24	Kondapak	Bandaram	Ooracheru	65345	5599	0.08	0.05	4.54	2.91	1.59
25	Kondapak	Kondapak	Annareddicheru	53832	4613	0.08	0.05	3.74	2.40	1.59
26	Kondapak	Thogita	Pothareddikunta	190000	16281	0.08	0.05	13.19	8.47	1.59
27	Kulcharam	Variguntham	Peddacheru	34700	2973	0.09	0.02	2.71	0.71	1.23
28	Mirdoddi	Mirdoddi	Peddacheru	18329	1571	0.08	0.04	1.27	0.63	1.40

Continued

Table 6. *Continued.*

Tank No	Mandal	Village	Name of tank	Cost incurred (Rs)	Amount of sediment (tons)	Nitrogen in sediment (%)	Phosphorus in sediment (%)	N in sediment (tons)	P in sediment (tons)	B/C ratio
29	Mirdoddi	Kangal	Peddacheru	3360	288	0.08	0.04	0.23	0.12	1.40
30	Mirdoddi	Jangapally	Peddacheru	45299	3882	0.08	0.04	3.14	1.55	1.40
31	Narayankhed	Gangapur	Ryalkal	36000	3085	0.04	0.02	1.30	0.59	0.70
32	Narayankhed	Sanjeevanraopet	Chowdaricheru	30000	2571	0.04	0.02	1.08	0.49	0.70
33	Narayankhed	Madwar	Peddacheru	8874	760	0.04	0.02	0.32	0.14	0.70
34	Narayankhed	Turkapally	Turkacheru	2135	183	0.04	0.02	0.08	0.03	0.70
35	Narsapur	Narsapur	Ooracheru	6000	514	0.05	0.03	0.26	0.13	0.87
36	Narsapur	Narsapur	Rairaocheru	7000	600	0.05	0.03	0.30	0.15	0.87
37	Papannapet	Cheekode	Nallakunta	20000	1714	0.09	0.02	1.56	0.41	1.23
38	Papannapet	Gandharpally	Giddakunta	20000	1714	0.09	0.02	1.56	0.41	1.23
39	Pulkal	Muddaipet	Kaminicheru	26592	2279	0.05	0.03	1.18	0.73	1.00
40	R.C.puram	Tellapur	Medicheru	85600	7335	0.08	0.03	5.72	2.05	1.18
41	Ramayampet	Nandigama	Saicheru	4956	425	0.09	0.04	0.37	0.18	1.48
42	Ramayampet	Chelmeda	Somaicheru	38000	3256	0.09	0.04	2.83	1.35	1.48
43	Ramayampet	D'Dharmaram	Ooracheru	21800	1868	0.09	0.04	1.63	0.78	1.48
44	Ramayampet	Katriyal	Peddacheru	45500	3899	0.09	0.04	3.39	1.62	1.48
45	Ramayampet	Katriyal	Chinnacheru	48400	4147	0.09	0.04	3.61	1.72	1.48
46	Shankarampet	Shankarampet (A)	Patancheru	22100	1894	0.09	0.04	1.65	0.79	1.48
47	Shankarampet®	Kamaram	Ooracheru	45500	3899	0.09	0.04	3.39	1.62	1.48
48	Shivampet	Peddagottimukkala	Bobbilicheru	85700	7344	0.05	0.03	3.67	1.84	0.87
49	Shivampet	Donthi	Kondalammacheru	42800	3668	0.05	0.03	1.83	0.92	0.87
50	Shivampet	Donthi	Konddalammcheru	50000	4284	0.05	0.03	2.14	1.07	0.87
51	Shivampet	Peddagottimukkala	Bobbilicheru	65344	5599	0.05	0.03	2.80	1.40	0.87
52	Siddipet	Narayanraopet	Malkacheru	21980	1883	0.08	0.04	1.53	0.75	1.40
53	Siddipet	Narayanraopet	Peddacheru	42852	3672	0.08	0.04	2.97	1.47	1.40
54	Toopran	Brahmanpally	Ooracheruvu	25564	2191	0.05	0.03	1.10	0.55	0.87
55	Toopran	Toopran	Peddacheru	84428	7235	0.05	0.03	3.62	1.81	0.87
56	Wargal	Majeedpally	BoinammaKunta	15627	1339	0.05	0.03	0.67	0.33	0.87
57	Zahirabad	Shaikapur	chinnacheru	37896	3247	0.08	0.05	2.70	1.69	1.61
	Total/Average			**2880326***	**246831***	**0.07****	**0.03****	**2.35****	**1.10****	**1.23****

* Total value

** Average value

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District Water Management Agency

Medak District, Government of Andhra Pradesh, India

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