International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

ISSN 2347-2677
IJFBS 2017; 4(5): 20-24
Received: 14-07-2017
Accepted: 15-08-2017

**Rajender Kumar Bishnoi**
Department of Zoology Ch. Ballu Ram Godara Govt. Girls (P.G.) College Sri Ganganagar, Rajasthan, India

**Correspondence**
**Rajender Kumar Bishnoi**
Department of Zoology Ch. Ballu Ram Godara Govt. Girls (P.G.) College Sri Ganganagar, Rajasthan, India

# Sedimentation studies of lotic water (The gang canal) In North-Western Rajasthan, India

**Rajender Kumar Bishnoi**

## Abstract
The sedimentation in Gang canal was studied with a specific aim to know its siltation rate, composition of sedimentation and the total sediment deposits that occurred during the existence of the canal for the last 65 years. In the sediments, the total sand was 50 to 95 percent; silt and clay come next in the order of abundance. Within the category of sand, the medium sand ranged from its total absence to 2.5%, very fine sand 17.5% to 37.5% and fine sand was 31%-63%. The gross total annual sediment load comes to 34525.2 MT. Seasonally the load is more during monsoon months followed by winter months and load was lowest summer months. The average deposition per square meter works out to 0.082562 tones/m$^2$/year (i.e.82.562 kg/m$^2$/year). Statistically it was found that each sediment component is directly proportional and thus related to the total sediment. In the case of Gang canal, with its shallowing by the sediment deposition of approximately 60 cm width during last 65 years, the water carrying capacity might have been reduced roughly by 20-30%.

**Keywords:** Lotic water, sedimentation, rate of sedimentation, siltation, bed load.

## Introduction
The water storage reservoirs are multipurpose, catering to flood control, generation of electricity, recreation, drinking water supply, navigation, fishery and irrigation. For irrigation a complicated network of supply channels- either cemented or bricks or excavated is laid out from the dam to the surrounding area depending upon the amount of water available for this channeling, its rate of flow and irrigation needs. Any lotic system, whether natural or manmade has varying velocities of water flow. In the later case, this velocity is normally high and determined by the slope gradient given to the canal by engineers. Closely linked to this current velocity, are the erosion, transportation and deposition of solid materials. The erosion of water course largely depends on this current velocity and also the characteristics of bed over which the water flows. The ultimate deposition of materials on the bed or bottom is also dependent on the local currents, density of water, slope gradient of the channel or canal and specific gravity of the particles themselves. The heavier particles are first dropped out and settle at the bottom as the velocity decreases. Fine sand, clay, silt and detritus remain in the suspension for a longer time and settle only when the current reaches zero or near zero level. The standard classifications of bottom soils and deposits proposed by United States Department of Agriculture is as follows-

**Classification of Soil according to United States Department of Agriculture**

| Size in mm | <0.002 | 0.05 | 0.1 | 0.25 | 0.5 | 1.0 | 2.0 | 6.0 |
|---|---|---|---|---|---|---|---|---|
| | Clay | Silt | Very Fine | Fine | Medium | Coarse | Very Coarse | Gravel |

The sedimentation in Gang canal was studied with a specific aim to know its siltation rate, composition of sedimentation and the total sediment deposits that occurred during the existence of the canal for the last 65 years. The present study deals with the rate of sedimentation and the sediment composition at stations 1, 2, and 3 of the part of Gang canal system investigated.

## Material and methods
The area of study Sri Ganganagar district is situated in the north-western part of the state of Rajasthan in the Thar Desert. (Latitude 28.4 to 30.6 and Longitude 72.2 to 75.3) The major work of the district is farming.

The river Ghagghar traversing this region is purely seasonal river but gets flash floods during monsoon. The soil of the region is moderate to highly porous and thus non-retentive for water. The canal system viz. Indira Gandhi Canal, Gang Canal and Bhakhara canal brought to this region from Punjab and irrigates extensive tracts of this region. The Gang canal brought from Harike barrage (river Sutlej) in Punjab. This Gang canal was built by Maharaja Ganga Singh of the erstwhile princely state of Bikaner in the year 1927. In Punjab the Gang canal is also known as Bikaner canal. The canal flows almost throughout the year carrying water to the inhabitants of the area for their domestic and agricultural use. The Length of Bikaner canal (Gang canal)is129 km (all lined), first 112 km lies in Punjab and 17 km lie in Rajasthan. Width of the canal is 88 ft at bottom & 98 ft at the top. Full supply depth is 10 ft and full supply discharge is 2720 Cu/ Sec. The length of the Gang canal feeder is 73.1 km (unlined). The station 1 was situated at Bikaner canal and stations 2 and 3 were at Gang canal feeder. The climate of this region is semi arid with extreme temperature conditions in summer touching up to $50^0$C and in winter up to $0^0$C. The site is influenced by the Indian Southern-west or summer monsoon (June-September) and during winter (December-February) by Siberian anti-cyclones.

The rate of sedimentation was studied by laying the sedimentation bottle on the canal bottom at 1-3 stations. These were the narrow mouth dark brown glass bottle of 3 liter capacity. A plastic funnel of 660 ml capacity was fixed at the mouth of each bottle. The duration of laying these bottles on the canal floor was one month. At the end of every month, the sediments collected in the bottles were brought to the laboratory, air dried and then weighed. A sub sample of 100 gm was oven dried, well mixed and sieved through a set of six standard sieves with an electric sieve shaker till a complete separation of different sized particles was obtained. This time period ranged from 15-20 minutes.

## Result

Table 1 show that the sediment deposition was more from July to November with peak in September (2087 g) and October (705 g) at the station 1. Similar situation existed at the other two stations (Table 1). The sedimentation rate drop from November 90 onwards with a lowest figure in February 91. From March 91, there is a slight but unconnected rise in the sedimentation till June 91. Thus there is a seasonal oscillation in the sedimentation rate at all the three stations in the stretch of Gang canal investigated. The contribution of five components viz. medium sand, fine sand, very fine sand, silt and clay to the sediment at the stations 1, 2 and 3 are presented in table 2. It will be seen from the table that the total sand contributes around 50 to 95 percent of the sedimentation. Silt and clay come next in the order of abundance. Within the category of sand, the medium sand is low from its total absence to 2.5%. Next to this is the very fine sand with its contribution ranging from 17.5% to 37.5%. The fine sand is relatively higher (31%-63%). Surprisingly, the fluctuation in the total sand deposition is not consonant with the seasonal fluctuation in the deposition of total sediments. The monthly variations in the individual components of sand does not depict the seasonality in the total sedimentation rate. In this case it is felt that the seasonality in the total sedimentation is greatly influenced by the silt and clay components which show rise from July to September and a minor drop in October and November. The situations are more or less same for all the three stations investigated. Referring back to the percent contribution of different sediment components to the total sediment load in experimental jars at each sampling stations (table-2), it could be observed that at station 1, the medium sand contributed 1.0% (lowest) to the total sediment. Higher contributions of 50.9 and 29.4% were by fine and very fine sands respectively. This means, the maximum sedimentation in the stretch of Gang canal studied was contributed by sand with major contributing components of fine and very fine sand. A look at the table2 clearly shows a similar situation at station 2 and 3. In fact at these two stations the contribution of sand to total sediment is higher than that at station 1 but silt and clay are less in comparison to station 1.

Table 3 gives the estimated monthly sediment load in its different components along the total area of canal basin from station 1 to 2 (stretch I) and from station 2 to 3 (stretch II). Table show that the monthly average of total load of sediment in tones in canal stretch-I comes to 2384.3 MT with a gross total annual load of 28612.0 MT. The peak (13064 MT) was in September 90 and the lowest (261.8 MT) in February 91. Within the different components of sediment, clay comes the lowest with its monthly average as 259.05 MT followed by silt (353.24 MT). The sand was the highest in its contribution with a monthly average of 1772.0 MT. Within the sand, medium sand was the lowest (15.55 MT). Next to this comes ‘very fine sand’ (645.91 MT) followed by ‘fine sand’ (1110.6 MT). In the canal stretch-II, the peak (2749.5 MT) was also found in September, 90 and lowest (49.0 MT) in February, 91 with a gross total annual load of 5913.19 MT. The monthly average of the total sediment comes to 492.77 MT. For the entire stretch of Gang canal investigated the gross total annual sediment load comes to 34525.1 MT. Seasonally the load is more during monsoon months of July- September followed by winter months (October- February). The sediment load was the lowest from March – June i. e., summer months (table 4).

**Table 1:** Monthly variations in weight(in gm)of different ingredients of sediment at sampling stations 1, 2 and 3 of Gang canal

| Station no. 1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Sept.** | **Oct.** | **Nov.** | **Dec.** | **Jan.** | **Feb** | **Mar** | **April** | **May** | **June** | **July** | **Aug.** |
| M. sand | _ | 14.1 | 6.6 | 5.6 | 1.8 | 0.9 | _ | _ | _ | 1.8 | 3.2 | _ |
| F. sand | 646.9 | 317.2 | 204.7 | 149.1 | 108.5 | 28.8 | 36.4 | 55.0 | 56.3 | 56.5 | 78.4 | 208.6 |
| V.F sand | 365.2 | 186.8 | 122.3 | 68.1 | 48.7 | 14.4 | 23.0 | 37.2 | 33.3 | 28.0 | 53.6 | 165.3 |
| T. sand | 1012.2 | 518.1 | 333.7 | 222.9 | 159.1 | 44.1 | 59.5 | 92.3 | 89.6 | 86.4 | 135.2 | 373.9 |
| Silt | 657.4 | 98.7 | 57.8 | 29.8 | 14.7 | 1.9 | 2.2 | 4.0 | 4.9 | 3.2 | 15.2 | 97.5 |
| Clay | 417.4 | 88.1 | 53.4 | 31.2 | 10.1 | 1.9 | 2.2 | 5.6 | 3.4 | 2.3 | 9.6 | 70.4 |
| Total sediment | 2087.0 | 705.0 | 445.0 | 284.0 | 184.0 | 48.0 | 64.0 | 102.0 | 98.0 | 92.0 | 196.0 | 542.0 |

**Station no. 2**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb | Mar | April | May | June | July | Aug. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 8.6 | 5.8 | 5.7 | 1.0 | 0.4 | _ | _ | _ | _ | 1.2 | _ |
| F. sand | 1009.1 | 332.9 | 162.0 | 110.5 | 53.5 | 18.7 | 20.1 | 44.4 | 40.3 | 44.7 | 67.8 | 183.0 |
| V F sand | 571.2 | 152.1 | 93.4 | 75.2 | 39.0 | 10.8 | 11.05 | 26.2 | 25.9 | 22.7 | 44.8 | 126.8 |
| T. sand | 1580.3 | 493.6 | 261.3 | 191.5 | 93.6 | 30.0 | 31.8 | 70.6 | 66.2 | 67.4 | 113.9 | 309.9 |
| Silt | 142.8 | 48.7 | 13.1 | 19.3 | 6.2 | 0.9 | 0.9 | 3.0 | 3.6 | 1.7 | 7.6 | 56.1 |
| Clay | 180.8 | 31.5 | 17.5 | 17.1 | 4.1 | 0.9 | 0.8 | 2.2 | 2.1 | 1.7 | 6.4 | 49.9 |
| Total sediment | 1904.0 | 574.0 | 292.0 | 228.0 | 104.0 | 32.0 | 33.0 | 76.0 | 72.0 | 71.0 | 128.0 | 416.0 |

**Station no. 3**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb | Mar | April | May | June | July | Aug. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 7.6 | 3.9 | 4.4 | 1.7 | 0.4 | _ | _ | _ | _ | _ | _ |
| F. sand | 633.3 | 261.1 | 142.0 | 113.7 | 46.4 | 15.6 | 18.7 | 36.6 | 43.6 | 41.2 | 66.0 | 189.1 |
| V F sand | 393.1 | 141.9 | 88.1 | 71.3 | 29.2 | 10.0 | 9.4 | 18.9 | 24.4 | 22.4 | 40.4 | 104.2 |
| T sand | 1026.5 | 410.6 | 234.0 | 189.5 | 77.4 | 26.1 | 28.2 | 55.5 | 68.0 | 63.6 | 106.5 | 293.3 |
| Silt | 196.5 | 38.0 | 11.8 | 14.4 | 4.7 | 1.1 | 1.0 | 2.7 | 2.9 | 1.6 | 5.3 | 54.0 |
| Clay | 232.9 | 58.3 | 17.0 | 18.9 | 3.8 | 0.7 | 0.7 | 1.8 | 2.9 | 1.6 | 7.1 | 38.6 |
| Total sediment | 1456.0 | 507.0 | 263.0 | 223.0 | 86.0 | 28.0 | 30.0 | 60.0 | 74.0 | 67.0 | 119.0 | 386.0 |

**Table 2:** Monthly percent variation of different ingredients of sediments at three sampling stations 1, 2 and 3 of Gang canal

**Station no. 1**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar | April | May | June | July | Aug. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 2.0 | 1.5 | 2.0 | 1.0 | 2.0 | _ | _ | _ | 2.0 | 2.0 | _ | 1.0 |
| F. sand | 31.0 | 45.0 | 46.0 | 52.5 | 59.0 | 60.0 | 57.0 | 54.0 | 57.5 | 61.5 | 49.0 | 38.5 | 50.9 |
| VF sand | 17.5 | 26.5 | 27.5 | 24.0 | 26.5 | 30.0 | 36.0 | 36.5 | 34.0 | 30.5 | 33.5 | 30.5 | 29.4 |
| T sand | 48.5 | 73.5 | 75.0 | 78.5 | 86.5 | 92.0 | 93.0 | 90.5 | 91.5 | 94.0 | 84.5 | 69.0 | 81.3 |
| Silt | 31.5 | 14.0 | 13.0 | 10.5 | 8.0 | 4.0 | 3.5 | 4.0 | 5.0 | 3.5 | 9.5 | 18.0 | 10.3 |
| Clay | 20.0 | 12.5 | 12.0 | 11.0 | 5.5 | 4.0 | 3.5 | 5.5 | 3.5 | 2.5 | 6.0 | 13.0 | 8.2 |

**Station no. 2**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar | April | May | June | July | Aug. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 1.5 | 2.0 | 2. | 1.0 | 1.5 | _ | _ | _ | _ | | _ | 0.8 |
| F. sand | 53.0 | 58.0 | 55.5 | 48.5 | 51.5 | 58.5 | 61.0 | 58.5 | 56.0 | 63.0 | 53.0 | 44.0 | 55.0 |
| VF sand | 30.0 | 26.5 | 32.0 | 33.0 | 37.5 | 34.0 | 33.5 | 34.5 | 36.0 | 32.0 | 35.0 | 30.5 | 32.8 |
| T sand | 83.0 | 86.0 | 89.5 | 84.0 | 90.0 | 94.0 | 94.5 | 93.0 | 92.0 | 95.0 | 89.0 | 74.5 | 88.7 |
| Silt | 9.5 | 8.5 | 4.5 | 8.5 | 6.0 | 3.0 | 3.0 | 4.0 | 5.0 | 2.5 | 6.0 | 13.5 | 6.1 |
| Clay | 7.5 | 5.5 | 6.0 | 7.5 | 4.0 | 3.0 | 2.5 | 3.0 | 3.0 | 2.5 | 5.0 | 12.0 | 5.1 |

**Station no. 3**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar | April | May | June | July | Aug. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 1.5 | 1.5 | 2.0 | 2.0 | 1.5 | _ | _ | _ | _ | _ | _ | 0.8 |
| F. sand | 43.5 | 51.5 | 54.0 | 51.0 | 54.0 | 56.0 | 62.5 | 61.0 | 59.0 | 61.5 | 55.5 | 49.0 | 54.7 |
| VF sand | 27.0 | 28.0 | 33.5 | 32.0 | 34.0 | 36.0 | 31.5 | 31.5 | 33.0 | 33.5 | 34.0 | 27.0 | 31.7 |
| T sand | 70.5 | 81.0 | 89.0 | 85.0 | 90.0 | 93.5 | 94.0 | 92.5 | 92.0 | 95.0 | 89.5 | 76.0 | 87.3 |
| Silt | 13.5 | 9.0 | 4.5 | 6.5 | 5.5 | 4.0 | 3.5 | 4.5 | 4.0 | 2.5 | 4.5 | 14.0 | 6.3 |
| Clay | 16.0 | 10.0 | 6.5 | 8.5 | 4.5 | 2.5 | 2.5 | 3.0 | 4.0 | 2.5 | 6.0 | 10.0 | 6.3 |

**Table 3:** Monthly variations of estimated weight (in tones) of different ingredients of sediments at Gang canal stretch I and II

**Canal stretch between stations 1 and 2 (Stretch I)**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar | April | May | June | July | Aug. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 73.4 | 42.2 | 37.70 | 9.42 | 4.58 | _ | _ | _ | 5.3 | 14.1 | _ | 15.55 |
| F. sand | 5486.9 | 2156.3 | 1224.3 | 846.3 | 520.8 | 155.2 | 187.3 | 327.7 | 315.8 | 332.1 | 480.8 | 1293.5 | 1110.6 |
| V. F sand | 3102.8 | 1109.5 | 717.7 | 477.6 | 301.7 | 83.8 | 110.4 | 206.8 | 194.8 | 166.8 | 322.9 | 956.4 | 645.91 |
| T. sand | 8589.7 | 3338.8 | 1984.2 | 1361.7 | 831.9 | 243.5 | 297.7 | 534.5 | 510.6 | 504.2 | 817.8 | 2249.9 | 1772 |
| Silt | 2678.1 | 470.9 | 211.08 | 159.2 | 66.0 | 9.2 | 10.3 | 23.3 | 27.8 | 16.0 | 73.1 | 493.9 | 353.24 |
| Clay | 1796.2 | 376.7 | 217.1 | 155.0 | 44.7 | 9.1 | 9.5 | 24.8 | 18.0 | 13.3 | 51.8 | 392.0 | 259.05 |
| Total sediment | 13064 | 4186.6 | 2412.4 | 1675.9 | 942.7 | 261.8 | 317.5 | 582.6 | 556.4 | 533.5 | 942.7 | 3135.8 | 2384.30 |

**Canal stretch between stations 2 and 3 (Stretch II)**

| | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar | April | May | June | July | Aug. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. sand | _ | 13.3 | 7.9 | 8.3 | 2.3 | 0.7 | _ | _ | _ | _ | 1.0 | _ | 2.80 |
| F. sand | 1326.7 | 484.3 | 248.7 | 183.6 | 82.0 | 28.1 | 31.8 | 66.5 | 68.7 | 70.3 | 109.7 | 305.2 | 250.46 |
| V. F sand | 783.6 | 241.0 | 148.7 | 119.9 | 55.6 | 17.2 | 16.7 | 36.7 | 41.2 | 37.0 | 69.7 | 188.7 | 146.35 |
| T. sand | 2110.3 | 738.6 | 405.3 | 311.8 | 139.9 | 46.0 | 48.5 | 103.2 | 109.9 | 107.3 | 180.4 | 493.9 | 399.60 |
| Silt | 316.2 | 77.4 | 20.4 | 27.7 | 8.9 | 1.7 | 1.7 | 4.7 | 5.4 | 2.8 | 10.6 | 90.2 | 47.32 |
| Clay | 323.0 | 66.3 | 28.4 | 29.5 | 6.6 | 1.3 | 1.3 | 3.3 | 4.1 | 2.8 | 11.1 | 72.1 | 45.85 |
| Total sediment | 2749.5 | 882.3 | 454.1 | 369.0 | 155.4 | 49.0 | 51.5 | 111.2 | 119.4 | 112.9 | 202.1 | 656.2 | 492.77 |

**Table 4:** Season wise total and average weight(in tones) of different components of sediment of Gang canal

| Canal stretch between stations 1 and 2 (Stretch 1) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Medium sand** | **Fine sand** | **Very Fine sand** | **Total sand** | **Silt** | **Clay** | **Total sediment** |
| **Winter** | | | | | | | |
| Total | 167.17 | 4902.76 | 2690.25 | 7760.18 | 916.43 | 802.86 | 9479.47 |
| Average | 33.43 | 980.55 | 538.05 | 1552.04 | 183.29 | 160.57 | 1895.89 |
| **Summer** | | | | | | | |
| Total | 5.33 | 1162.99 | 678.66 | 1846.98 | 77.43 | 65.69 | 1990.1 |
| Average | 1.33 | 290.75 | 169.66 | 461.75 | 19.36 | 16.42 | 497.53 |
| **Monsoon** | | | | | | | |
| Total | 14.14 | 7261.16 | 4381.99 | 11657.29 | 3245.05 | 2240.1 | 17142.44 |
| Average | 4.71 | 2420.38 | 1460.66 | 3885.76 | 1081.68 | 746.7 | 5714.15 |
| **Canal stretch between stations 2 and 3(Stretch-II)** | | | | | | | |
| **Winter** | | | | | | | |
| Total | 32.56 | 1026.68 | 582.49 | 1641.73 | 136.15 | 132.19 | 1910.07 |
| Average | 6.51 | 205.34 | 116.5 | 328.35 | 27.23 | 26.43 | 382.01 |
| **Summer** | | | | | | | |
| Total | NIL | 237.3 | 131.66 | 368.96 | 14.58 | 11.61 | 395.15 |
| Average | NIL | 59.32 | 32.92 | 92.24 | 3.65 | 2.9 | 98.79 |
| **Monsoon** | | | | | | | |
| Total | 1.01 | 1741.5 | 1042.04 | 2784.55 | 417.05 | 406.37 | 3607.97 |
| Average | 0.34 | 580.5 | 347.35 | 928.18 | 139.02 | 135.46 | 1202.66 |

The deposition of sediment per square meter area of the canal basin was calculated and it was found that between the first stretch, the deposition is 0.085521 tones/m$^2$/year i.e., 85.521 kg/m$^2$/year. In the second canal stretch the per square meter deposition works out to 0.070721 tones/m$^2$/year i.e., 70.721 kg/m$^2$/year. The total area of the canal basin investigated here being 418173.4 m$^2$, the average deposition per square meter works out to 0.082562 tones/m$^2$/year (i.e. 82.562 kg/m$^2$/year) with a total annual deposition of 34525.4 MT.

## Discussion

The transport of sediment in flowing water system is a very complex subject. It is distinguished arbitrarily into two division viz., suspended load and bed load. The suspended load is the sediment remaining in the main body of flow because of the upward movement of turbulent eddies. At times, it is difficult to distinguish suspended load from bed load because the material rolling on the bottom as bed load under some conditions, may turn into a suspended load under a higher water discharge with greater flow velocity. Under low flowing conditions, a little or even no sediment transport is affected. With increasing discharge, the shear stress on the bottom and the shore of the stream increases till a threshold is reached when the sediment from these areas get dislodged and commence movement (Henderson, 1966 [8]). The important aspect of the potamic system is the transportation of load in terms of the dissolved solids and gases, suspended sediments and bed load. Many workers have contributed to the transportation of load in potamic systems (Livingston, 1963 [12]; Langbein and Dawdy, 1964 [11]; Terwindt, 1967 [20]; Holeman, 1968 [9]; Edwards and Thornes, 1970 [2]; Grove, 1972 [6]; Golterman, 1973 [4]). Serruya, 1969 [19] and deGroot *et al*. 1971[5] worked on the transport of silt and associated chemicals in rivers Rhine and Eems. Einstein, 1950 [3] was the first to formulate the equation for calculating the bed load of open channel flows. Guy and Norman, 1970 [7] described the field methods for measurement of fluvial sediment.

Studies on man-made irrigation canals should form a very interesting piece of research. However, this area appears almost totally neglected. The notable contribution in the field of lotic system are by Olaniya *et al*., 1976 [13], Palria, 1983 [14], Agarwal, 1986 [1], Rana and Palria, 1988 [17] and Prasad, 1988 [16].

In tropical reservoirs, 90% of silt and clay inputs are recruited during July to September i.e., in rainy season. This silt and clay is originated through erosion in the catchment area. The seasonal factor thus has a high impact under tropical conditions in comparison to that in temperate regions where most of the precipitation is in the form of snow. This is well supported in the present investigation where the sediment load is more in monsoon than in winter and summer. The station wise distribution of sediment ingredients is more or less uniform at all the three stations except to a very minor extent in the case of medium sand which show slight increase in its deposition at the station 1. However, when the two stretches are considered, the deposition of medium sand by weight is about seven times more in the stretch between stations 1and 2 than in the stretch between stations 2 and 3. The near uniform distribution of sedimentation in the Gang canal is attributable to a uniform unidirectional flow of water with almost no existence of semi stagnant or stagnant niche near the canal banks.

When different sediment components were statistically related to the total sediment load in order to find out whether each is proportional to the degree of total sedimentation at the three stations investigated, it was found that each sediment component is directly proportional and thus related to the total sediment. This mean, higher the total sediment, higher and proportionate is the contribution of individual component to the total sedimentation except in the case of medium sand which shows relatively higher share in the total sediment. All the above mean that the pattern of deposition of medium sand over the entire canal stretch is different than that of other components.

The nature of deposition of sand, silt, clay etc. in the sediment of fresh water is well explained by Thomas *et al*. 1972 [21], 1973 [22], Verneto *et al*, 1972 [25], Jaquet *et al*, 1975 [10], Thomas and Jaquet, 1975 [23], Thomas *et al*., 1976 [24]. Rao *et al*., 1988 [18] have also indicated a view in contrast to those of the above workers through their work in lake Gandhi Sagar. The total deposition of sediment in the stretch of Gang canal investigated has been calculated as 0.082562 tones /m$^2$ / year with a total estimated annual deposition of 34525.4 MT. In the case of Gandhi Sagar, Panjwani and Dhurve, 1978 [15] reported the silt input as 964 $m^3$ / $km^2$ / year which works out to 0.964 kg / $m^2$ / year. This siltation is very low in comparison to the total sedimentation rate of 82.562 kg / $m^2$ / year observed in Gang canal. Based on their values, the above authors have opined that 46% dead storage of the Gandhi Sagar lake has been covered in 25 years. In the case of Gang canal, with its shallowing by the sediment deposition of approximately 60 cm width during last 65 years, the water carrying capacity might have been reduced roughly by 20-30%.

**Conclusion**

Gang Canal transports a large amount of sediments in the terms of suspended load and bed load. The average sediment rate was worked out to 1.97 tones/ hour. The degree of sedimentation observed in the canal clearly warrants its deepening so as to increase its water carrying capacity. It is suggested that the possibilities of cage culture practices recommended for adoption in this canal should also be phased out in such a way that the high turbidity during certain month is avoided in setting up of the cages.

**Reference**


1. Agarwal SK. Ecology of Chambal River at Kota. Acta Ecologica. 1986; 8(1):13-19.
2. Edwards AM, JB Thomas. Observations on the dissolved solids of the Cosiquiare and upper Orinoco. Amazoniana. 1968, 1970; 2(3):245-256.
3. Einstein HA. The bed load function for sediment transportation in Open channel flow. U.S. Department Agriculture Technical Bulletin 1026, 1950, 70.
4. Goltenaan HL. Deposition of river silts in the Rhine and Meuse Delta. Freshwater Biol. 1973; 3:267-281.
5. Groot AJ de, JJM de, Zegers C. Contents and behavior of mercury as compared with other heavy metals in sediments from the river Rhine and Ems. Geologie Mijnbouw. 1971; 50(3):393-398.
6. Grove AT. The dissolved and solid load carried by some West African rivers: Senegal, Niger, Benue and Shari, J. Hydrol. 1972; 16:277-300.
7. Guy HP, Norman VW. Field methods for measurement of fluvial sediment. Techniques of water resources investigations of the U.S. Geol-Surv. Book3, Applications of Hydraulics chapter C. 1970; 2:59.
8. Henderson FM. Open channel flow. Mac Millan New York, 1966, 522.
9. Holeman FM. The sediment yield of major rivers of the world. Wat. Resour. Res. 1968; 4:737-747.
10. Jaquet JM, Vernet JP, Thomas RL. Etude granulometrique des sediments du lac Leman. Abstr, Int. Sediment Congr. Nice (France). 1975; 11:8.
11. Langbein WB, Dawdy DR. Occurrence of dissolved solids in surface waters in the United States. Prof. Pap. U.S. geol. Surv. 1964, 501-D, 115-D 17.
12. Livingston DA. Chemical composition of rivers and lakes (professional G) in Data of geochemistry, 6th ed. U.S. Geol. Surv. Govt. Printing Office, Washington D.C, 1963, 440.
13. Olaniya MS, Saxena KL, Sharma HC. Pollution studies of Chambal river and its tributaries at Kota, Indian J. Environ. Hlth. 1976; 18:219-226.
14. Palria S. Ecological studies of certain polluted rivers of Rajasthan with special reference to algae. Ph.D. Thesis, Univ. of Udaipur, Udaipur, 1983.
15. Panjwani LA, Dhurve KK. Sedimentation studies in Gandhisagar reservoir- Directorate Irrigation Res. M.P, 1978, 1-22.
16. Prasad SK. Assessment of the cause and consequences of pollution of Ahar river at Udaipur. Ph.D. Thesis, M.L. Sukhadia University Udaipur, 1988.
17. Rana BC, Palria S. Assessment, evaluation and abatement studies of a polluted river Bandi (Rajasthan). In: Ecology and pollution of Indian rivers (Ed. R.K.Trivedi). Asian Pub. House, New Delhi, 1988, 345-359.
18. Rao KS, Srivastava S, Usha Choube. Studies on the superficial sediments of a tropical reservoir: Observations on Gandhi Sagar lake MP, India Arch. Hydrobiol. 1988; 114(1):147-160.
19. Serruya C. Problems of sedimentation in the lake of Geneva- Verh. int. Verein. theor. angew. Llmnol. 1969; 17(2):209-218.
20. Terwindt JHJ. Mud transport in the Dutch Delta area and along the adjacent coastline. Med. J. Sea Res. 1967; 3(4): 505-531.
21. Thomas RL, Kemp ALW, Lewis CFM. Distribution, composition and characteristics of the superficial sediments of lake Ontario. J. Sediment. Petrol. 1972; 42: 68-84.
22. Thomas RL, Kemp ALW, Lewis CFM. The superficial sediment of lake Hurton. C.J. Earth Sc. 1973; 10:226-271.
23. Thomas RI, Jaquet JH. The superficial sediments of lake Superior Abs. Int. sediment congr. Nice (France). 1975; 11:7.
24. Thomas RL, Jaquet JM, Kemp LW, Lewis CFM. Superficial Sediment of Lake Erie. J. Fish. Res. Bd. Canada. 1976; 33(3):385-403.
25. Vernet JP, Thomas RL, Jaquet JM, Friedl R. Texture of sediments of the Petiti lake (Western Geneva). Ecologae Geo. Helv. 1972; 65:591-610.