Effect of Residues amd Chemical Oxygen Demand in Hyderabad City Sewage Added on the Fuleli Canal Water Contents

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Summary: Fuleli canal takes off from left bank of river Indus and passes through Hyderabad city. There are five main entry points where Hyderabad municipal sewage is added to Fuleli canal. The water discharge at each entry point was calculated and water quality was examined in terms of chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (D.O) total, filterable/nonfilter able, volatile and fixed residues, to calculate load of residues/day, month and year added to Fuleli canal. Fuleli canal was also sampled at seven different locations to cover the region. Total residues added to Fuleli canal were calculated to $2.2x10^6$ to $1.2x10^4$ tonnes/year. The effect of residues added and COD during low and high water discharge in Fuleli canal was calculated. Some of the residue were lost to bottom sediments but there was a positive shift in the base line during its travel from Hyderabad city. The effect was more pronounced during low water discharge.

Introduction

The serious surface water pollution in large and medium sized cities located at the banks of the rivers or canals and industrialized areas have been reported [1-6]. Pakistan environmental Agency (EPA) has also proposed water quality standards for municipal and industrial effluents [7].

Fuleli canal takes off from river Indus and passes through Hyderabad city with population of about 1.5 million. Sewage water is added to Fuleli canal by different pumping stations and surface drains, while it travels through Hyderabad city and affects its water quality [8]. A little has been reported about Fuleli canal and water quality of sewage water of Hyderabad city added to Fuleli canal [8-10]. The present work examines COD, BoD, DO and the residues in terms of quality and quantity in Hyderabad sewage water added to Fuleli canal and its effect on Fuleli canal water.

Results and Discussion

Composition of Sewage Water

a) The DO was below the detection limits at all the five sewage sampling stations throughout the study period, the maximum value of COD was 938 mg/L at sampling station II, while the minimum value of 400 mg/L was estimated at IV with over all range was between 160-1797 mg/L (Table 1).

Similarly BOD was observed with average maximum of 828 mg/L at sampling station II and average minimum was 226 mg/L at IV with over all range of 140-1150 mg/L. The high values of COD and BOD at sampling station II (Kali Mori) reflect the strength of organic matter. The sampling station II is an open sewerage line which drains it effluents directly into the canal, where as waste water at IV is biologically treated partially in sewage pond then is pumped into the canal, hence reducing the COD and

Table-I Evaluation of different parameters at different sewage stations (n=17) mean value ± confidence interval at 95% parenthesis show min-max values

Name of Parameter	Sampling Stations in Sewage Water				
	I	II	III	IV	V
DO (mg/L) n=20	N.D	N.D	N.D	N.D	N.D
COD(mg/L) n=15	491.25 ± 217 (200-1260)	938 ± 286.3 (443-1797)	557.5 ± 171.42 (180-1090)	400 ± 115.38 (160-580)	577 ± 190 (220-1210)
BOD(mg/L) n=15	269 ± 97 (159-932)	828.57 ± 178.3 (433-1050)	392.14 ± 131 (225-635)	226.4 ± 62 (140-305}	414 ± 90 (310-750)
Raio of BOD/COD	0.58 (0.36-0.89)	0.79 (0.64-0.99)	0.62 (0.25-0.88)	0.47 (0.25-0.71)	0.55 (0.50-0.96)
Total residue mg/L	2893 ± 315 (1825-4800)	2081 ± 346 (1377-4023)	1822 ± 278 (1277-3195)	1573 ± 237 (1188-2835}	2261 ± 495 (1220-4374)
Total filterable (TDS) mg/L	2498 ±.274 (l425-3625)	1148 ± 118 (818-1733)	1396 ± 193 (1200-2450)	1277 ± 180 (990-2210)	1764 ± 424 (1107-3120)
Total (Non-filterable mg/L	386 ± 14 (112-890)	897 ± 254 (305-2158)	457 ± 178 (2ll-1238)	253 ± 48 (104-387)	498 ± 196 (189-1377)
Total Volatile mg/L	418 ± 50 (240-440)	885 ± 205 (465-2028)	456 ± 94 (300-925)	345 ± 71 (215-756)	539 ± 114 (297-1025)
Total fixed mg/L	2443 ± 312 (1590-4310	1129 ± 135 (810-1917)	228 ± 152 (835-2050)	1145 ± 150 (904-2100)	1643 ± 431 (694-3483)
Volatile in total filterable mg/L	308 ± 49 (115-400)	453 ± 96 (297-999)	327 ± 65 (200-612)	251 ± 66 (135-590)	423 ± 94 (225-837)
Fixed in total filterable mg/L	2176 ± 234 (1275-3225)	693 ± 65 (459-919)	978 ± 91 (710-1307)	1025 ± 157 (810-1900)	1358 ±373 (739-2719)
Volatile in total Non-filterable mg/L	113 ± 26 (48-192)	425 ± 129 (178-970)	174 ± 42 (88-325)	99 ± 29 (42-152)	156 ± 35 (45-270)
Fixed in total Non-filterable mg/L	274 ± 140 (54-1010)	808 ± 151 (135-1211)	270 ± 155 (50-980)	140 ± 39 (47-292)	298 ± 43 (64-1168)

N.D. = Not detected

BOD levels. Thus the work support the importance of sedimentation ponds in reducing COD, BOD and residues of sewage.

The ratio of BOD: COD indicates the biodegradability of waste organic compounds and the ratio in Hyderabad city sewage varied between 0.26-0.99, with an average highest of 0.79 at sampling station II. The BOD:COD ratio was higher than ideal domestic sewage ratio 0.2-0.51 [17] and supports the finding that sewage water is heavily loaded with organic polluting material and could have adverse effects on receiving Fuleli canal.

The total budget of cabron from all the sewage sources calcualted for COD was estimated 1013 tonnes/month with maximum input of 365 tonnes/month from III and minimum of 43 tonnes/month by I.

b) Total Residue

The range of total residue observed in sewage water was 1188-4800 mg/L (Table 2). The average of total residue at each sampling station was calcualted and maximum of 2893 mg/L was observed at sampling station I (Cantonment Board Pumping Station) and minimum of 1573 mg/L at sampling station IV (Darya Khan Pumping Station). The total residue was in following decreasing order:

I>V>II>III>IV

The total load of residue calculated from all the sewage stations was 2.22 million tonnes/annum with maximum contribution of 80474 tonnes/annum from III (29.0%) and minimum of 26372 tonnes/annum from V (11.86%) (Fig. 2).

c) Total Filterable Residue

The filterable residue is due the presence of water soluble salts and was found in the range of 818-3625 mg/L with average maximum of 2498 mg/L at I and minimum of 1118 mg/L at II. The percentage of total filterable residue with respect to total residue was 86.34% and 55.16% at sampling stations I and II respectively indicating that a large amount of electrolytic substances are contributed by I. The concentration of filterable residue in the sewage sampling stations followed the sequence-

I>V>III>IV>II

The flux of total dissolved solids from the sewage stations was $2x10^5$ tonnes/annum with maximum contribution of $6.2x10^4$ tonnes/annum (30.6%) from IV and minimum of $2.1x10^4$ tonnes/annum (10.4%) from V (Fig. 2).

d) Total Nonfilterable Residue

Nonfilterable residue which is due to presence of suspended solids in sewage water was observed in the range of 104 to 2158 mg/L with average maximum of 897 mg/L at II and minimum of 253 mg/L at IV. The maximum was higher by a factor 3.54 than average minimum at IV.

The % of nonfilterable residue in total residue was 43.1% at II, 24.8% at III, 20.2% at V, 16.1% at IV and 13.3% at I. The total load carried by the sewage was $6.4x10^4$ tonnes/annum with contribution of 33.9% from II (Fig. 2).

e) Fixed Residue

Fixed residue in total, filterable and nonfilterable residues were determined and is assumed to contain mainly inorganic components, stable upto 550 ± 50°C. The total residue contained 695-4310 mg/L with average maximum of 2443 mg/L at I and minimum of 1129 mg/L at II. Filterable residue indicated parallel results with 2176 mg/L at I and 693 mg/L at II with a range within 459-3225 mg/L (Table 1). The sewage sampling stations indicated, the following pattern for fixed residue.

Total residue I > V> III> IV>II Filterable residue I> V> IV> III>II

Nonfilterable residue contained 47-1211 mg/L with average maximum of 808 mg/L at II with following decreasing order.

II>V>I ~ III>IV

f) Volatile Residue

Volatile residue was determined in total, filterable, and nonfilterable residue and is a rough index of available biodegradable organic matter present. It was 885 mg/L with an average maximum at II and the average minimum was 345 mg/L at IV. The range in total residue was 215-2028 mg/L. The % of volatile residue in total residue was 42.5%.

Table-II Evaluation of different parameters at stations of fuleli canal (n=24) mean value ± confidence interval at 95% parenthesis show min-max values

Name of Parameter	Sampling Stations						
	1	2	3	4	5	6	7
DO(mg/L)	7.66 ± 0.61	5.16 ± 0.91	2.56 ± 0183	4.36 ± .79	3.68 ± .87	4.11 ± 0.79	5.66 ± .0.84
n=20	(5.65-8.9)	(0-6.6)	(0.5-5.2)	(0.6-4.3l)	(0-6.22)	(0-6.1)	(O.6-7.5)
% Saturation	90.51 ± 5.8	62.35 ± 10.64	29.25 ± 11	52-55 ± 10.29	46.55 ± 11.1	48 ± 10.4	65.38 ± 10.7
n=20 DO	(73-98.5)	(0-88)	(0-70)	(0-85)	(0-81)	(0-81.4)	(0-91)
COD ((mg/L)	25 ± 5.04	63 ± 29.8	134 ± 71	80.86 ± 38	122.6 ± 36	86.8 ± 83	69.5 ± 28.6
n=15	(10-40.5)	(11.5-241)	(16.1-533.6)	(12-301)	(13-626)	(14-278)	(12.5-232)
BOD (mg/L)	2.55±0.21	16.4 ± 13.0	29.7 ± 28	19.8 ± 16.3	32.43 ± 31.1	18.2 ± 15	13.5 ± 15.7
n=15	(1.95-3.41)	(2.75-91.5)	(3.l-197)	(2.68-115.4)	(2.98-217.7)	(2.91-103.5)	(2.65-110)
Total Residue	666 ± 321	1073 ± 410	915 ± 361	959±361	868 ± 219	877 ± 250	883 ± 2.85
mg/L	(320-2780)	(445-2960)	(475-2580)	(497-3140)	(395-1340)	(487-1980)	(442-2040)
Total Filterable	247 ± 48	603 ± 297	526 ± 238	466 ± 180	599 ± 139	475 ± 145	452 ± 165
(TDS) mg/L	(132-566)	175-2205^	(155-1850^	(150-1490.	(190-1380	(145-1290)	(140-1148)
Total Non- Filterable	428 ± 326	475 ± 269	289 ± 171	496 ± 341	230 ± 93	407 ± 241	434 ± 230
TSS mg/L	(40-2563)	(70-2012)	(121-1240)	(99-2719}	(52-740)	(73-1425)	(68-1382)
Total volatile	88 ± 19	154 ± 27	185 ± 42	171 ± 45	167±30	163 ± 38	112 ± 31
mg/L	(38-170}	(80-260)	(66-380)	(45-417)	(51-280)	(42-300)	(39-200)
Total Fixed	575±315	883 ± 403	797 ± 297	765 ± 347	645 ± 153	723 ± 244	781 ± 266
mg/L	275-2620)	(295-2700)	(305-2200)	(315-2880)	(320-1400)	(275-1800)	(297-1940)
Voltile in total	57 ± 13.5	99 ± 17	105 ± 24	101 ± 25	100 ± 15	106 ± 28	69 ± 21
filterable	(15-110)	(40-160)	(36-178)	(30-200)	(55-192)	(18-192)	(16-147)
Fixed in total	186 ± 44	494 ± 285	417 ± 228	367 ± 166	478 ± 134	385 ± 129	391 ± 153
ilterable	(91-456)	(100-2040)	(98-1704)	(89-1340)	(125-1170)	(110-1130)	(112-1038)
Volitel in total	34 ± 8.1	60 ± 14.3	79 ± 22.3	71 ± 24	61 ± 20	58 ± 16	50 ± 13
Non-filterable	(11.3-70)	(13.3-105)	(28-210)	(19-220)	(16-150)	(23-140)	(10-92)
Fixed total	389 ± 323	412 ± 264	310 ± 166	419 ± 341	170 ± 89	327 ± 202	383 ± 226
Non-filterable	(26-2493)	(28-1907)	(64-1212)	(36-2626)	(29-700)	(42-1405)	(39-1302)

The volatile residue in filterable and nonfilterable residues followed same pattern as for total with average maximum and minimum at sampling stations II and IV, respectively.

The sewage water is highly loaded with residues and nonfilterable residue crossed the safe limits of 150 mg/L recommended by NEQS, Environmental Protection Agency Govt. of Pakistan [7]. This could cause blockage of sewage lines by sedimentation of suspended particles and may become a source of pollution.

B. Composition of Fuleli Canal Water

a) Average D.O at sampling station I before the addition of sewage water was 7.66 mg/L. However a decline in the contents of DO was observed along Fuleli canal and at samplintg stations 2 to 7, average values were within 2.56 to 5.66 mg/L due to the addition of sewage water to Fuleli canal (table 2).

Mean concentrations of COD and BOD in Fuleli canal before the addition of sewage water at sampling station 1 were 25 mg/L and 2.6 mg/L respectivley. A significant increase in the cocnentration of COD and BOD was observed at stations 2 to 7 due to the addition of sewage water with average maximum of 134.2 mg/L and 29.7 mg/L and average minimum of 63 .0 mg/L and 13 .5 mg/L respectively (Table-II). Statistically reciprocal relation was osberved for DO with respect to COD and BOD with regression coefficients (r) of -0.90 and -0.85, whereas COD and BOB themself indicated positive relationship with r = + 0.94.

In the month of August when there was heighest dilution ratio due to high flow in the canal, some decrease in % saturation of DO was observed throughout the canal due to high amount of nonfilterable residues carried by extensive flow in the canal with decrease in the levels of COD and BOD. However again maximum value of COD and BOD reached at sampling station 3. Thereafter some improvement in the contents of DO was observed with decrease in the values of COD and BOD upto station 7. During the month of lowest discharge in canal from river Indus (January), there was a maximum drop in the contents of DO, with maximum value of COD and BOD, because of little dilution of sewage added.

b) Variation of Residues Along Fuleli Canal

The average total residue before addition of sewage to Fuleli canal (sampling station 1) was 668 mg/L, which increased to 1073 mg/L at 2 due to the addition of sewage water to Fuleli canal (Table 2) . The over all fluctuation of residue along the canal was observed between 395-3140 mg/L.

Similarly mean filterable residue 243 mg/L at sampling station 1 increased to 603 at 2. However, a similar variation in nonfilterable residue along the Fuleli canal was not observed. The mean nonfilterable residue observed 428 mg/L at sampling station 1 decreased to 230 mg/L at 5 (Table 2)

Total and filterable residue indicated a positive shift along Fuleli canal with increase in filterable residue as compared to 1. The high amount of nonfilterable residue at 1 is due to the silt carried by water from Indus and during travel along Fuleli canal sedimentation is involved, with some decrease of nonfilterable residue, in spite of addition of sewage water.

The mean total volatile and fixed residue at sampling station 1 of Fuleli canal were 88 mg/L and 575 mg/L respectively but with the introduction of sewage water the average'volatile residue increased in range of 154-185 mg/L and fixed residue within 645-883 mg/L. The variation in volatile and fixed residue along the canal were 39-417 mg/L and 275-2880 mg/L. The results indicated that organic matter in the canal from sampling station 2 to 7 was concentrated more in the nonfitierable residue than in fitlerable fraction. The % of fixed residue in the nonfilterable fraction was significantly higher than in filterable component at sampling station 1, while at sampling station 2 to 7 fixed residue in nonfilterable and fitlerable fraction indicated reciprocal pattern with voaltile residue (Table 2).

The % of filterable fraction in total residue was 36.4% and was lower than nonfilterable fraction at sampling station 1, while % of fitlerable fraction was 65 at sampling station 5 and was higher than its nonfilterable fraction. The results suggest that the sewage water was heavily loaded with organic matter and soluble salts, which have significant effect on filterable and voaltile fraction of total residue. The linear relations of residues (total and nonfilterable) with water discharge were observed (Fig. 3). The

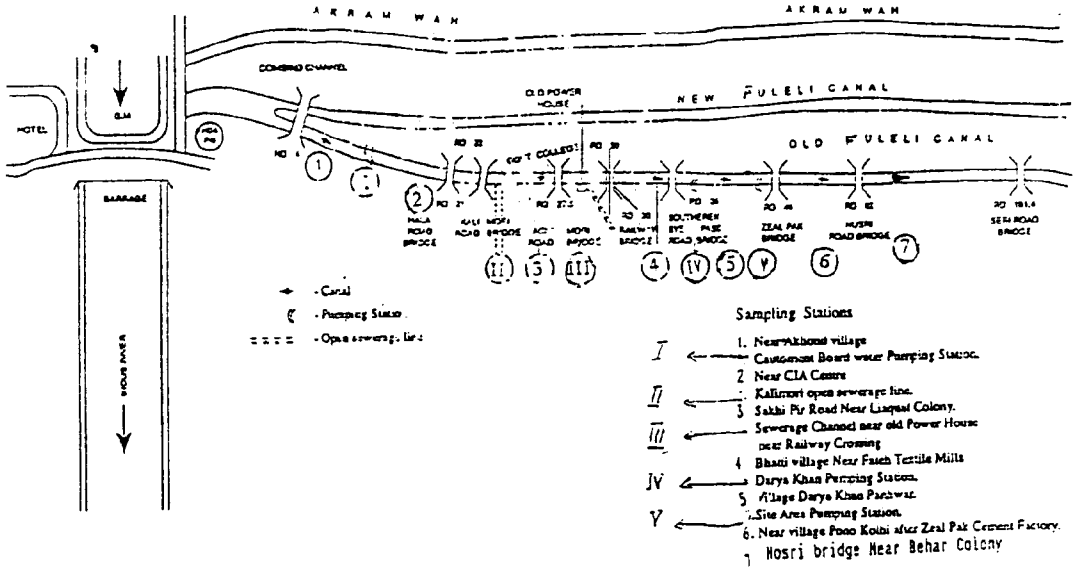

Fig. 1: Map indicating Fuleli canal and sampling stations.

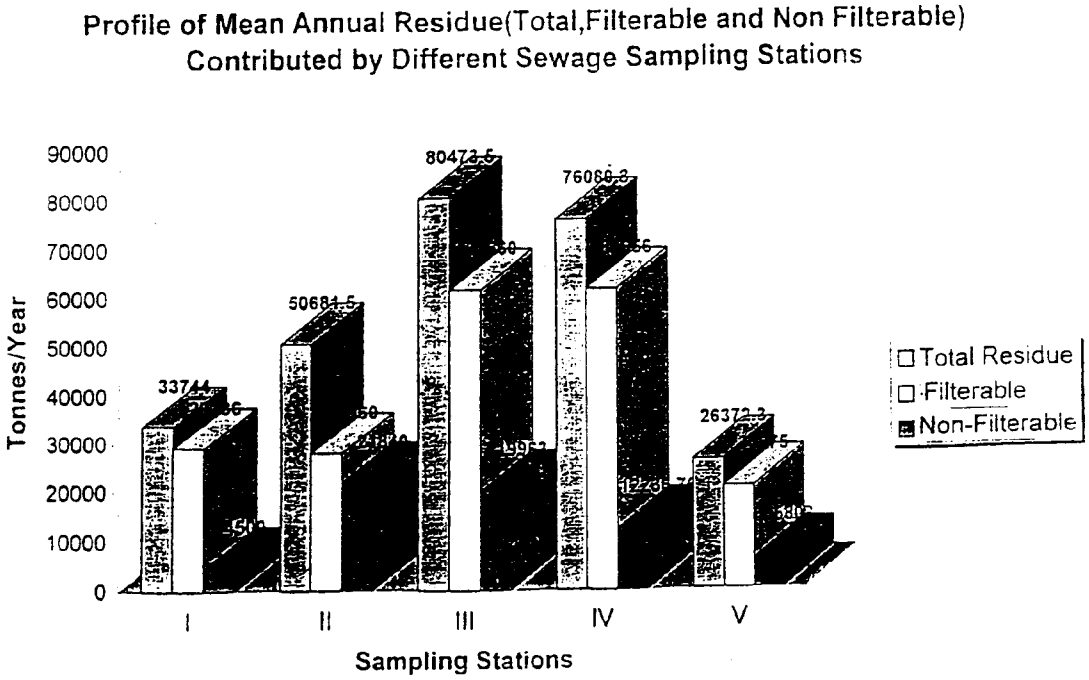

Fig. 2: Mean annual residues tones/year (total, filterable and nonfilterable) contributed by sewage sampling stations (I) contonment Board waste pumping station (II) Kali Mori Open sewage Line (III) Sewage Channel near old Power House (IV) Darya Khan Pumping Station and (V) site area Pumping Station.

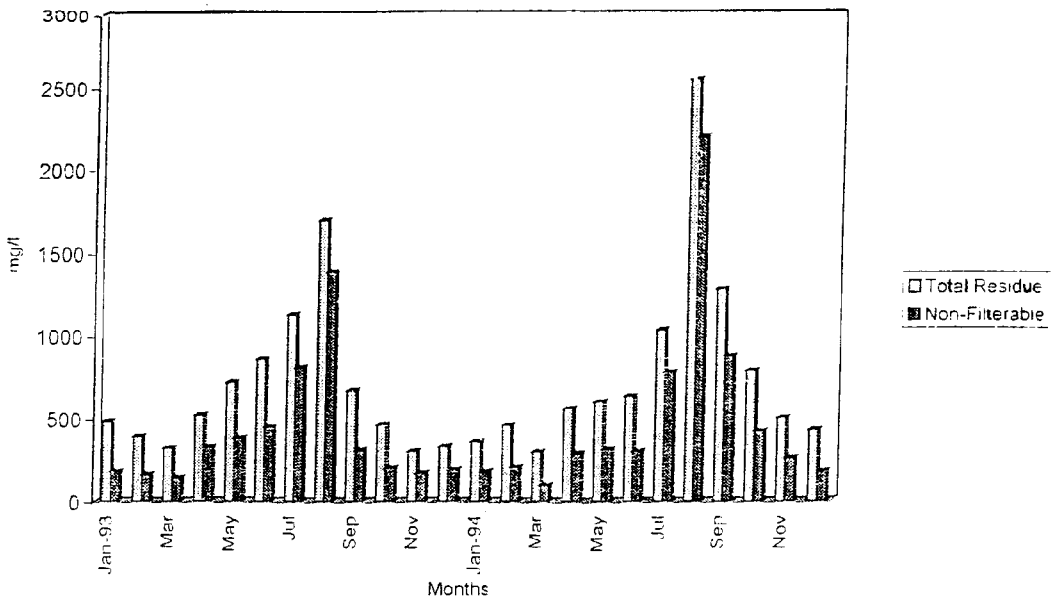

Fig. 3: Monthly variation of total and nonfilterable residue at sampling station 1, before the addition of sewage to Fuleli canal.

regression coefficient of total and nonfilterable residue with discharge at sampling station 1 and 3 were observed 0.81 and 0.72, and 0.76 and 0.69 respectively.

The variation in residue along canal during peak flow of water (August) was less due to high dilution factor in the canal, while during the low water discharge there was a significant variation in total, filterable and volatile residue at sampling stations 2 to 7. During the month of January, February and March, there was a sharp shift in a total, filterable and volatile residues at sampling station 2 and onwards with remarkable increase in different forms of residues.

Experimental

Five main sewage station (1 to V) were selected and seven samples (1 to 7) along Fuleli canal were collected (Fig. 1), Grab water sampling scheme was used for the collection of the sample from the sewage lines [11-12]. However because of extremely high pressure it was not possible to collect a cross section of the flow or from the middle of the flow, but it was possible to penetrate a few cm in the flow of water and sample was collected. The sample from Fuleli canal, where possible two to four sub-samples from the cross-section were taken from the bridge by lowering the bucket with a rope. Where it was not possible the sample was collected 3-4 m from the side of canal. The scheme was repeated every 4-6 weeks for 27 months (1993-1995).

Sub-samples collected from each of the sampling station were mixed thoroughly and were transferred to 2.5 L prewashed glass bottle rinsed with sample water several times before transfer of sample. The samples for residues were analysed within 24 hrs.

The residues (total, filterable, nonfilterable, volatile and fixed) were determined as reported [11]. The residue (Total) in canal and sewage water was obtained by weighing the material left after evaporation of well mixed samples (100 ml) and drying the residue at 105°C. Residue (Filterable and non-filterable) were obtained by filtering the measured volume (50-200 ml) on glass fiber filter 47 mm, 0.47 um (Gelman Sciences, Australia)]. The filter was dried and reweighed. Similarly the filterate was evaporated, dried at 105°C and weighed. Each of the residue was heated at 550 ± 50°C for 2 hrs in a

muffle furnace (Rheonix Alpha 1, Shaffield, England) to determine volatile and fixed matter in the residue. The loss in weight corresponded to volatile residue and the weight left to fixed residue.

Dissolved oxygen (D.O) was determined by Wrinkler (iodemetric) method [11]. Chemical oxygen demand (COD) was estimated by dichromate oxidation method [13-14]. Biological oxygen demand (BOD) for five days at 20°C was carried out using standard procedure [11,15].

Average water discharge in Fuleli canal was obtained from the records of control room Kotri Barrage. Quantity of the water discharge of sewage was calculated using the relation

$$Q = \{ (BxD) \times (S/T)\}$$

where B = breath, D = depth, S = specified distance in drain and T=time taken by water for specified distance. For trapezoid shaped drain Q was calcualted form the relation.

$$Q - [\{(A+B/2) \times D\} \times S/T]$$

A = top width of water level and B = bottom width of drain. Time of flow over a specified distance and the depth and width of the channel were calculated at the site. For the sewage ponds where the pumps are lifting the waste water and introducing into the canal the discharge was estimated from the capacity of pumps x 0.108 and average operating hr. of pumps.

The total load of residue or COD in tonnes/month was calcualted from relation. Residues or COD tonnes/month = Residues (Total, filterable, nonfilterable) (COD) (g/m^3) x average water discharge (m^3/s) x (60x60x24x30 x.000001) = (g/m^3) x av. water discharge (m3/S)x2.592. Residue or COD mg/L were multiplied by 1 to convert into g/m3 and water discharge in cusec was multiplied by 0.028 to convert into m^3/S. The results of COD were multiplied with 0.375 to convert them into carbon unit [16].

Conclusions

Hyderabad city sewage was highly loaded with COD, BOD and residues. DO was also found absent. The effect of sedimentation ponds, in reducing COD, BOD and residues from sewage was visible. The addition of sewage water to Fuleli canal enhanced the parameters, which reached to the maximum values during low water discharge. It is therefore suggested that direct inlet of sewage may be stopped and sewage may be diverted to pass through sedimentation ponds for primary biological treatment.

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