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Original Research Paper

Physico-Chemical Characteristics of Storm Water Flow Canal Under the Influence of Tides

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ABSTRACT

Present study, conducted during low tide (Feb. 2007) and high tide (Apr. 2007), revealed that the tannery effluents after mixing with the sewage canals near Karaidanga changes the water chemistry of storm weather flow canal culminating into Bidyadhari river to a large extent with respect to conductivity, total alkalinity, total nitrogen and trace metals. The effect of dilution during high tide greatly reduces the concentration of these parameters downstream before mixing with Bidyadhari river.

INTRODUCTION

For centuries, rivers and lakes have been used as dumping grounds for domestic sewage and industrial wastes of different kinds, many of them have been highly toxic. The development due to fast urbanization and industrialization has negatively affected the environment. The fast springing industries let out untreated effluent into the neighbouring waters. The Municipal Corporations often discharge the untreated sewage to nearby areas which ultimately find its way into waterbodies and thereby alter their physico-chemical and biological characteristics.

MATERIALS AND METHODS

During the present study five sampling sites from Storm Weather Flow (SWF) canal were chosen for examining the chemical characteristics in the three fractions, viz., water, sediments and plants of the canal. This 35 km long canal, carrying tanning effluents, starts near Topsia sewage pump station and enters into Bidyadhari river near Baman Pukur. Samples were collected covering both receding and high tidal conditions from the selected sampling sites as given below and shown in Fig. 1.

Site No.	*Sampling station*	*Latitude*	*Longitude*
1.	Starting point of SWF and DWF near Topsia Sewage Pump Station	22°32’22"N	88°23’17"E
2.	Bantala after meeting of SWF and DWF	22°31’35"N	88°26’38"E
3.	Tannery waste effluent	22°30’29"N	88°31’29"E
4.	SWF near tannery waste effluent discharge point	22°30’29"N	88°31’31"E
5.	Gusighata SWF before the lock gate	22°31’23"N	88°41’14"E

Water samples were collected using a clean polythene bucket and analysed for selected parameters. Physico-chemical estimations were made according to Trivedy & Goel (1986) and APHA (1998).

Analysis of trace metals Cd, Cr, Cu and Pb was carried out in finely ground plant and sediment samples.

RESULTS AND DISCUSSION

The data on physico-chemical characteristics of the Storm Weather Flow (SWF) canal during low and high tides are given in Table 1, 2 and Figs. 2, 3. Low tide period reveals that air temperature varied from 31°C to 32°C with minimum values observed at sites 1 and 5, and maximum at sites 2, 3 and 4. On the other hand, during high tide period the air temperature varied from 33°C to 39°C with minimum value observed at site 5, and maximum value at site 3.

During low tide period, temperature of effluent varied from 29°C to 30°C with minimum values observed at sites 1 and 6, and maximum values at sites 2, 3, 4 and 5. On the other hand during high tide period, temperature of effluent varied from 30°C to 37°C with minimum values observed at site 5, and maximum values at sites 2 and 4. During high tide both air and water temperature was high in comparison to low tide period.

pH of the effluent varied from 7.0 to 8.0 with minimum value observed at site 1, and maximum value at site 4. On the hand during high tide period, pH of effluent varied from 7.0 to 7.55 with minimum value observed at site 1, and maximum value at site 3. pH recorded was alkaline which shift towards downward sites.

During low tide period, total alkalinity of effluent changed from 479.4 ppm to 2175.625 ppm with minimum value observed at site 5, and maximum value at site 4. At high tide period, total alkalinity of effluent varied from 553.1 ppm to 3429.3 ppm with minimum value observed at site 5, and maximum value at site 3. No specific trend has been observed for total alkalinity.

During low tide period, dissolved oxygen of effluent varied from below detection level (sites 1, 2, 3 and 4) to 4.42 ppm (site 5). During high tide period dissolved oxygen of effluent again varied from below detection level to 3.84 ppm with minimum values observed at sites 1, 2, 3 and 4, and

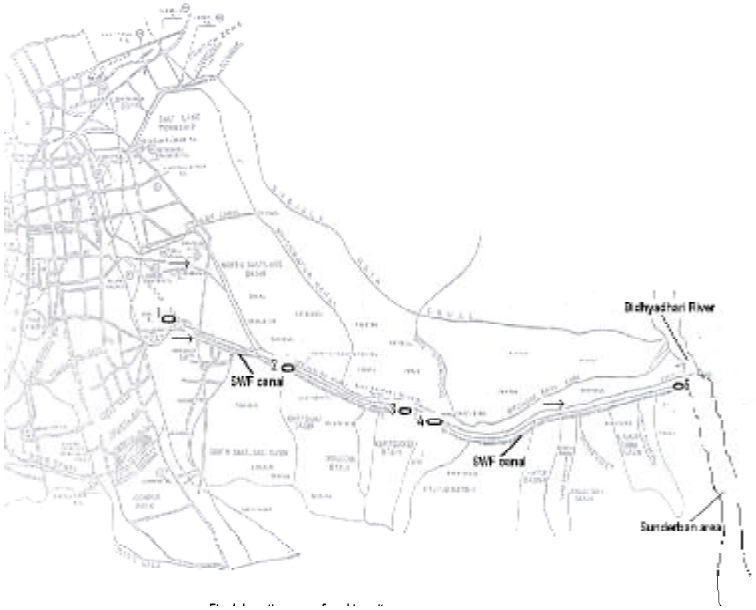

Fig. 1: Location map of working sites.

Table 1: Physico-chemical parameters of canal water during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

Elements		Minimum	Maximum
Air temp. (°C)	Low tide	31 (S 1,2)	32 (2,3,4)
	High tide	33 (S 5)	39 (S 3)
Water temp. (°C)	Low tide	29 (S 1)	30 (S 1)
	High tide	30 (S 1)	37 (S 1)
pH	Low tide	7.0 (S 1)	8.0 (S 4)
	High tide	7.0 (S 1,2)	7.5 (S 3)
DO (ppm)	Low tide	0.00 (S 1,2,3,4)	4.42 (S 5)
	High tide	0.0 (S 1,2,3,4)	3.84 (S 5)
Total alkalinity (ppm)	Low tide	479.4 (S 1,5)	2176 (S 4)
	High tide	553.12 (S 5)	3429.40 (S 3)
Total hardness (ppm)	Low tide	420 (S 1)	920 (S 5)
	High tide	190 (S 1)	42000 (S 5)
Ca^{++} Hardness(ppm)	Low tide	160 (S 1)	440 (S 4)
	High tide	105 (S 1)	490 (S 5)
Mg^{++} Hardness (ppm)	Low tide	39.04 (S 4)	126.90 (S 5)
	High tide	64.26 (S 1)	31457.16 (S 5)
Hardness on account of other metals (ppm)	Low tide	120.20 (S 4)	393.12 (S 5)
	High tide	21 (S 1)	10153 (S 5)
COD (ppm)	Low tide	87 (S 4)	330 (S 5)
	High tide	40 (S 4)	1120 (S 5)

Notes: Name of sampling sites
Site 1. Starting point of SWF and DWF near Topsia Sewage Pump Station; Site 2. Bantala after meeting of SWF and DWF. Site 3. Tannery waste effluent; Site 4. SWF near Tannery waste effluent discharge point; Site 5. Gusighata SWF before the lock gate.

maximum value at site 5. Enhancement in DO value at site 5 is on account of sedimentation of effluents before reaching the lock gate side.

During low tide period total hardness of effluent varied from 420 ppm to 920 ppm with minimum value observed at site 1, and maximum value at site 5. Total hardness of effluent during high tide period varied from 190 ppm to 42000 ppm with minimum value observed at site 1, and maximum value at site 5. The values enhanced from site 3 onwards up to the last site. During both the periods Ca and Mg hardness was relatively more in comparison to previous sites viz., 1 and 2.

During low tide period COD of the effluent varied from 87 ppm to 330 ppm with minimum value observed at site 4, and maximum value at site 5. On the other hand, during high tide period COD of effluent varied from 40 ppm to 1120 ppm with minimum value at site 4, and maximum value at site 5. COD was recorded more during high tide period than low tide period.

Electrical conductivity of the effluent water during low tide period varied from 1073 µS/cm (site 1) to 15190 µS/cm (site 4). On the other hand, during high tide period, conductivity of effluent waters varied from 1154 µS/cm to 19330 µS/cm with minimum value at site 1, and maximum value at site 5. An increase in electrical conductivity and salinity values towards downstream is an obvious feature in such streams through a decline in total suspended solids and increase in chloride.

During low tide period total phosphate of the effluent varied from 1.90 ppm to 37.65 ppm with minimum value at site 5, and maximum value at site 1. On the other hand, during high tide period total phosphate of the effluent varied from 0.021 ppm to 0.124 ppm with minimum value at site 4, and maximum value at site 1.

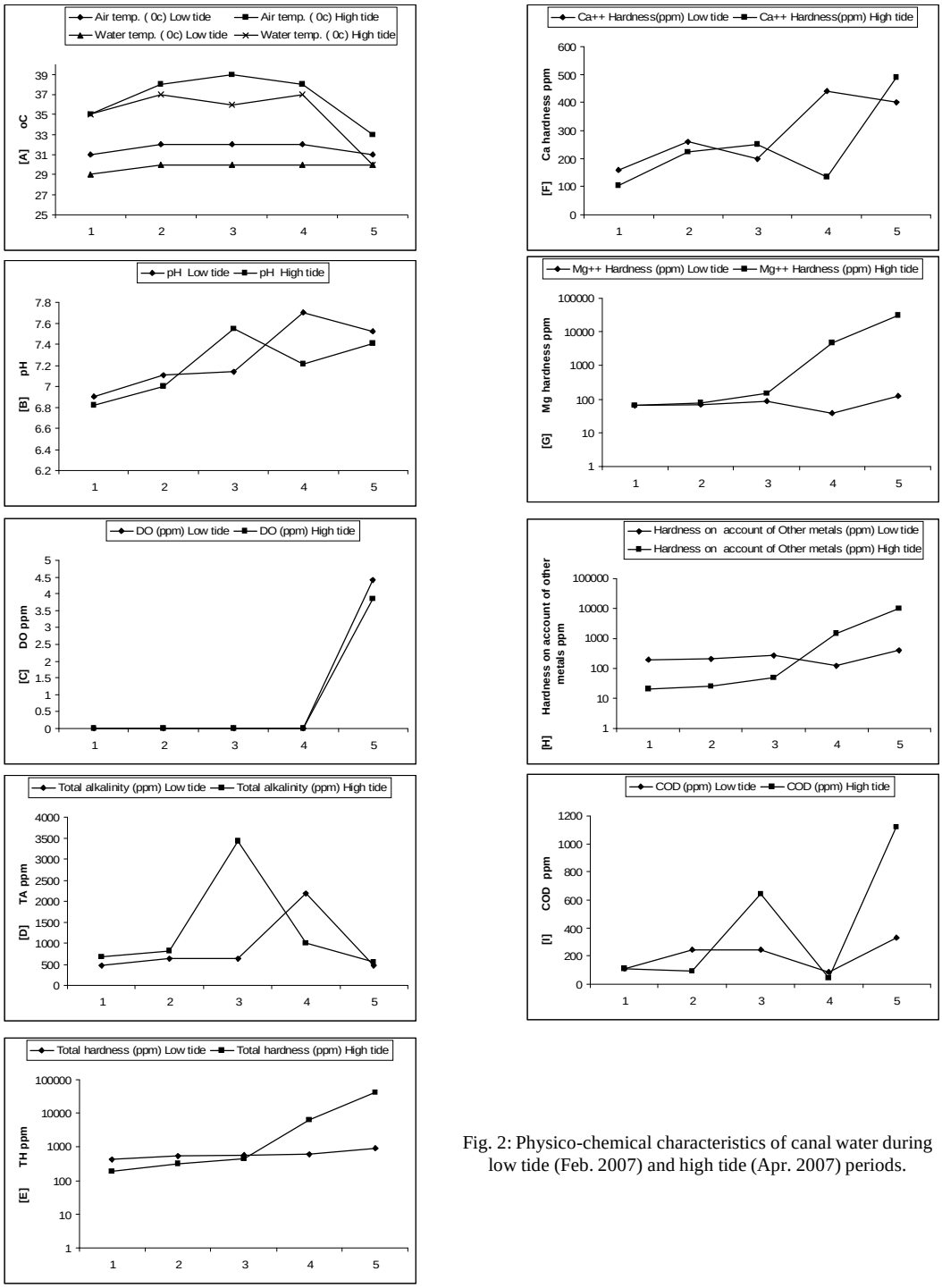

Fig. 2: Physico-chemical characteristics of canal water during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

Table 2. Physico-chemical characteristics of canal water during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

Elements		Minimum	Maximum
Conductivity (iS /cm)	Low tide	1073 (S 1)	15190 (S 4)
	High tide	1154 (S 1)	19330 (S 5)
Salinity (ppm)	Low tide	0.3 (S 1)	9.0 (S 4)
	High tide	0.3 (S 1)	12.0 (S 5)
TSS (ppm)	Low tide	2.1 (S 5)	53 (S 3)
	High tide	11.4 (S 1)	18.3 (S 3)
Chloride (ppm)	Low tide	99.4 (S 4)	1335 (S 2)
	High tide	117.5 (S 1)	682 (S 5)
Total PO_4 (ppm)	Low tide	1.90 (S 5)	37.65 (S 1)
	High tide	0.021 (S 4)	0.062 (S 1)
Total Nitrogen(ppm)	Low tide	42.25 (S 3)	113.62 (S 4)
	High tide	0.01 (S 4)	0.14 (S 5)
Ammonical Nitrogen (ppm)	Low tide	0.43 (S 5)	2.75 (S 4)
	High tide	0.00 (S 1)	133.4 (S 4)
Nitrite[NO_2-N](ppm)	Low tide	0.00 (S 1)	1.42 (S 1)
	High tide	0.00 (S 1)	167.3 (S 3)

Notes: Name of sampling sites
Site 1. Starting point of SWF and DWF near Topsia Sewage Pump Station; Site 2. Bantala after meeting of SWF and DWF. Site 3. Tannery waste effluent; Site 4. SWF near Tannery waste effluent discharge point; Site 5. Gusighata SWF before the lock gate.

During low tide period total nitrogen of effluent varied from 4.25 ppm to 135.875 ppm with minimum value at site 3, and maximum value at site 4. On the other hand during high tide period total nitrogen of effluent varied from 0.01 ppm to 0.14 ppm with minimum value at site 4 and, maximum value at site 5. The values were more during low tide period at all the sites in comparison to high tide period. The reason for low values of total phosphate and total nitrogen during high tide is on account of dilution; however, on the other hand ammonical nitrogen and nitrite nitrogen values were more during high tide period.

The tannery waste water entering near site 4 has been found to change the water chemistry to a large extant with respect to conductivity, total alkalinity and total nitrogen during low tide period. During high tide period, the effect of dilution greatly reduces the concentration of these parameters as recorded during low tide period.

Trace metal concentration in canal water: During low tide period, cadmium concentration of effluent varied from 0.0651 ppm to 0.251 ppm with minimum value at site 4 and, maximum value at site 3. On the other hand, during high tide period cadmium concentration of effluent varied from 0.1343 ppm to 0.4277 ppm with minimum value at site 4 and, maximum value at site 3 (Table 3, Fig. 4).

Chromium concentration of effluent waters during low tide period varied from 0.9181 ppm to 12.888 ppm with minimum value at site 4 and, maximum value at site 3. On the other hand, during high tide period chromium content of effluent varied from 0.9301 ppm to 6.367 ppm with minimum value at site 5 and, maximum value at site 2 (Table 3, Fig. 4).

During low tide period copper content of effluent varied from 0.0433 ppm to 0.2962 ppm with minimum value at site 3 and, maximum value at site 2. On the other hand, during high tide period copper content of effluent varied from 0.3691 ppm to 0.934 ppm with minimum value at site 5 and, maximum value at site 2 (Table 3, Fig. 4).

Table 3: Toxic metal characteristics of canal water during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

Elements		Minimum	Maximum
Cd (ppm)	Low tide	0.0651 (S 4)	0.251 (S 3)
	High tide	0.1343 (S 4)	0.4277 (S 3)
Cr (ppm)	Low tide	0.9161 (S 4)	12.888 (S 3)
	High tide	0.9301 (S 5)	6.367 (S 2)
Cu (ppm)	Low tide	0.0433 (S 3)	0.2962 (S 2)
	High tide	0.3691 (S 5)	0.934 (S 2)
Pb (ppm)	Low tide	0.9046 (S 2)	2.0655 (S 3)
	High tide	1.1229 (S 4)	2.6384 (S 3)

Table 4: Physical characteristics of sediment during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

Elements		Minimum	Maximum
Soil temp. (°C)	Low tide	26.2 (S 2)	26.4 (S 5)
	High tide	29.4 (S 1)	29.4 (S 1)
pH	Low tide	7.6 (S 2)	7.85 (S 5)
	High tide	7.03 (S 2)	7.18 (S 5)
Conductivity	Low tide	445 (S 2)	1316 (S 5)
(μS/cm)	High tide	556 (S 2)	2010 (S 5)

Notes: Name of Sampling sites
Site 1. Starting point of SWF and DWF near Topsia Sewage Pump Station; Site 2. Bantala after meeting of SWF and DWF. Site 3. Tannery waste effluent; Site 4. SWF near Tannery waste effluent discharge point. Site 5. Gusighata SWF before the lock gate.

Concentration of lead in effluent waters varied from 0.9046 ppm to 2.0655 ppm with minimum value observed at site 2 and, maximum value at site 3. On the other hand, during high tide period lead concentration of effluent varied from 1.12 ppm to 2.63 ppm with minimum value observed at site 4 and, maximum value at site 3 (Table 3, Fig. 4).

Trace metal concentration at site 3 was relatively higher in comparison to other sites, the reason being that the tannery effluent directly meets at this point. In general, water of the canal remained impregnated with trace elements throughout the study period. Trace metals, viz., chromium and lead were recorded in higher proportion in comparison to Cu and Cd during both the periods of tides.

Trace metal concentration in sediments: Physico-chemical characteristics and heavy metal content of sediments are given in Tables 4 and 5. Cadmium content of sediment during low tide period varied from 0.0875 ppm to 0.1731 ppm with minimum value at site 5 and, maximum value at site 2. During high tide period cadmium content of sediment varied from 0.0739 ppm to 1.6488 ppm with minimum value at site 5 and, maximum value at site 2.

Chromium concentration of sediment during low tide period varied from 1.3718 ppm to 3.0817 ppm with minimum value at site 5 and, maximum value at site 2. On the other hand, during high tide period the concentration of chromium in sediment varied from 1.48 ppm to 31.2 ppm with minimum value at site 5 and, maximum value at site 2.

Table 5: Toxic metal concentration in sediment during low tide (Feb. 2007) and high tide (Apr.2007) periods.

Elements		Minimum	Maximum
Cd (ppm)	Low tide	0.0875 (S 2)	0.1731 (S 5)
	High tide	0.0739 (S 2)	1.6488 (S 5)
Cr (ppm)	Low tide	1.3718 (S 2)	3.0815 (S 5)
	High tide	1.4848 (S 2)	31.2 (S 5)
Cu (ppm)	Low tide	0.5947 (S 2)	0.9592 (S 5)
	High tide	0.4436 (S 2)	7.386 (S 5)
Pb (ppm)	Low tide	1.2885 (S 2)	1.746 (S 5)
	High tide	8.98 (S 2)	1.2943 (S 5)

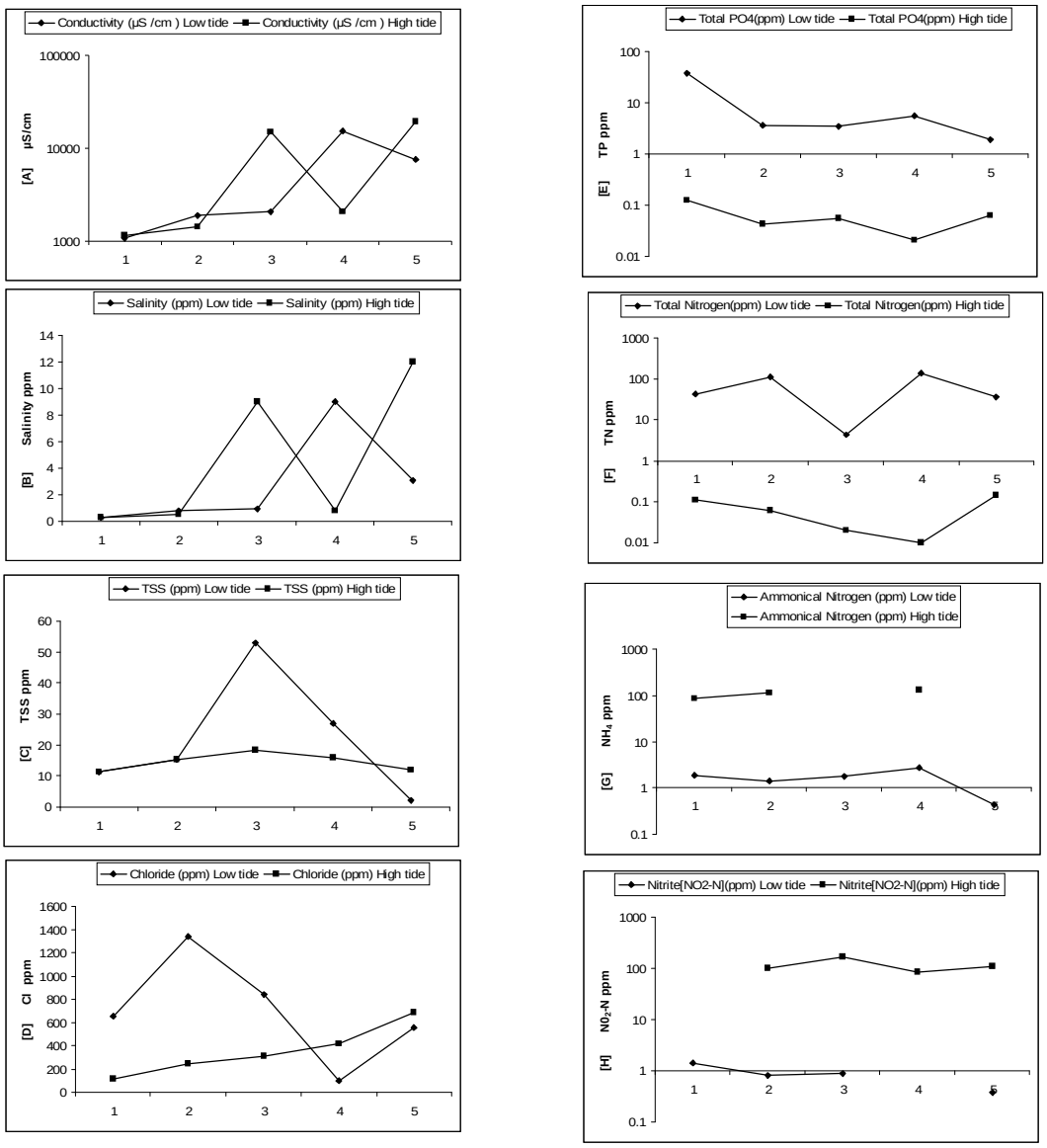

Fig. 3: Physico-chemical characteristics of canal water during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

Copper content of sediment during low tide period varied from 0.59 ppm to 0.95 ppm with minimum value at site 5 and, maximum value at site 2. On the other hand, during high tide period copper content of sediment varied from 0.44 ppm to 7.38 ppm with minimum value at site 5 and, maximum value at site 2.

During low tide period lead concentration of sediment varied from 1.28 ppm to 1.74 ppm with minimum value observed at site 5 and, maximum value at site 2. During high tide period lead

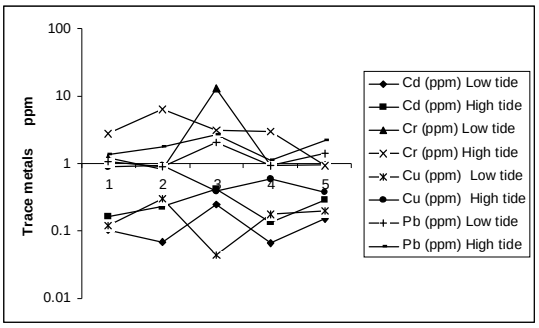

Fig. 4: Toxic metal characteristics of canal water during low tide (Feb. 2007) and high tide (Apr. 2007) periods.

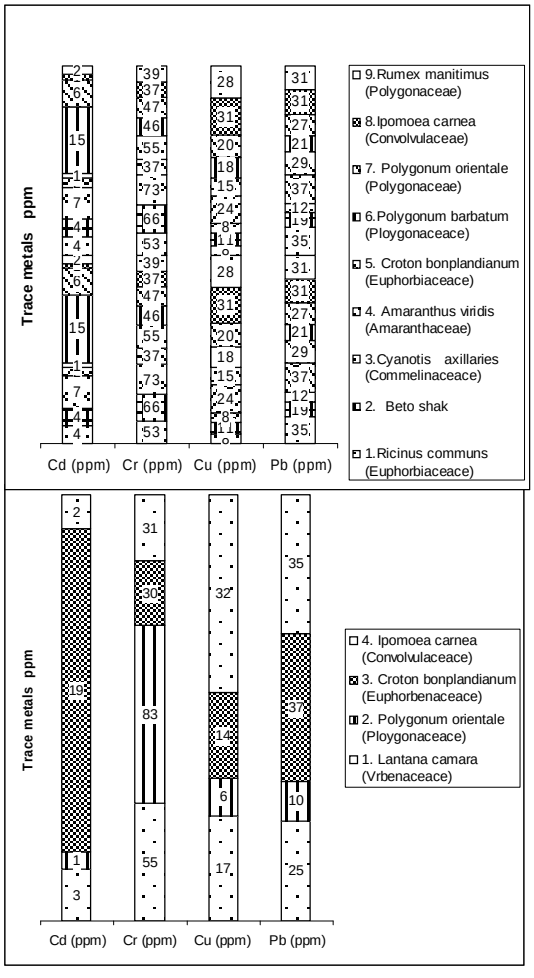

Fig. 5: Toxic metal concentration in plants collected during low and high tide periods.

concentration of sediment fluctuated from 1.29 ppm to 8.98 ppm with minimum value at site 5 and, maximum value at site 2.

Sediments were enriched with trace metals at site 2 in comparison to site 5 during both the tidal periods. During high tide period, level of trace elements towards down site would considerably decrease in concentration.

Trace metal concentration in plants: During low tide minimum concentration of Cd, Cr and Pb was recorded in *Rumex manitimus* sps., while *Ricinus communis* recorded low concentration of Cu. On the other hand, maximum concentration of Cd and Cr was recorded in *Cyanotis axillaries* and that of Cu and Pb in *Polygonum barbatum* (Table 6 and Fig. 5). Likewise, minimum and maximum concentration of metals varied during high tide also. Minimum concentration of Cr and Pb was recorded in *Ipomoea carnea*. *Lantana camara* and *Polygonum orientale* recorded low concentration of Cd and Cu respectively. High concentration of Cr, Cu and Pb was recorded in *Polygonum orientale*. *Croton bonplandianum* recorded high concentration of Cd (Table 7 and Fig. 5). During high tide period vegetation collected from site S1 and S2 were different from the vegetation collected from same sites during low tide. All the plants during low tide and high tide accumulated trace metals in the following sequence.

Cr > Pb > Cu > Cd

Polygonum barbatum recorded high concentration of Cd (15 ppm) in comparison to other plants at site 4. *Polygonum orientale* in comparison to other plants absorbs chromium, lead and copper to a great extant during high tide period (Table 6). Likewise during low tide *Polygonum barbatum* was efficient in absorbing copper and lead in comparison to other plants, while *Cyanotis axillaries* was efficient in absorbing copper and lead during low tide period (Table 6). In general, almost all the plants have the capability of absorbing good

Table 6: Toxic metal concentration in plants collected during low tide (Feb. 2007) period.

Elements	Minimum	Maximum
Cd (ppm)	0.0232 (S 5, P 9)	0.6344 (S 2, P 3)
Cr (ppm)	0.5561 (S 5, P 9)	6.8276 (S 2, P 3)
Cu (ppm)	0.2252 (S 1,P 1)	1.016 (S 4, P 6)
Pb (ppm)	0.4345 (S 5, P 9)	1.1918 (S 4, P 6)

Notes: Name of sampling sites
Site 1. Starting point of SWF and DWF near Topsia Sewage Pump Station; Site 2. Bantala after meeting of SWF and DWF. Site 3. Tannery waste effluent. Site 4. SWF near Tannery waste effluent discharge point. Site 5. Gusighata SWF before the lock gate.

Plant samples during low tide (Feb. 2007) period
1. ***Ricinus communis***(Euphorbiaceae); 2. Beto shak; 3. ***Cyanotis axillaries*** (Commelinaceace)
4. ***Amaranthus viridis*** (Amaranthaceae); 5. ***Croton bonplandian*** (Euphorbiaceace) 6. ***Polygonum barbatum*** (Ploygonaceace)
7. ***Polygonum orientale*** (Polygonaceae); 8. ***Ipomoea carnea*** (Convolvulaceae); 9. ***Rumex manitimus*** (Polygonaceae)

Table 7: Toxic metal concentration in Plants collected during high tide (Apr. 2007) period.

Elements	Minimum	Maximum
Cd (ppm)	0.031 (S 5, P 1)	0.3747(S 4, P 3)
Cr (ppm)	0.518(S 5, P 4)	6.4628(S 2, P 2)
Cu (ppm)	0.2816(S 4, P 2)	0.5593(S 2, P 2)
Pb (ppm)	0.5779(S 5, P 4)	0.8504(S 2, P 2)

Notes: Name of sampling sites
Site 1. Starting point of SWF and DWF near Topsia Sewage Pump Station; Site 2. Bantala after meeting of SWF and DWF. Site 3. Tannery waste effluent. Site 4. SWF near Tannery waste effluent discharge point. Site 5. Gusighata SWF before the lock gate.

Plant samples during High tide (Apr. 2007) period.
1. ***Lantana camara*** (Vrbenaceace); 2. ***Polygonum orientale*** (Ploygonaceace); 3.***Croton bonplandianum*** (Euphorbenaceace)
4. ***Ipomoea carnea*** (Convolvulaceace)

Table 8: Trace metals composition in three components of system.

Elements	*Canals waters*		*Sediments*		*Macrophytes*	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Cd (ppm)	0.0651	0.251	0.0875	0.1731	0.0232	0.6344
[Low tide]	Site 4	Site 3	Site 5	Site 2	Site 5 Plant no. 9	Site 2 Plant no. 3
Cr (ppm)	0.9161	12.888	1.3718	3.0815	0.5561	6.8276
[Low tide]	Site-4	Site 3	Site 5	Site 2	Site 5 Plant no. 9	Site 2 Plant no. 3
Cu (ppm)	0.0433	0.2962	0.5947	0.9592	0.2252	1.016
[Low tide]	Site 3	Site 2	Site 5	Site 2	Site 1 Plant no. 1	Site 4 Plant no. 6

Table Cont....

Cont. Table...

Pb (ppm)	0.9046	2.0655	1.2885	1.746	0.4345	1.1918
[Low tide]	Site 2	Site 3	Site 5	Site 2	Site 5	Site 4
					Plant no. 9	Plant no. 6
Cd (ppm)	0.1343	0.4277	0.0739	1.6488	0.031	0.3747
[High tides]	Site 4	Site 3	Site 5	Site 2	Site 5	Site 4
					Plant no. 4	Plant no. 3
Cr (ppm)	0.9301	6.367	1.4848	31.20	0.518	6.4628
[High tides]	Site 5	Site 2	Site 5	Site 2	Site 5	Site 2
					Plant no. 4	Plant no. 2
Cu (ppm)	0.3691	0.934	0.4436	7.386	0.2816	0.5593
[High tides]	Site 5	Site 2	Site 5	Site 2	Site 4	Site 2
					Plant no. 3	Plant no. 2
Pb (ppm)	1.1229	2.6384	1.2943	8.98	0.5779	0.8504
[High tides]	Site 4	Site 3	Site 5	Site 2	Site 5	Site 2
					Plant no. 4	Plant no. 2

Notes: Name of Sampling sites
Site 1. Starting point of SWF and DWF near Topsia Sewage Pump Station; Site 2. Bantala after meeting of SWF and DWF. Site 3. Tannery waste effluent. Site 4. SWF near Tannery waste effluent discharge point. Site 5. Gusighata SWF before the lock gate.

Plant samples during low tide (Feb. 2007) period
1. Ricinus communs (Euphorbiaceace)
2. Beto shak
3. Cyanotis axillaries (Commelinaceace)
4. Amaranthus viridis (Amaranthaceae)
5. Croton bonplandian (Euphorbiaceace)
6. Polygonum barbatum (Ploygonaceace)
7. Polygonum orientale (Polygonaceae)
8. Ipomoea carnea (Convolvulaceae)
9. Rumex manitimus (Polygonaceae)

Plant samples during high tide (Apr. 2007) period.
1. Lantana camara (Vrbenaceace)
2. Polygonum orientale (Ploygonaceace)
3. Croton bonplandianum (Euphorbenaceace)
4. Ipomoea carnea (Convolvulaceace)

Table 9: Changes in various parameters over a period of one decade at site-1.

Parameters	Unit	Saha et al. 1995 to 1997 (Unpublished)			Present Observation 2007		
		Min.	Max.	Average	Min.	Max.	Average
Water temp.	°C	22	31	26.5	29	35	32
pH		6.5	7.5	7.0	6.82	6.89	6.85
TSS	ppm	Nil	680	172.72	11.4	11.4	11.4
BOD	ppm	Nil	232.3	100.53	-	2.442	2.442
Total alkalinity	ppm	93.6	1211	428.55	479.37	663.75	571.56
Total Hardness	ppm	270	746.6	511.87	190	420	305
COD	ppm	107	584	359	110	110	110
Total inorganic nitrogen	ppm	126	1092	553.09	0.11	42.25	21.18
Total phosphorus	ppm	4.4	48.32	15.04	0.124	37.65	18.88
Dissolved phosphorus	ppm	0.4	25.3	5.6	-	1.851	1.851
Total chromium	ppm	BD	1.6	0.26	1.2	2.73	1.97
Copper	ppm	BD	0.04	0.01	0.12	0.88	0.5
Lead	ppm	BD	1.72	0.53	1.09	1.32	1.21

Note: BD = Below Detection level.

Table 10. Changes in various parameters over a period of one decade at site-2

Parameters	Unit	Saha et al. 1995 to 1997 (Unpublished)			Present Observation 2007		
		Min.	Max.	Average	Min.	Max.	Average
Water temp.	°C	23	32	27.9	30	37	33.5
pH		6.8	7.5	7.2	6.98	7.11	7.04
TSS	ppm	-	590	122.72	15.4	15.4	15.4
BOD	ppm	17.5	452.5	97.88	-	0.165	0.165
Total alkalinity	ppm	187.20	1287	525.39	626.87	811.25	719.06
Total Hardness	ppm	310	856	623.12	325	540	432.5
COD	ppm	115	573	298.54	90	243.6	166.8
Total inorganic nitrogen	ppm	238	896	424.036	0.06	113.625	56.842
Total phosphorus	ppm	1.7	32.8	9.987	0.043	3.625	1.834
Dissolved phosphorus	ppm	1.35	30.0	4.8	-	2.071	2.071
Total Chromium	ppm	0.03	19.12	5.28	0.837	6.367	3.602
Copper	ppm	BD	0.08	0.027	0.2962	0.934	0.6151
Lead	ppm	BD	2.02	0.571	0.904	1.784	1.344

Note: BD= Below Detection level.

Table 11: Changes in various parameters over a period of one decade at site-3.

Parameters	Unit	Saha et al. 1995 to 1997 (Unpublished)			Present Observation 2007		
		Min.	Max.	Average	Min.	Max.	Average
Water temp.	°C	-	32	27.6	30	36	33
pH		-	9.0	7.6	7.55	7.14	7.34
TSS	ppm	-	1810	776.36	18.3	53	35.65
BOD	ppm	-	-	-	-	1.089	1.039
Total alkalinity	ppm	-	3484	839	625	3429	2027
Total Hardness	ppm	Nil	1254	913	445	560	502..5
COD	ppm	Nil	508	619	246.5640	640	443.25
Total inorganic nitrogen	ppm	Nil	558	143.85	0.02	4.25	2.13
Total phosphorus	ppm	Nil	5.8	2.94	0.55	3.5	2.025
Dissolved phosphorus	ppm	Nil	0.98	0.37	-	1.59	1.59
Total Chromium	ppm	Nil	99.2	33.97	3.14	12.88	8.01
Copper	ppm	BD	0.1	0.0325	0.0433	0.3859	0.2146
Lead	ppm	-	1.38	0.3314	2.0655	2.638	2.351

quantity of Cr, Cu and Pb during both the periods of tides.

High concentration of Cr during both low tide and high tide has been recorded in almost all the three components of the system (Table 8); same was true for Cr, Cu and Pb. Over a period of one-decade, enhancement in the parameters like conductivity, total alkalinity, total chromium, copper and lead has been found at site 1. At site 2, parameters like pH, conductivity, total alkalinity, copper and lead showed an enhancement. Likewise, enhancement in the parameters like total alkalinity, BOD, total hardness, copper and lead was observed at site 3 and, at site 5, pH, conductivity, total alkalinity, total hardness, COD, copper and lead (Table 9, 10, 11, 12). The rise in almost all trace metals Cd, Cr, Cu and Pb is a matter of concern as their bioaccumulation in humans has been reported to cause many ailments like Pb causes encephalopathy, seizures and metal retardation

Table 12: Changes in various Parameters over a period of one decade at site-5.

Parameters	Unit	Saha et al. 1995 to 1997 (Unpublished)			Present Observation 2007		
		Min.	Max.	Average	Min.	Max.	Average
Water temp.	°C	21	32.8	27.2	30	30	30
pH		5.5	7.5	6.89	7.71	7.52	7.46
TSS	ppm	-	1110	293.63	2.1	11.7	6.9
BOD	ppm	10	85	42.16	-	0.792	0.792
Total alkalinity	ppm	151.99	757.42	375.81	479.37	553.12	516.25
Total Hardness	ppm	310	1950	700	920	1200	21460
COD	ppm	45	726	161	330	1120	725
Total inorganic nitrogen	ppm	190	728	337	0.14	36.25	18.19
Total phosphorus	ppm	0.48	29.6	7.309	0.062	1.875	0.9685
Dissolved phosphorus	ppm	0.35	12.4	2.079	0.386	-	0.386
Total Chromium	ppm	BD	1.96	0.356	0.93	0.969	0.9495
Copper	ppm	BD	0.08	0.0225	0.197	0.3691	0.28305
Lead	ppm	BD	0.78	0.30157	1.4272	2.221	1.8241

Note: BD= Below Detection level.

(Schumann 1990). Cd has been found to be neurotoxic (Puranik & Pakniker 1997), besides this, Cd acts synergistically with Cu to increase its toxicity. Cu is toxic to most aquatic life. Present paper lays emphasis on checking the input of toxic elements from the industries into the canal which finally meets Bidyadhari river culminating into Sunderban.

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