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THE GANGA WATER POLLUTION AND WASTE WATER SUPPLY SYSTEM IN VARANASI

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ABSTRACT

The most vanerated and sacred river of our country the Ganges plays a major role in the recognisation of Varanasi as a spiritual centre. The city Varanasi is situated on the concave bank of the river. In recent years due to heavy growth in population and number of factories around the city situated along the river Ganges, the pollution load has increased to an alarming stage. Now therefore it has been the moral duty of the scientists and technologists concerned to study and manage the polution problem in the interest of the nation.

The primary step in study of the problem in the environmental impact assessment of the river. Most of the scientists working in this field are concentrating their efforts mainly to study the quality of the river water. But in rivers the pollution load is not only managed by the volumetric dilution at the site and the quality of the river water but also due to mixing induced by the dynamic behaviour of flowing water. Thus, the pollution managing capacity at the site varies from place to place and also from time to time. This paper stresses here the need for utilization of the natural energy available in river water to manage the pollution load. The data presented systematically, might be helpful to adopt the means to manage the pollution.

INTRODUCTION

The effluents (either treated or untreated) are usually discharged in ponds, lakes or rivers. The water surface in river is usually at the lowest level in the area, the effluent fed at any location has to effect the river water quality and quantity. Ponds and lakes manage the pollution load mainly by volumetric dilution, and also depends on water quality. In river the pollutants are not only affected by the volumetric dilution at the site and the quality of the river water but also subjected to mixing induced by the dynamic behaviour of flowing water. Thus, the natural energy available in river water to manage the pollution load is much more than that in ponds and lakes. The natural energy available at the outfall site of the river may be expressed in terms of depth of water at the site and dynamic terms of the energy $V^2/2g + U^2/2g$

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(if the vertical component of flow is neglected). The energy terms available for improving the water quality must be considered in analysing all the parameters related with the river pollution.

The more important factor DO concentration in river can be represented by the oxygen balance equation:-

$$Q = P \pm D - B - S \qquad \ldots \quad (1)$$

Where,

Q = gain or loss of oxygen between two DO monotoring stations in the river.

P = gain of oxygen due to photosynthesis.

D = gain or loss of oxygen through the streamed surface (this includes the process of mixing).

B = loss of oxygen due to respiration of plants and bottom deposits.

S = loss of oxygen due to dissolved and the suspended matter in the water.

Out of the different parameters mentioned above the parameter 'D' plays a very important role and effect of D cannot be ignored in the study of variation of different parameters in river. The other term in the equation P, B and S are also related with the quality, quantity of the effluent and the outfall site.

Thus, from the discussion made above river potential for managing the pollutants (reaching either through surface or subsurface) may be defined in terms of total energy i.e. $h + U^2/2g + V^2/2g$ available at the outfall site. The river flow is highly nonprismatic and unsteady, therefore, the pollution managing potential of the river varies from place to place and also from time to time. In general, the variation of pollutants parameters must be described either with the dynamic property of the flow (at the point under consideration) or simply with the depth of the water (assumping no variation in the cross-sectional shape of the river).

For the analysis of dispersion characteristics of effluent parameters the dispersion equations No. 2 and 3 may be considered for the analysis.

$$D_e = 2\,(F_e, F_r, \theta_c, K_{qc}) \quad \ldots \quad (2)$$

and,

$$D_{et} = 3(F_e, F_{re}, \theta_c, K_{qc}) \quad \ldots \quad (3)$$

Thus, the data if systematically collected may be useful to reduce the zone of effluent dispersion. The data may also be helpful to device the technical know-how to manage the growth in future load of effluent (may be due to increase in population or the growth in industrialisation). The pollution problem usually becomes more acute when the surface aeration term 'D' is not favourable and the effluent is fed in the zone of reversal flow. In this zone the effluent is forced to remain for longer period and thus the ecological balance may be locally disturbed. In general the outfall site is situated in the zone of the reversal flow and thus this causes the local pollution in water. In Varanasi, many outfall sites are situated in the zone of reversal flow and their effects are carried on in a large distance in the downstream site. The confluence point may affect the pollutants to speard in the upstream site also. The Table -1 given below describes the variation of different parameters of the outfall sites at Varanasi and their effects in upstream and down-stream direction along the Ghats.

The data shown in the Table -1 clearly indicates that the dispersion characteristics of the effluent depends upon the various parameters as given by Eq. 2 and 3 . Further, if one observes the various flow parameters at different locations of River Ganga at Varanasi (Table-2;Fig. 1-8) one may feel that the value of D (in Eq. (1) varies from location to location. It is thus clearly seen that the dispersion phenomenon of the effluent reaching in the river either through surface or subsurface resources is difficult to analyse analytically. The relationship, no doubt can be established if sufficient data are obtained in the physical model and in the river Ganga.

The quality and quantity of effluent and also its way to approach the river water vary from place to place and from time to time. The important data collected at Rajendra Prasad Ghat is only presented here. Table-2 and also Fig. 1-8 show the variation of some important physico-chemical properties of effluent collected near Rajendra Prasad Ghat and the river flow parameters at the sampling points are also presented in Figure-9. The results and discussions are made on the basis of the river flow behaviour at the locations.

DATA COLLECTION AND ANALYSIS

In the present research paper data collected at Rajendra Prasad Ghat near Dashashwamedh Ghat has only been presented in

TABLE - 1: EFFLUENT THROUGH SOME IMPORTANT NALA IN RIVER GANGA AT VARANASI.

Parameters		Assi Ghat Nala	Choki Ghat Nala	R.P. Ghat Nala
Confluence angle		60^o	90^o	80^o
Average width (meter)		3.0	1.52	3.1
Average depth (meter)		.125	.1	.1
Average Velocity (cm/sec)		49.2	.15	
Discharge (m^3/hr)		417.6	82.8	324
PH:	Nala	8.5	8.2	8.9
	confl.	8.02	7.02	7.2
D.O. (mg/l):	Nala	.75	1.37	.8
	Confl.	3.68	4.25	3.2
BOD (mg/l):	Nala	105	60.9	470
	Confl.	20	115	115
COD (mg/l):	Nala	360	638	1020
	Confl.	158	312	380

TABLE -2 : SOME PHYSICO-CHEMICAL CHARACTERISTICS OF THE GANGA RIVER WATER AT RAJENDRA PRASAD GHAT.

Longitudinal distance from Conf.(meter)	Transverse distance (meters)	Temp. (°c)	Electrical Cond(mhos)	PH	D.O. (mg/1)
At Conf.	2	22.3	.620	8.0	3.0
	4	22.3	.610	7.8	3.2
	6	21.8	.585	8.13	3.2
	8	21.4	.583	8.2	3.5
	10	21.2	.582	8.3	3.6
10 upstream	2	22.2	.543	8.00	3.6
	4	22.2	.499	8.23	4.2
	6	22.1	.500	8.26	4.6
	8	21.9	.494	8.29	4.9
	10	21.9	.490	8.30	4.8
20 upstream	2	22.1	.499	8.22	3.7
	4	21.9	.513	8.10	3.8
	6	22.0	.508	8.14	3.9
	8	22.0	.493	8.20	4.2
	10	21.9	.494	8.30	4.1
30 upstream	2	22.3	.504	7.90	4.1
	4	22.1	.490	8.00	4.8
	6	22.2	.493	8.14	4.8
	8	22.0	.490	8.18	5.1
	10	22.0	.493	8.19	5.2
40 upstream	2	22.0	.502	8.05	4.2
	4	22.0	.495	8.04	4.9
	6	21.9	.491	8.12	4.6
	8	21.8	.491	8.16	4.8
	10	21.7	.489	8.17	4.9

Contd...

Longitudinal distance from conf.(meter)	Transverse distance (meters)	Temp. (°c)	Electrical Cond.(mhos)	pH	D.O. (mg/1)
10 Down stream	2	22.0	.600	8.34	3.9
	4	21.7	.570	8.44	3.8
	6	21.7	.562	8.46	4.3
	8	21.5	.560	8.45	4.4
	10	21.6	.542	8.48	4.2
20 Down stream	2	21.7	.574	8.43	4.1
	4	21.6	.567	8.44	4.3
	6	21.6	.567	8.47	4.6
	8	21.5	.563	8.48	4.6
	10	21.8	.564	8.49	4.9
30 !Down stream	2	21.7	.610	8.28	3.8
	4	21.7	.574	8.32	3.9
	6	21.7	.559	8.35	4.0
	8	21.6	.554	8.36	4.3
	10	21.2	.544	8.49	4.6
40 Down Stream	2	21.9	.580	8.10	3.9
	4	22.0	.567	8.30	4.3
	6	21.8	.559	8.36	4.6
	8	21.7	.538	8.49	4.9
	10	21.7	.508	8.46	4.7
Midstream	30	21.9	.497	8.37	5.1
	32	22.0	.489	8.42	5.5
	34	21.9	.490	8.40	5.5
	36	21.9	.493	8.45	5.8
	38	21.9	.490	8.46	6.5

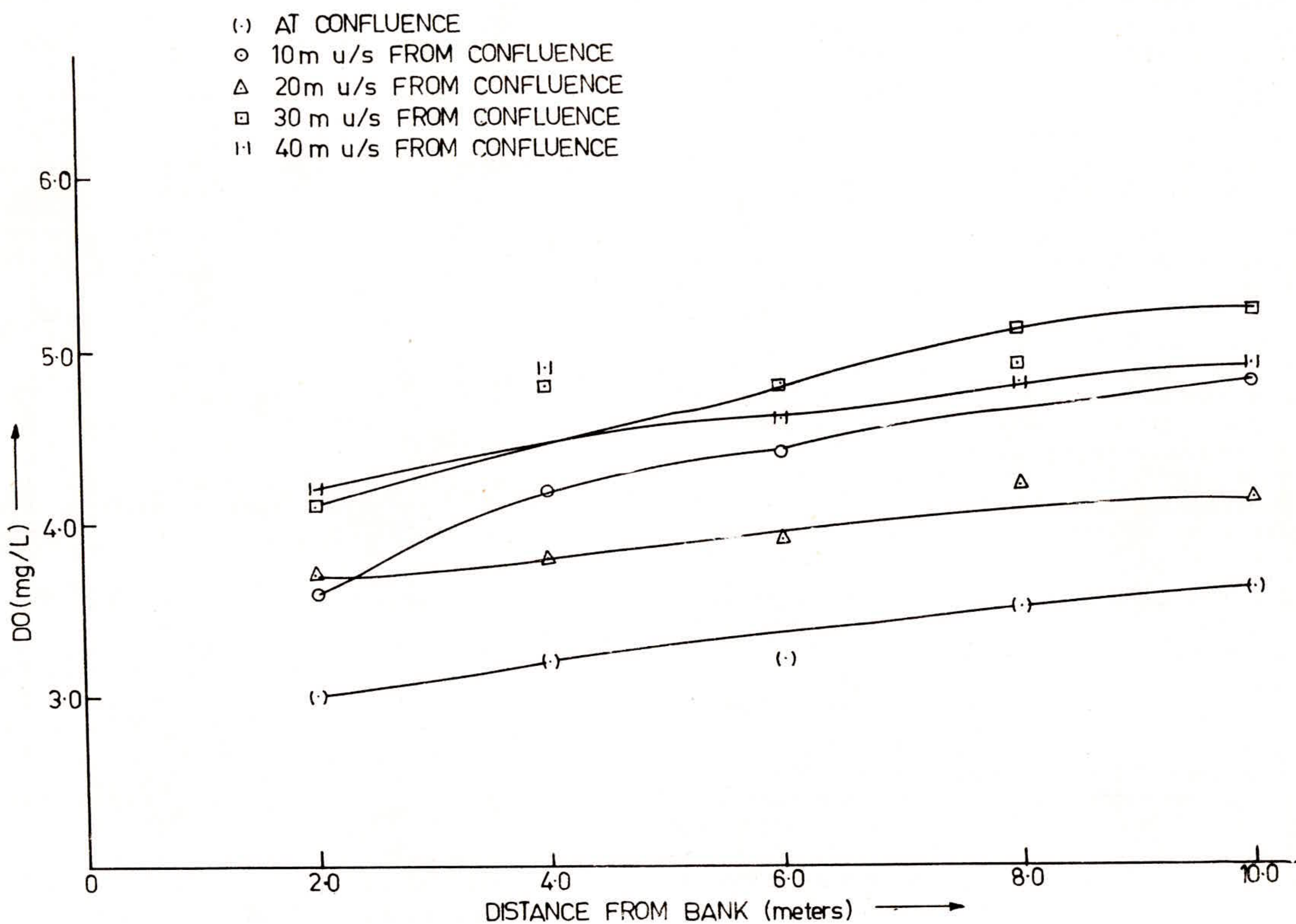

FIG.1- LONGITUDINAL AND TRANSVERSE VARIATION IN DO AT DIFFERENT LOCATIONS AROUND RAJENDRA PRASAD GHAAT

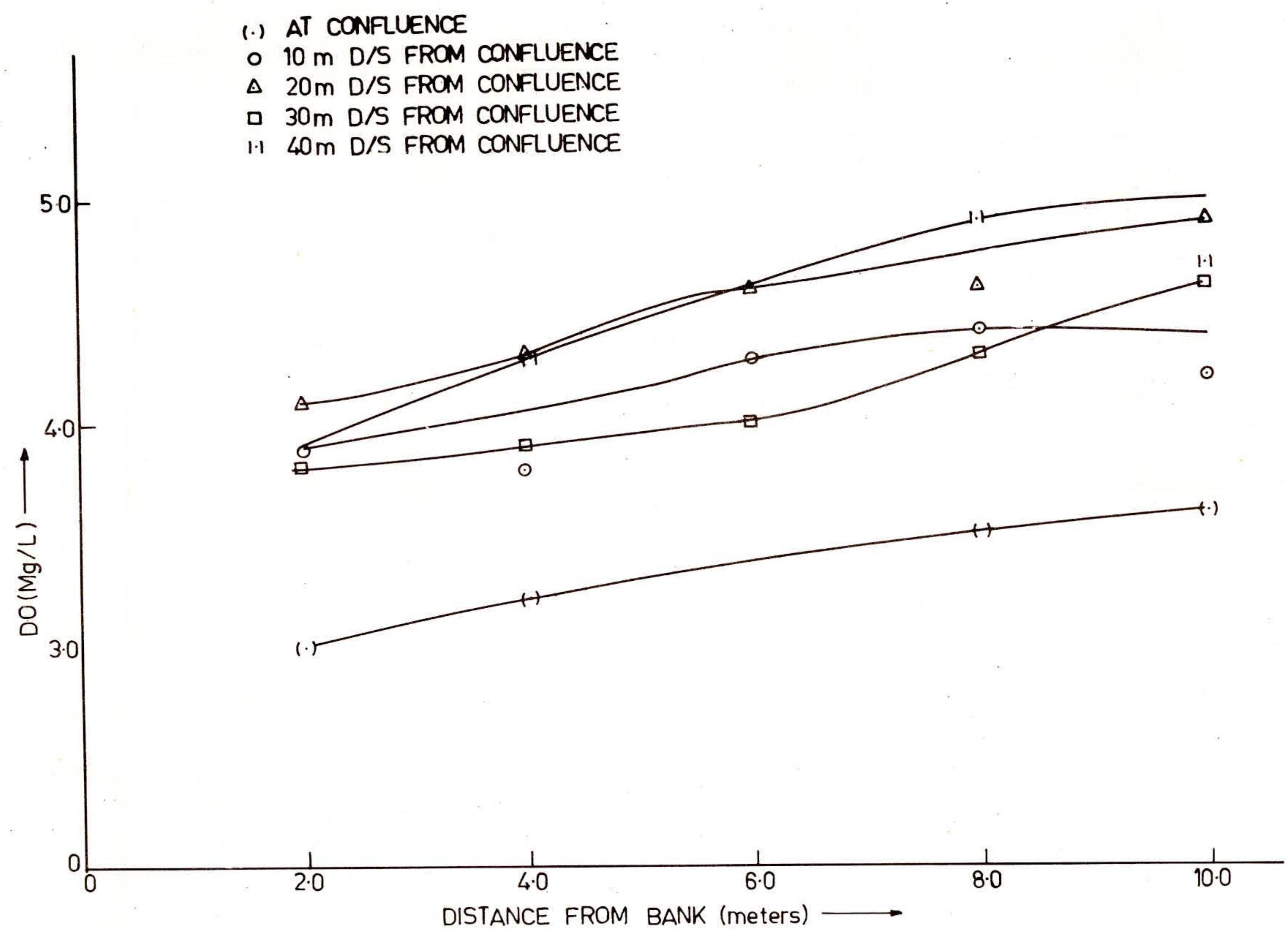

FIG.2-LONGITUDINAL AND TRANSVERSE VARIATION IN DO AT DIFFERENT LOCATIONS AROUND RAJENDRA PRASAD GHAAT

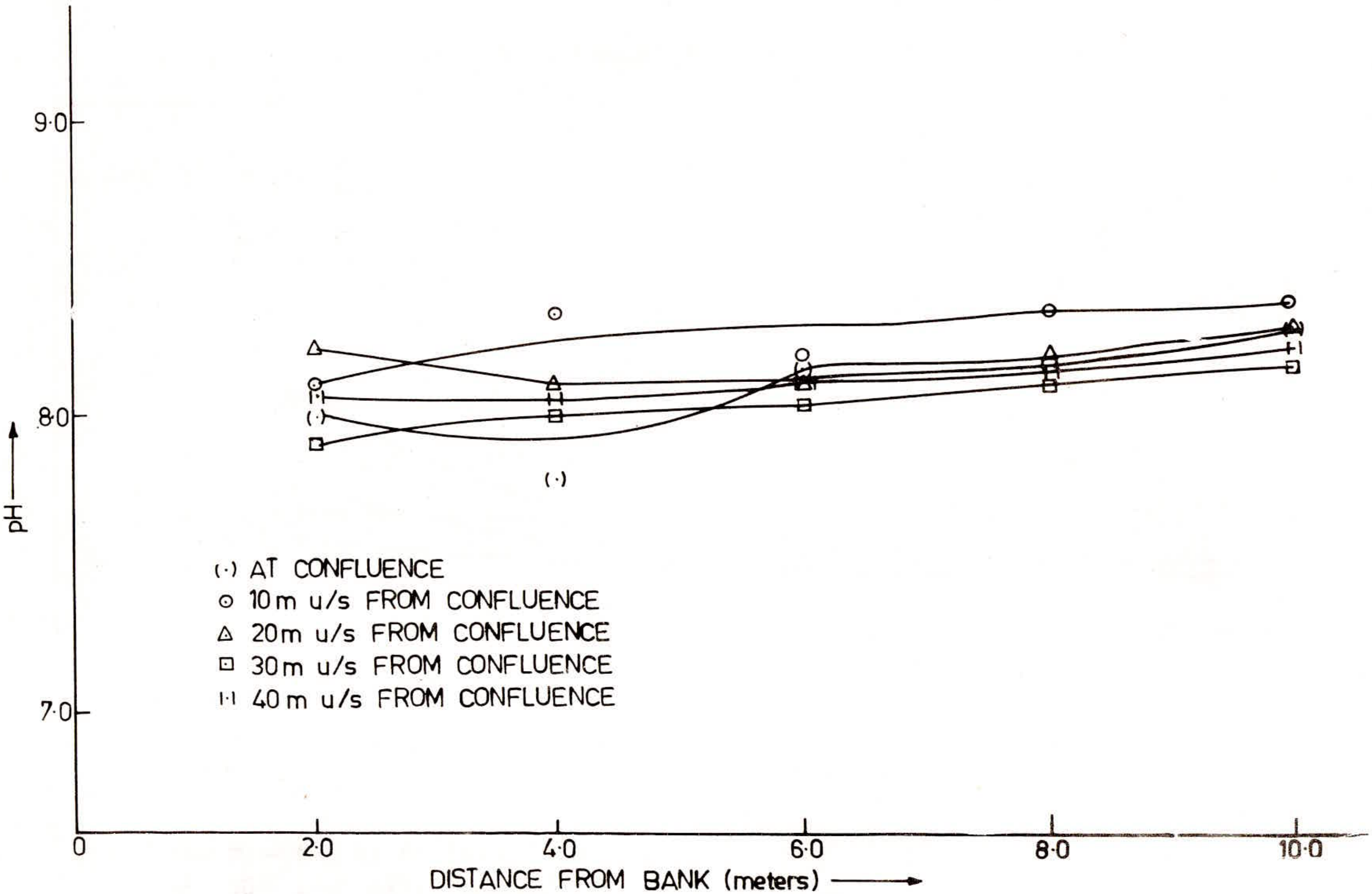

FIG.3- LONGITUDINAL AND TRANSVERSE VARIATION IN PH AT DIFFERENT LOCATIONS AROUND RAJENDRA PRASAD GH..

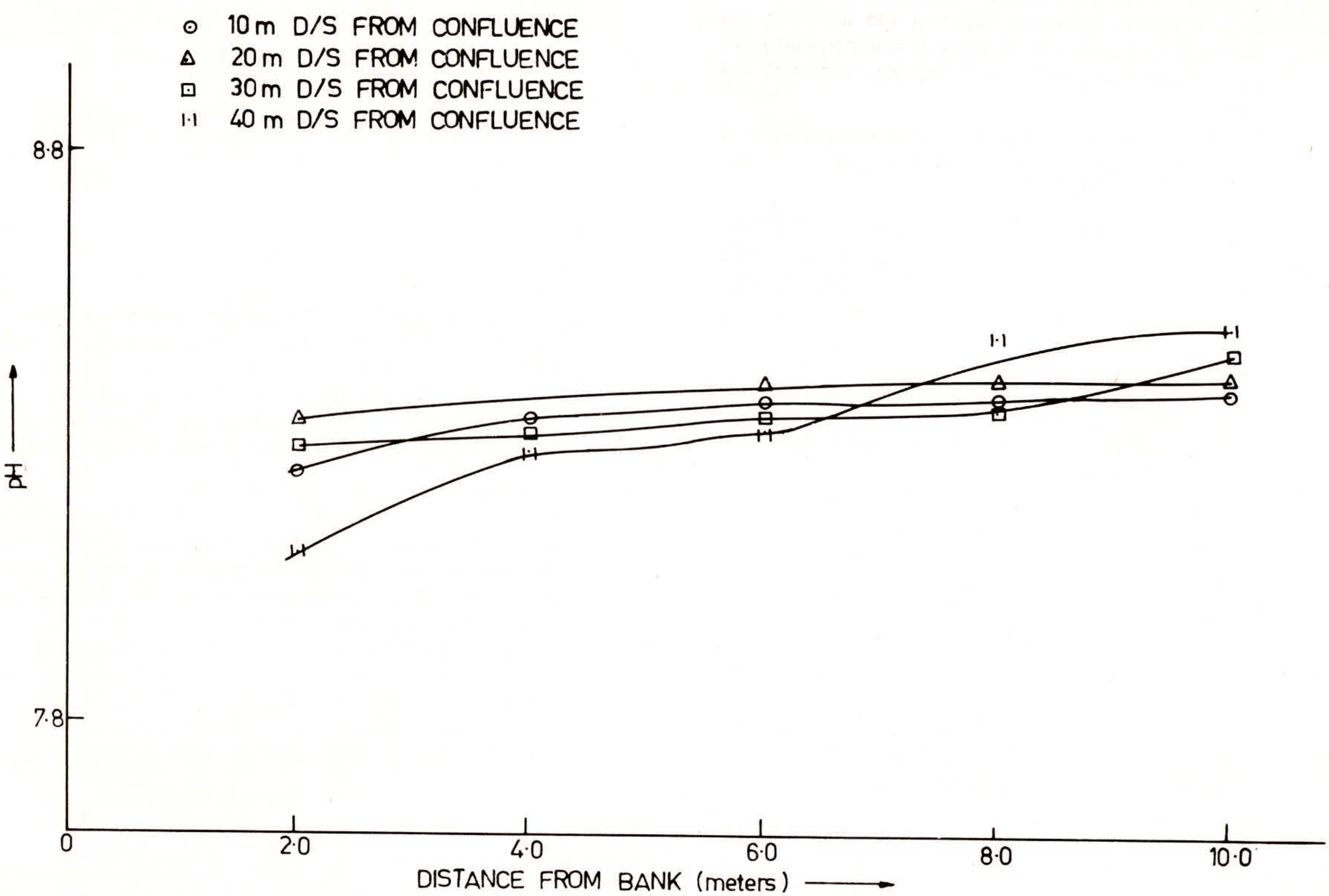

Fig.4-LONGITUDINAL AND TRANSVERSE VARIATION IN pH AT DIFFERENT LOCATIONS AROUND RAJENDRA PRASAD GHAT

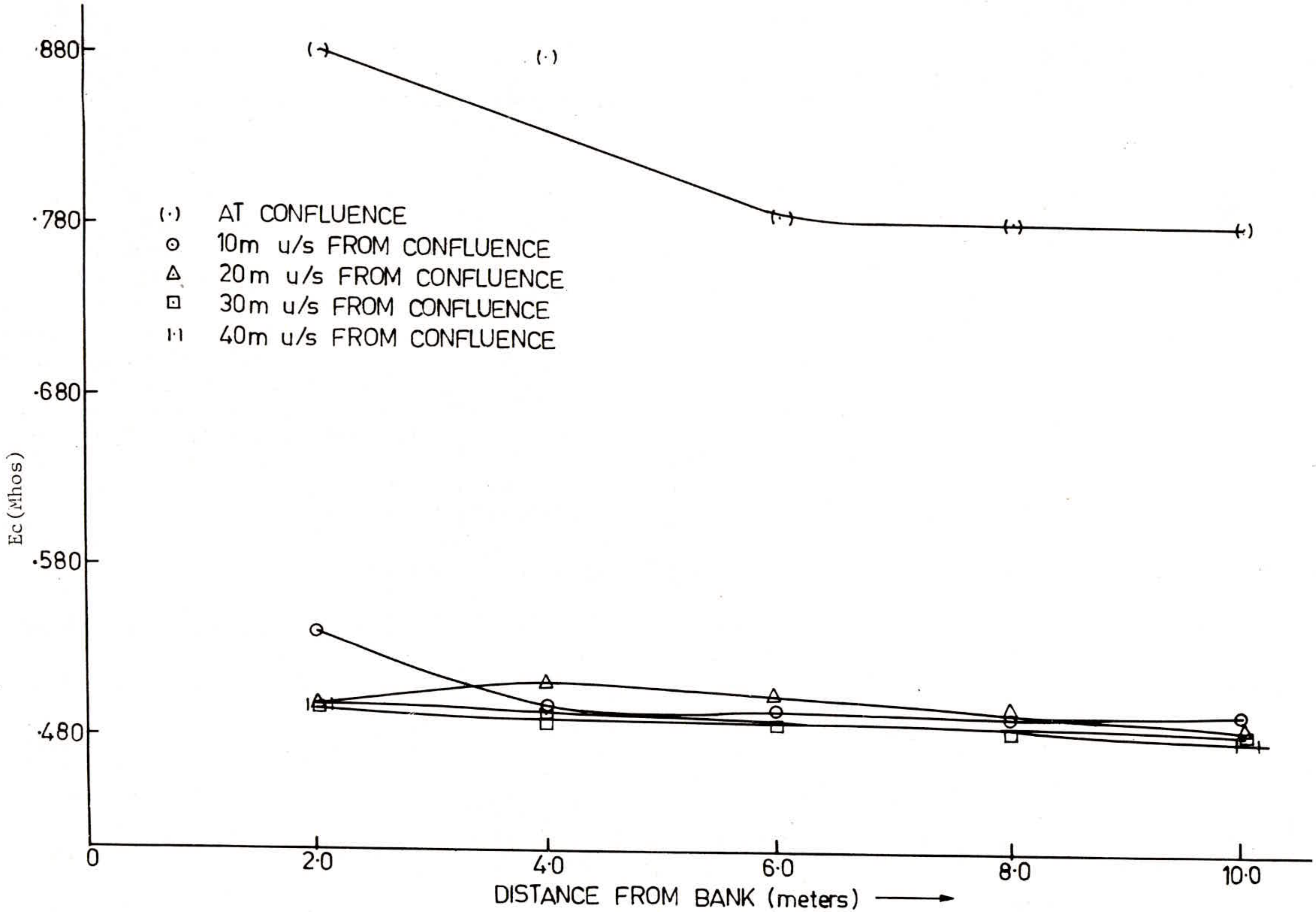

Fig.5- LONGITUDINAL AND TRANSVERSE VARIATION IN Ec AT DIFFERENT LOCATIONS AROUND RAJENDRA PRASAD GHAT

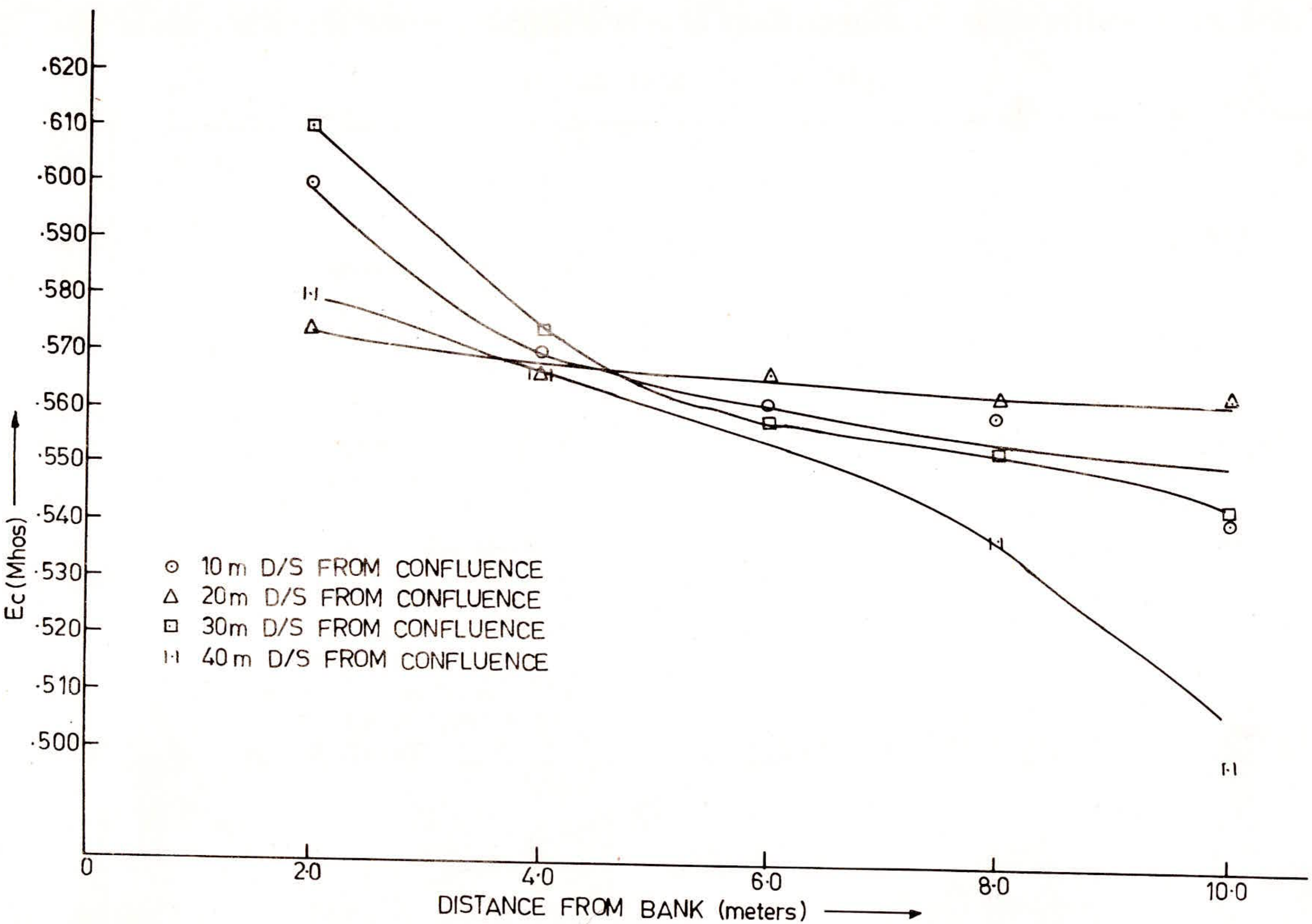

Fig.6- LOGITUDINAL AND TRANSVERSE VARIATION IN Ec AT DIFFERENT LOCATIONS AROUND RAJENDRA PRASAD GHAT

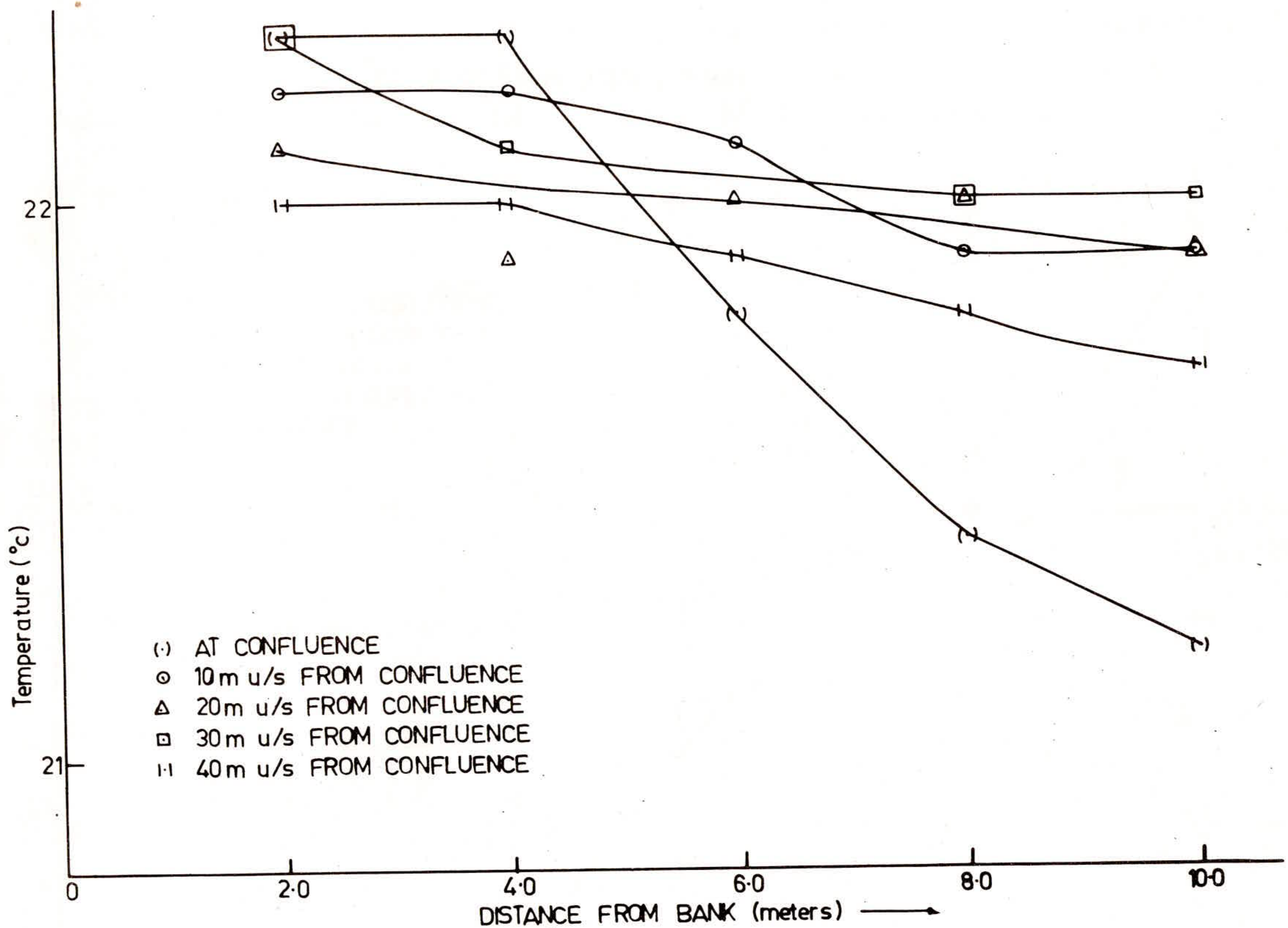

Fig.7- LONGITUDINAL AND TRANSVERSE VARIATION IN TEMPERATURE AT DIFFERENT LOCATIONS AROUND R.P.GHAT

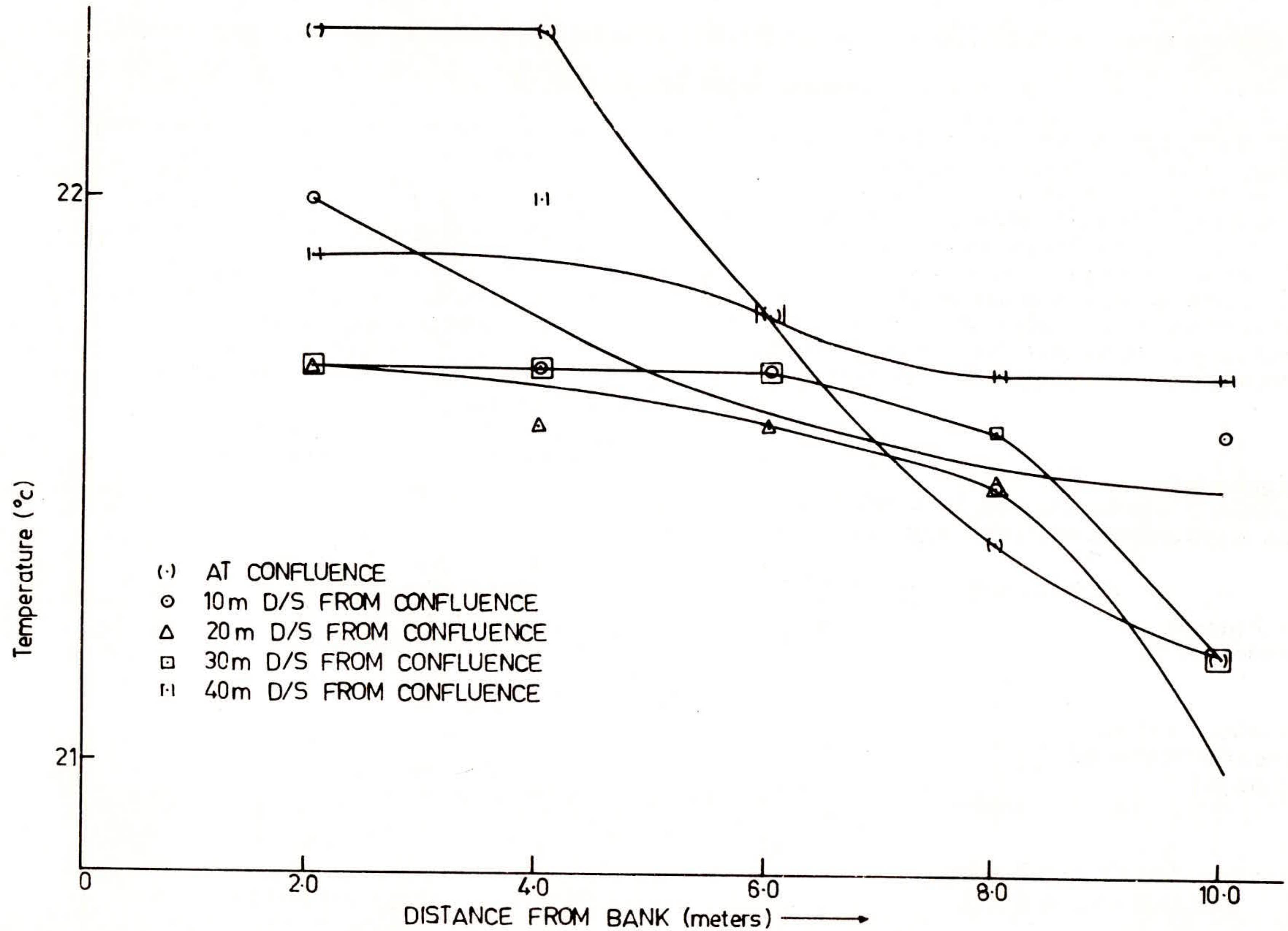

Fig.8- LONGITUDINAL AND TRANSVERSE VARIATION IN TEMPERATURE AT DIFFERENT LOCATIONS AROUND R.P.GHAT

detail. This location main sewer discharges the effluent into the river periodically. The location of the outfallsite has been made without proper assessment of (i) the pollution management potential of the river at the site, (ii) importance of the Ghat, (iii) confluence design parameters and (iv) the quality of the pollutants to be fed at the location. The samples have been collected periodically and dispersion of different parameters (in longitudinal and lateral directions) have been estimated. River flow parameters such as velocities and depth of water of the sampling points have also been recorded In the present research paper, variations in dissolved oxygen, electrical conductivity, PH and the temperature with the velocity and depth of the water have been shown. The data has been presented here in table -2. The longitudinal and transverse dispersions and various parameters discussed above have been presented in the figures -1-8. The river parameters (velocities and depths) at the sampling points are shown in Figure-9.

RESULTS AND DISCUSSION

The data presented in Table-2 and also the figs-1 and 2 describe the pattern of variation in dissolved oxygen in up and downstream sections around the confluence. In rivers the pollution is estimated by measuring the level of dissolved oxygen in the water. The result shows that D.O at various up and downstream sections is badly affected as compared to D.O. of mainstream. As one proceeds towards the Dashashwamedh Ghat, D.O. of river water reduces. In the downstream side D.O. along the Ghat slightly increases and starts further reducing as the distances increase, thus, the pattern of D.O. variation of various sections are different. The effect of nala pollute the river water to the largest length (in transverse direction) near the confluence with the further increase in distance in transverse direction the affected zone reduces whereas water remains more contaminated near the bathing Ghats (in the downstream side).

The result mentioned above is supported by the surface velocity characteristics along the Ghats. The velocity profile (Fig-9) indicates that the Rajendra Prasad Ghat drain is feeding the effluent to the river in the zone of reversal flow. The flow pattern around the confluence can be well visualised by the naked eye also. The reduction in Dissolved oxygen with the increase in longitudinal distance further infers that the deposited solid materials around the confluence gets digested and affect the water quality in both upstream and downstream directions. The local actions by the bathers also can't be ignored. Thus, the D.O. concentration really indicates that the outfall system provided at the confluence is not effecient to disperse the effluent load properly. The geometrical configuration of the

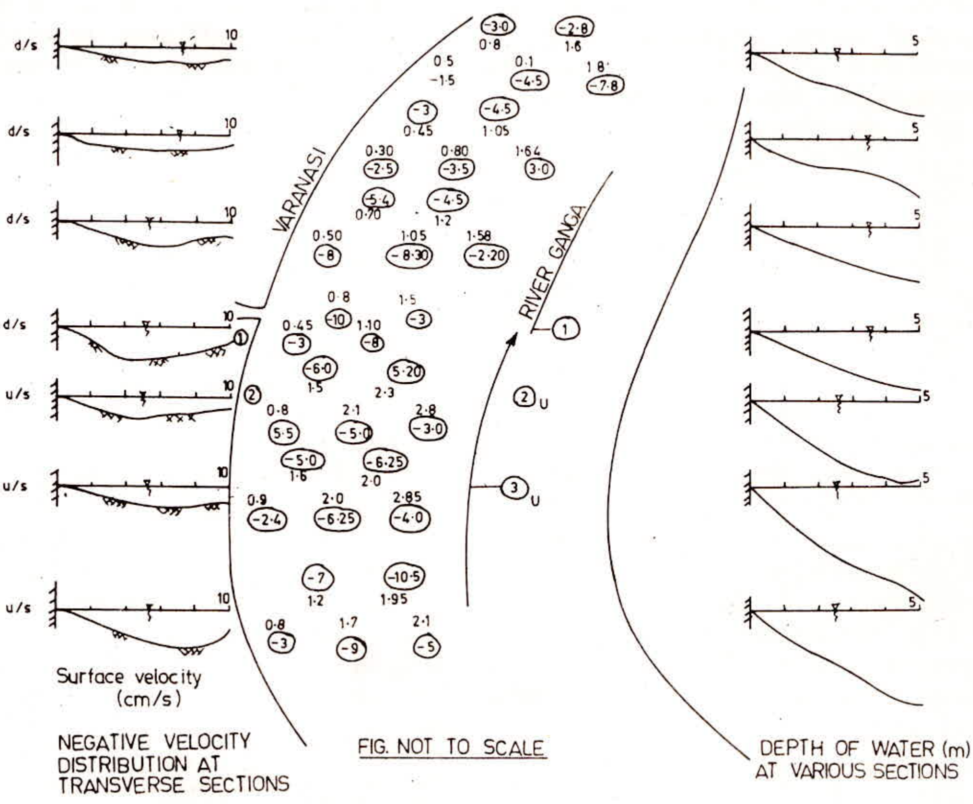

Fig.9- VARIATION IN SURFACE VELOCITY AND DEPTH OF WATER IN GANGA RIVER NEAR RAJENDRA Pd. GHAT AT VARANASI

river is certainly deaccelerating the water particles to move towards the Varanasi side. This type of movement of the fluid particles further induces the phenomena to keep the pollutants near the bank. The local activity such as the activity of the people who take bath and also the boat pliers further reduces the effluent dispersing potential at the river site. The result is supported by the pattern of variation in PH and also the electrical conductivity (Figs.-3-6). The average values of other physico-chemical properties mentioned in Table -1 support the above discussion. The figs-7 and 8 indicate that temperature is higher near the banks as compared to the temperature of the midstream. The depth of water is low near the bank, therefore, rise in temperature near the bank is natural. From the above discussion it is pertinent to note that the dynamic behaviour of the river flow and the depth of river at the various sections under consideration are the dominant parameters the effect of which can't be ignored in the process of effluent dispersion. Further, the angle at which drains meet to the river and the quality and quantity of the effluent which is fed at the outfall site are no less important parameters. It is therefore, the location, quality and quantity of the effluents and methodology to feed the effluent into the water body must be properly assessed before selecting the outfall site.

CONCLUSIONS

From the above discussion following conclusions can be drawn:

1. The effect of pollution load exists in both upstream and downstream sides and the load may increase with the increase in distances in both the direction (upstream and down stream).

2. Dispersion of the pollutants is associated with river flow parameters at the outfall site and also with the quantity and quality of the pollutants.

3. Before deciding the outfall site the importance of the site and the activity of the people in the area must be assessed.

4. The quality and quantity of the effluent to be fed at the location must be decided and varied on the basis of river potential available at the site and at the time.

5. To accommodate the future load of the pollutants at the site proper technical know-how must be developed to maintain the ecological balance.

6. River quality models can be used to forecast dissolved oxygen level at a point in the river system resulting from the interaction of physical and biological assimilation.

To analyse all types of Ganga river problems, the Ganga laboratory has been established in B.H.U. The laboratory occupies the area of 80,000 sq. ft. and the river model representing 30 km. length of the river can be made at a time.

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