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Pollutional studies of few rivers of Western Uttar Pradesh with reference to biological indices

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Abstract. The pollution studies of four rivers of Western Uttar Pradesh with reference to biological indices are reported. Physico-chemical and biological characteristics of the river water at 16 sampling points have been studied and the correlation between them have been made. It is observed that the species number (n) and the total number of organisms (N) of the phytoplankton and zooplankton, though exhibit a relationship at certain stretch with the increase or decrease of pollution intensity yet it is not found very specific and so no definite conclusions could be made. However, the quantitative and qualitative changes in the distribution of benthic macroinvertebrates are clear and specific. Benthic production is observed lower at the points having BOD below 20 mg/l, perhaps because of low availability of food, while at 110 mg/l BOD the highest benthic production (547 per Ekman grab) was observed and this may be due to the presence of good amount of food. Further, the species number (n) and organism number (N) of benthic fauna decline very much and finally disappear completely with the increase of BOD i.e. more than 310 mg/l or with the disappearance of DO (dissolved oxygen).

Keywords. Water pollution; biological indices.

1. Introduction

Water pollution is an important problem, mainly arising out of the improper disposal of sewage and industrial wastes. Stresses caused by these wastes, have a variety of effects on faunal and floral communities living therein either declining their number severely or eliminating them altogether. As such there exists a correlation between the intensity of pollution and the organisms living therein. This correlation, when established, offers a good test for the examination of water quality. The important references available on biological indices of pollution are those of Srivastava (1962a and b), Hussainy (1965), Hussainy and Abdulappa (1967), Verma and Dalela (1975) and Sarkar and Krishnamoorthi (1977). In the present paper, the data on the biological characteristics of 4 lotic water bodies in Western UP with varying water quality are presented along with parallel physico-chemical parameters during three seasons (March 1976 to February 1977).

2. Materials and methods

Survey of the four rivers viz., Pandhoi, Dhamola, Hindon and Western Kalinadi was made and the water samples were collected throughout the year for the analysis of

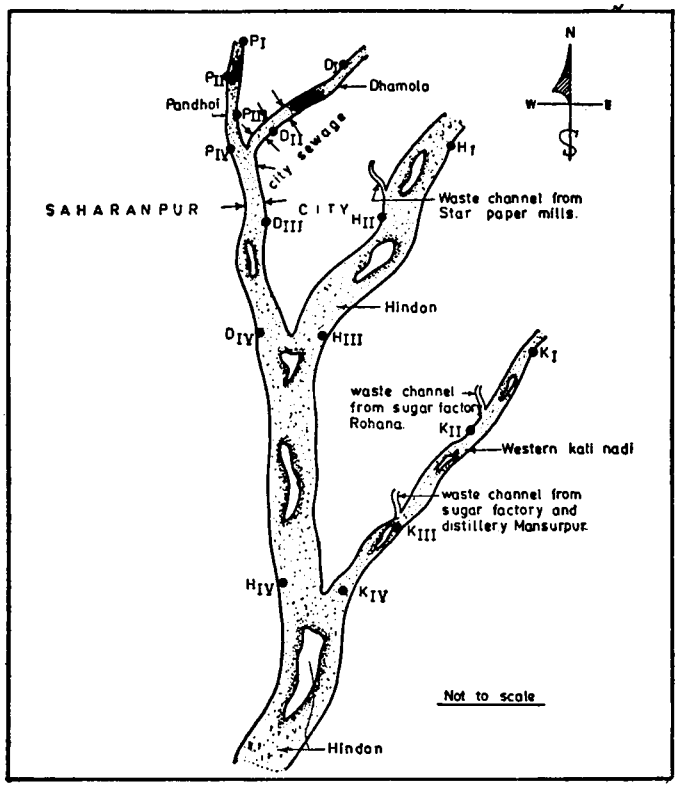

Figure 1. Location of sampling points at different rivers.

physico-chemical and biological characteristics. At each river, 4 sampling points were selected, according to the visible intensity of pollution (figure 1).

2.1. *Pandhoi river*

A tributary of river Dhamola, it carries much of the drainage and sewage from the western part of Saharanpur city. 4 sampling points are:

P I- 5 km before the discharge of Saharanpur city sewage.
P II- 2 km before the discharge of Saharanpur city sewage.
P III- At the discharge of Saharanpur city sewage.
P IV- At the confluence of Pandhoi river with Dhamola river.

2.2. *Dhamola river*

An important tributary of Hindon river which picks up much of the drainage and sewage from Saharanpur city, it also collects the wastes from textile factory, sugar factory, card board factory and some small industries. 4 sampling points are:

D I- 3 km before the discharge of Saharanpur city sewage.
D II- Just before the confluence of Dhamola river with Pandhoi river.
D III- At the discharge of city sewage and industrial effluents from Saharanpur.
D IV- At the confluence of Dhamola river with Hindon river.

2.3. *Hindon river*

One of the important rivers of Western UP, it receives in its way rivers Dhamola and Western Kalinadi. It further receives the waste from Star Paper Mill, Saharanpur. The four sampling points are:

H I- 3 km before the discharge from Star Paper Mill, Saharanpur.
H II- ½ km down stream from the Star Paper Mill waste discharging point.
H III- At the confluence of Hindon river with Dhamola river.
H IV- At the confluence of Hindon river with Western Kalinadi.

2.4. *Western Kalinadi*

This perennial stream carries waste from sugar factory, Rohana and distillery, Mansurpur. The four sampling points are:

K I- 2 km before the discharge of waste from Rohana sugar factory.
K II- ½ km down stream from the discharging point of the waste from Rohana sugar factory.
K III- ½ km down stream from the waste discharging point from the distillery, Mansurpur.
K IV- At the confluence of Western Kalinadi with Hindon river.

Samples of water were collected from all the 16 sampling points. Each sample was subjected to analytical procedures described by Klein (1973) and the standard methods described in Am. Public Health Assoc. (1971). Average of the three observations in each season at each sampling point was calculated.

Plankton study of the river water was made by collecting 10 litres of water and filtering it through a bolting silk net (200 meshes per linear inch) and the concentrate was preserved in 5% formaline solution. Plankton count was made with Sedgwick Rafter Counting Cell under Towa binocular research microscope. The quantity of the plankton was calculated with the help of Welch (1952) formula.

Bottom sludge was collected with Ekman dredge. Bottom organisms were filtered through B & T sieves of different sizes of 10, 20 and 40 meshes per linear inch. The macroinvertebrates were picked out of the sieves, identified and counted.

3. Results and discussion

The season-wise variations in the physico-chemical and biological characteristics of the four rivers at different sampling points have been shown in tables 1, 2, 3 and 4. It is clear from the table 1 that in river Pandhoi the temperature ranges between 19·4 and 32·1°C, pH between 7·8 and 8·3, DO from 0·7 to 8·3 mg/l and BOD between 3·5 and 185 mg/l at all the four sampling points. In river Dhamola, the temperature ranges between 19·3 and 31·9°C, pH between 7·9 and 8·3, DO from 0·2 to 7·9 mg/l and BOD between 8·4 and 240 mg/l respectively. In river Hindon the temperature ranges between 19·4 and 36·4°C, pH from 7·8 to 8·8, DO between nil and 7·8 mg/l while BOD from 8·6 to 380 mg/l respectively. In Western Kalinadi temperature ranges from 19·4 to 32·4°C, pH between 5·4 and 8·1, DO from nil to 7·5 mg/l and BOD from 10·4 to 560 mg/l. In view of the presence of DO and BOD at different sampling points, these rivers can be suspected as polluted rivers.

Table 1. Physico-chemical characteristics of rivers Pandhoi, Dhamola, Hindon and Western Kalinadi at 16 sampling points.

Sampling Points	Summer Season				Rainy season				Winter season			
	Temp. °C	pH	DO mg/l	BOD mg/l	Temp. °C	pH	DO mg/l	BOD mg/l	Temp. °C	pH	DO mg/l	BOD mg/l
P I	29·2	7·8	8·2	9·5	28·4	8·0	8·3	3·5	19·4	7·9	8·2	9·2
P II	29·4	8·0	7·9	17·2	28·3	8·1	8·1	8·8	19·6	8·2	8·0	16·8
P III	32·1	8·2	0·9	160	29·1	8·2	3·1	35·6	20·2	8·3	1·2	148
P IV	31·6	8·1	0·7	185	28·5	8·1	2·9	40·8	19·2	8·2	1·0	167
D I	28·8	7·9	6·1	15	28·2	7·9	7·9	8·4	19·3	8·0	6·3	12
D II	29·1	8·0	1·1	127	28·3	8·0	7·0	42·7	19·4	8·1	1·4	95
D III	31·9	8·2	0·2	240	29·4	8·3	1·9	65·4	19·9	8·2	0·3	231
D IV	29·7	8·1	1·3	110	28·6	8·1	3·5	30·9	19·3	8·1	1·5	86
H I	28·8	7·9	7·2	12·0	28·4	8·0	7·8	8·6	19·4	7·8	7·3	10·5
H II	36·4	8·8	Nil	380	31·2	8·8	1·1	157	30·4	8·8	Nil	362
H III	35·2	8·2	0·3	230	29·2	8·2	2·3	78·2	26·2	8·5	0·5	227
H IV	29·8	7·8	1·1	132	28·4	8·0	3·7	32·3	20·3	8·0	1·4	108
K I	28·4	7·4	7·1	14·6	28·2	8·1	7·5	10·4	19·4	7·8	7·4	12.2
K II	31·2	7·1	0·6	185	28·5	7·9	3·2	38·2	20·1	7·5	0·8	172
K III	32·4	5·4	Nil	560	29·5	7·1	0·5	192	23·2	5·8	Nil	527
K IV	28·8	6·1	0·1	310	28·3	7·8	1·2	135	19·6	6·4	0·3	237

However, it is difficult to get an exact picture for the intensity of water pollution in receiving waters by physico-chemical analysis alone because of the changing nature of pollutants. The life in aquatic environment comprises a large number of different species of organisms and a limited number of any species maintain a bio-dynamic equilibrium. So the effect of a pollutant on a stream is often understood better when biotic factors are correlated with physico-chemical data. Therefore, the biological examination for aquatic biota (phytoplankton, zooplankton and bottom organisms) at various sampling points in the four rivers have been studied.

Palmer (1959) investigated the possibility of using the qualitative and quantitative analysis of algal flora as biological indicator of water pollution. Lackey (1938) pointed out that the *Eudorina*, *Pandorina* and *Gonium* are the characteristic forms of polluted water. The authors observed *Eudorina* at the mildly polluted stretches of rivers in a quite good number. However, their presence have also been noted in the unpolluted stretch. As such the *Eudorina* cannot be considered as indicator of pollution in strict sense. *Pediastrum* and *Trachelomonas* may be considered as sensitive forms to pollution as they are absent at high BOD (86 to 560 mg/l) and low DO (nil to 1·5 mg/l). The *Chlamydomonas* is quite tolerant to high BOD (310 mg/l) but at H II and K III where DO is nil and BOD is very high it was found totally absent. The *Staurastrum*, *Scenedesomus*, *Zygnema* and *Closterium* are the resistant, forms to pollution. But at stations H II and K III they were totally absent due to complete absence of dissolved oxygen. The total number of Chlorophyceae species is observed highest (7) at station P II while lowest (zero) respectively at H II and K III, where the DO was nil. The total number of Chlorophyceae members (N) present at various sampling points varies greatly but this variation does not show any definite correlation with the intensity of pollution. As such it may be concluded that

Table 2. Biological characteristics of rivers Pandhoi, Dhamola, Hindon and Western Kalinadi, phytoplankton number per litre

Types	Pandhoi river				Dhamola river				Hindon river				Western Kalinadi			
	PI	PII	PIII	PIV	DI	DII	DIII	DIV	HI	HII	HIII	HIV	KI	KII	KIII	KIV
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Chlorophyceae									
Eudorina	*a*	*a*	*b*	*b*	*a*	*a*	—	*b*	*a*	—	—	*b*	*a*	*b*	—	—
Chlamydomonas	*a*	*a*	*c*	*c*	*a*	*c*	*a*	*b*	*a*	—	*b*	*b*	*b*	*c*	—	*b*
Pediastrum	*b*	*b*	—	—	*b*	—	—	—	*b*	—	—	—	*b*	—	—	—
Trachelomonas	*b*	*a*	—	—	*a*	—	—	—	*b*	—	—	—	*b*	—	—	—
Staurastrum	—	—	*a*	*b*	—	*a*	*a*	*a*	—	—	*a*	*a*	—	*a*	—	*a*
Scenedesomus	—	*a*	*b*	*b*	—	*b*	*a*	*a*	—	—	*a*	*a*	—	*b*	—	*a*
Zygnema	*a*	*a*	*b*	*b*	*a*	*a*	—	*a*	*a*	—	*a*	*a*	*b*	*a*	—	*a*
Closterium	*a*	*a*	*c*	*b*	*a*	*c*	*a*	*a*	*a*	—	*a*	*a*	*a*	*a*	—	*a*
Total species number (*n*)*	6	7	6	6	6	6	4	6	6	0	5	6	6	6	0	5
Total organisms number (*N*)*	65	61	133	142	60	132	41	66	68	0	43	63	69	121	0	40
							Myxophyceae									
Spirulina	—	—	*b*	*b*	—	*b*	*b*	*a*	—	—	*a*	*b*	—	*a*	—	*a*
Nostoc	*a*	*b*	*b*	*b*	*a*	*b*	*b*	*b*	*a*	—	*b*	*b*	—	*a*	—	*b*
Anabaena	*b*	*a*	*a*	*a*	*b*	*b*	*a*	*a*	*b*	—	*a*	*b*	*b*	*b*	—	*a*
Oscillatoria	—	—	*c*	*b*	—	*b*	*c*	*c*	—	—	*c*	*c*	*a*	*b*	—	*b*
Phormedium	*a*	*a*	*a*	—	*b*	*a*	—	*a*	*b*	—	*a*	*b*	—	*a*	—	—
Merismopedia	*a*	*b*	—	—	*a*	*a*	—	*a*	*a*	—	—	*a*	*a*	*a*	—	—
Total species number (*n*)*	4	4	5	4	4	6	4	6	4	0	5	6	3	6	0	4
Total organisms number (*N*)*	27	31	73	47	31	81	52	78	33	0	73	87	27	51	0	30
							Bacillariophyceae									
Cyclotella	*b*	*a*	—	—	*b*	—	—	—	*b*	—	—	—	*b*	—	—	—
Nitzschia	—	—	*a*	*a*	—	*a*	*b*	*a*	—	—	*a*	*b*	—	*a*	—	*b*
Fragillaria	*b*	*b*	*b*	*b*	*a*	*c*	*b*	*a*	*a*	—	*b*	*c*	*a*	*b*	—	*a*
Synedra	*a*	*b*	*c*	*b*	*b*	*b*	*a*	*a*	*a*	—	*b*	*a*	*a*	*b*	—	*a*
Navicula	*a*	*a*	*b*	*b*	*a*	*b*	*b*	*a*	*a*	—	*b*	*a*	*b*	*a*	—	*a*
Gomphonema	*b*	*b*	—	—	*b*	—	—	—	*b*	—	—	—	*a*	—	—	—
Stauroneis	—	—	*b*	*b*	—	*b*	*a*	*a*	—	—	*a*	*a*	—	*a*	—	—
Milosira	*a*	*a*	*b*	*b*	*a*	*b*	*a*	*a*	*a*	—	*a*	—	*a*	*a*	—	—
Epithemia	*a*	—	—	—	*a*	—	—	—	*a*	—	—	—	*a*	—	—	—
Total species number (*n*)*	7	6	6	6	7	6	6	6	7	0	6	5	7	6	0	4
Total organisms number (*N*)*	67	71	162	137	82	169	121	93	71	0	127	87	71	123	0	33

— =species absent; *a*=species present; *b*=species subdominant; and *c*=species dominant.

(*n*)* and (*N*)* are the average of three observations.

Table 3. Biological characteristics of rivers Pandhoi, Dhamola, Hindon and Western Kalinadi, zooplankton number per litre.

	Pandhoi river				Dhamola river				Hindon river				Western Kalinadi			
Types	PI	PII	PIII	PIV	DI	DII	DIII	DIV	HI	HII	HIII	HIV	KI	KII	KIII	KIV
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
								Protozoa								
Arcella	*a*	*a*	—	—	*b*	—	—	—	*b*	—	—	—	*a*	—	—	—
Centrophyxis	*b*	*a*	—	—	*b*	—	—	—	*a*	—	—	—	*b*	—	—	—
Paramecium	—	—	*c*	*b*	—	*b*	*b*	*c*	*a*	—	*b*	*c*	—	*b*	—	*b*
Phacus	—	—	*b*	*a*	—	*a*	*a*	*a*	—	—	*a*	*a*	—	*a*	—	*a*
Epistylis	*a*	—	*b*	*a*	*a*	—	—	*b*	*b*	—	*a*	*b*	*a*	—	—	*a*
Nebela	*b*	*a*	—	—	*a*	—	—	—	*b*	—	—	—	*b*	—	—	—
Total species number (*n*)*	4	3	3	3	4	2	2	3	4	0	3	3	4	2	0	3
Total organisms number (*N*)*	19	13	22	12	21	23	10	15	18	0	11	13	17	14	0	12
								Rotifers								
Filinia terminals	*b*	*a*	—	—	*a*	—	—	—	*b*	—	—	—	*b*	—	—	—
Brachiomus quadridentata	*c*	*b*	—	—	*c*	—	—	—	*c*	—	—	—	*b*	—	—	—
Monostyla	—	—	*a*	*b*	—	*a*	*a*	*b*	—	—	*a*	*b*	—	*a*	—	*a*
Philodina	—	—	*b*	*b*	—	*b*	*b*	*b*	—	—	*a*	*b*	—	*b*	—	*b*
Anapus	—	—	*b*	*b*	—	*a*	*b*	*a*	—	—	*b*	*b*	—	*a*	—	*a*
Total species number (*n*)*	2	2	3	3	2	3	3	3	2	0	3	3	2	3	0	3
Total organisms number (*N*)*	13	9	14	15	12	12	14	13	10	0	14	15	13	12	0	11
								Entomostraca								
Moina brachiata	*c*	*b*	—	—	*a*	—	—	*a*	*b*	—	—	*a*	*b*	—	—	—
Daphnia	*b*	*a*	—	—	*b*	*a*	—	*a*	*c*	—	—	*a*	*a*	—	—	*a*
Cyclops	*a*	*a*	—	—	*a*	—	—	*a*	*a*	—	—	*a*	*b*	—	—	—
Total species number (*n*)*	3	3	0	0	3	1	0	3	3	0	0	3	3	0	0	1
Total organisms number (*N*)*	15	11	0	0	12	3	0	8	14	0	0	9	13	0	0	4

—=species absent; *a*=species present; *b*=species subdominant and *c*=species dominant.

(*n*)* and (*N*)* are the average of three observations.

the quantitative presence of the members of Chlorophyceae as a whole cannot be considered as a parameter for measuring water pollution intensity at a particular place.

Members of Myxophyceae thrive well in polluted water at all the sampling points except H II and K III where DO was nil during winter and summer seasons and BOD ranges between 362 and 380 mg/l and between 527 and 560 mg/l. It is observed that *Spirulina*, *Nostoc*, *Anabaena* and *Oscillatoria* are the resistant forms and are present at all the mildly polluted sampling points. *Phormedium* and *Merismopedia* are the sensitive forms to the pollution as such they are present in very low number at slightly polluted stretch and absent at highly polluted points. Gaufin and Tarzwell

Table 4. Biological characteristics of rivers Pandhoi, Dhamola, Hindon and Western Kalinadi, bottom organisms per Ekman grab

Types	Pandhoi river				Dhamola river				Hindon river				Western Kalinadi			
	PI	PII	PIII	PIV	DI	DII	DIII	DIV	HI	HII	HIII	HIV	KI	KII	KIII	KIV
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Limnodrilus	—	—	*b*	*b*	—	*a*	*b*	*b*	—	—	*b*	*a*	—	*b*	—	—
Tubifex	—	—	*c*	*b*	—	*b*	*a*	*c*	—	—	*a*	*b*	—	*b*	—	—
Eristalis	—	—	*b*	*b*	—	*b*	—	*b*	—	—	*b*	*b*	—	*c*	—	—
Chironomus	—	—	*c*	*c*	—	*b*	*a*	*c*	—	—	*b*	*c*	—	*b*	—	—
Unio sps	*b*	*c*	—	—	*b*	—	—	—	*b*	—	—	—	*b*	—	—	—
Goniobasis	*b*	*a*	—	—	*a*	—	—	—	*b*	—	—	—	*a*	—	—	—
Anculosa	*a*	*b*	—	—	*a*	—	—	—	*a*	—	—	—	*b*	—	—	—
Lymea	—	—	*a*	*a*	—	*a*	—	*a*	—	—	—	*a*	—	*a*	—	*a*
Physia	—	—	*b*	*a*	—	*a*	—	*a*	—	—	—	*a*	*a*	*a*	—	*a*
Total species number (n*)	3	3	6	6	3	6	4	6	3	0	4	6	3	6	0	2
Total organisms number (N)*	38	41	213	192	41	412	139	547	33	0	147	232	39	183	0	23

—=Species absent; a=species present; b=species subdominant and c=species dominant.

(n)* and (N)* are the average of three observations.

(1956) and Oliff (1960) are also of the opinion that the blue green algae like *Spirulina* and *Oscillatoria* are the very resistant forms to pollution. The highest number (n) of the Myxophyceae species is 6 which is present at most of the sampling points clearly indicating that the members of Myxophyceae are highly tolerant to organic pollution.

Among the members of Bacillariophyceae *Cyclotella, Gomphonema* and *Epithemia* could not be collected from the polluted region which might be due to their great sensitivity towards organic pollution. *Nitzschia* and *Stauroneis* are the resistant forms to the mild pollution as they are present at all the sampling points having high BOD (86 to 310 mg/l) and low DO (0·1 to 1·5 mg/l). However, at points H II and K III these forms are entirely absent. The BOD at these points is comparatively very high and DO is nil. *Fragillaria, Synedra, Navicula* and *Milosira* are observed to be highly resistant forms to the pollution, thrive well in highly nutritive waters and as such are present densely in polluted region. However, the total number of species (n) of Bacillariophyceae is higher at unpolluted stretch.

Zooplankton have also been used by various workers for the assessment of water quality. Lackey (1938) and Bick (1971) used protozoan for the assessment of water quality. Gray (1952) and Bick (1972) identified ciliates as indicator of water quality. Among the protozoans *Arcella, Centrophyxis* and *Nebela* are the sensitive forms to pollution as they have been observed only at the unpolluted stretch. *Paramecium* is the tolerant and dominant form among protozoans, present at all the polluted sampling points except at H II and K III. *Phacus* is a moderately tolerant form found to be present at some polluted points but in lesser number. Species of *Epistylis* exhibit a relationship to the organic pollution as it is present in the stretch of mild pollution. The number of species (n) and the total number (N) of protozoans at a

particular sampling point do not exhibit any direct correlation with the intensity of pollution. The same has also been observed by Mohr (1952).

Filinia terminalis and *Brachiomus quadridentata* are sensitive forms of rotifers which have been observed in the unpolluted stretch while the *Monostyla*, *Philodina* and *Anapus* are the tolerant forms to the mild organic pollution. These tolerant forms were found absent in the zone of highly intense pollution i.e. H II and K III points. Similar observations have also been made by Verma and Dalela (1975). Arora *et al* (1973) emphasized the role of rotifers in assessing the environmental conditions of the receiving waters. The highest species number (n) of rotifers was observed (3) at mildly polluted sampling points except H II and K III which indicate the conditions of sapsis. *Moina brachiata*, *Daphnia* and *Cyclops* have been observed at unpolluted and at slightly polluted sampling points. However, their absence from certain stretch of the rivers is indicative of intense organic pollution. However, Warren (1971) pointed out that continued persistence of a species at a particular location is a sure evidence that conditions in that environment are favourable for its existence, but its absence does not mean that the unfavourable conditions prevail.

Srivastava (1962b) studied the oligochaetes as indicators of gross pollution. Snails and calms have been taken as indicators of organic pollution by Ingram (1957). Hussainy (1965) carried out the hydrobiological studies on bottom sediments, taking phytoplankton and benthic macroinvertebrates as the indicator organisms. Arora *et al* (1973) reported bottom dwellers as important indicators of pollution. On the basis of BOD range, amount of DO and the benthic fauna the rivers can be differentiated into different zones i.e. purified zone, mildly polluted zone and septic zone.

The first zone constituting the stretch before the discharge of effluents and sewage may be named as the purified zone. At these points BOD values lie below 20 mg/l and sufficient amount of dissolved oxygen, above 6·1 mg/l. This condition lies at sampling points P I, P II, D I, H I and K I. Further, the benthic production was lower at these points perhaps because of low availability of food in the form of detritus in the bottom deposits.

In the second zone, food is present in good amount due to the discharge of organic wastes which results in high benthic production. These conditions lie at the P III, P IV, D II, D III, D IV, H III, H IV and K II points. BOD ranges below 240 mg/l. As such these points show the zone of mild pollution. Maximum number of benthos (N) is 547 per Ekman grab at D IV while minimum is 139 per Ekman grab at K II point. Moreover, *Limnodrilus*, *Tubifex*, *Eristalis* and *Chironomus* are the dominant forms and vary greatly in number (N) and their presence can be correlated with the availability of the food, BOD and DO at a particular point.

In the third zone no benthic species have been recorded. This zone includes the H II, K III and K IV points. The BOD is always above 310 mg/l, with the complete absence or very little dissolved oxygen. This zone is as such called as septic zone. The total absence of benthic life is due to the extreme environmental conditions which are unsuitable for their lives.

The distribution of *Unio sps*, *Goniobasis* and *Anculosa*, these are very sensitive forms to the organic pollution, hence they are found to be absent both at mildly polluted and septic zones which includes the sampling points P III, P IV, D II, D III, D IV, H II, H III, H IV, K II, K III and K IV. At these points there is organic environment which is not favourable for their growth. The same conditions have also been

reported by Ortman (1909). *Lymea, Physa* and *Planorbis* were observed at mildly polluted sampling points which compare well with the results reported by Srivastava (1962).

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