

21. Orsbog, C., Ott, F. and Yorke, J. A., *Phys Rev Lett*, 1986, **56**, 1011-1014  
 22. Vazghese, M. and Thorp, J. S., *Phys Rev Lett*, 1988, **60**, 665-668  
 23. Solomon, M. S. and Thompson, J. M. F., *Phys Rev*, 1992, **145**, 3425-3431

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## Rotifers – pollution or productivity indicators?

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In order to test whether rotifers are most efficient as pollution or productivity indicators, impact of abiotic parameters and primary productivity on abundance of rotifers was studied. Population of rotifers was found to be more in polluted zone with numerical superiority of *Brachionus rubens* and *Brachionus angularis*. Different inter-correlations were estimated and from multiple regression analysis it was observed that rotifers were influenced most by chloride, which is an index of pollution.

ROTIFERS as component of zooplankton are widely distributed. Since they are very sensitive to ambient ecosystem, they are used as bio-indicators in monitoring pollution<sup>1-7</sup> and productivity<sup>8-12</sup>. To ascertain whether rotifers are bio-indicators more of pollution or productivity, we have investigated the inter-relations of abiotic parameters including chloride (pollution indicator) and primary productivity on abundance of rotifers.

The study was conducted during September 1979 and February 1982 at clean and polluted sites of river Ganga

at Bhagalpur (25°14' N; 86°57' E)<sup>6,7</sup>. Hydrobiological samples were collected at monthly intervals and were subsequently analysed. Data on temperature, pH, dissolved oxygen, total alkalinity, dissolved organic matter, chloride, primary productivity and rotifers from both zones were pooled together and analysed for estimating different inter-correlations. The data were also subject to multiple regression analysis.

Out of 22 taxa of rotifers available in this stretch, eight rotifers, viz. *Keratella tropica*, *Brachionus calyciflorus*, *B. forficula*, *B. falcatus*, *B. caudatus*, *Anuraeopsis fissa*, *Polyarthra ehrenburg* and *Filinia terminalis*, were found both in clean and polluted zones. They seem to be tolerant to wide fluctuations of abiotic parameters and hence they are being used as indicators of both polluted and productive waters. The remaining 14, viz. *Brachionus rubens*, *B. angularis*, *B. bakeri*, *B. urceolaris*, *Lepadella ovalis*, *Platylas patulus*, *Porales* sp., *Rotaria rotatoria*, *Asplanehna brightwell*, *Horaella brehmi*, *Filinia longispina*, *F. opoliensis*, *Lecane ohioensis* and *Mytilina ventralis* were confined to polluted zone. Amongst them *B. rubens* and *B. angularis* occur in swarms. A shift in species composition of rotifers from clean to polluted zones was apparent.

Inter-relations of abiotic parameters and primary productivity on abundance of rotifers are given in Table 1. The correlation analysis showed that correlation coefficients of rotifers with water temperature ( $r = 0.398$ ), chloride ( $r = 0.304$ ) and primary productivity ( $r = 0.296$ ) were statistically significant at 5% level. From multiple regression analysis (with logarithmic transformation), it was observed that the effect of chloride on rotifers was statistically significant at 5% level. Multiple regression fitted to the observed data was:

$$\log Y = -7.146 + 1.438 \log X_1 + 1.396 \log X_2 + 0.236 \log X_3$$

(1.037)                      (0.278)                      (0.185)

( $n = 51, R^2 = 0.47$ )

where  $X_1$ ,  $X_2$ ,  $X_3$  and  $Y$  represent water temperature, chloride, primary productivity and rotifers respectively. Figures within parenthesis indicate the standard error of the respective regression coefficients.

From the estimates of standard partial regression coefficients<sup>19</sup> it was observed that abundance of rotifers

Table 1 Correlation matrix

	Temp	pH	DO	T Alk	DOM	Cl	GP	Rotif
Temp	1.000*	0.083	-0.194	0.061	-0.320*	0.090	0.345*	0.398*
pH	0.083	1.000*	0.075	0.024	-0.147	0.208	0.232	0.197
DO	-0.194	0.075	1.000*	-0.460*	-0.208	-0.614*	-0.356*	-0.255
T Alk	0.061	0.024	-0.460*	1.000*	0.368*	0.642*	0.296*	0.037
DOM	-0.320*	-0.147	-0.208	0.368*	1.000*	0.331*	0.178	-0.066
Cl 0.090	0.208	-0.614*	0.642*	0.331*	1.000*	0.542*	0.304*	
GP	0.345*	0.232	-0.356*	0.296*	0.178	0.542*	1.000*	0.296*
Rotif	0.398*	0.197	-0.255	0.037	-0.66	0.304*	0.296*	1.000*

\* Indicate significance at 5% level.

was influenced most by chloride followed by water temperature and primary productivity. Chloride, which has been regarded as an index of organic pollution<sup>17</sup>, was recorded in higher concentration in water bodies polluted by community sewage<sup>7,8,18</sup>. Overall population of rotifers was more both in number and taxa in polluted zone probably due to availability of plenty of bacteria on which they feed<sup>15,16</sup>. An abundance of *B. angularis* and *B. calyciflorus* was reported from water showing higher chloride by others<sup>13,14</sup>. These assertions support the present findings that rotifers may be used as potential bio-indicators for monitoring more of pollution than productivity.

- 1 Arora, H C, *Cent Publ Health Eng Res Inst Bull*, 1961, 3, 4, 24
- 2 Rao, Kameshwara, R and Chandra Mohan, P, *Curr. Sci.*, 1977, 46, 190
- 3 Kolkwitz, R and Marsson, M, *US Dept of the Interior Federal Water Pollution Control Administration*, 1967, 85-95
- 4 Sladeczek, V, *Arch Hydrobiol Beih Erqeqbn Limnol*, 1973, 7, 218
- 5 Sampath, V, Sreenivasan, A and Ananthanarayanan, R, *Proc Symp Environ Biol*, 1979, pp 441-452
- 6 Laal, A K, Sarkar, S K and Sarkar, A, *Proc Natl Symp Fish Environ*, 1986, 51-55

- 7 Laal, A K, Sarkar, S K and Sarkar, A, *J Inland Fish Soc India*, 1982, 14, 73-79
- 8 Laal, A K, Sarkar, S K and Sarkar, A, *Bull Bot Soc*, 1988, 35, 21-38
- 9 Hakkari, L, *Aqua Fenn*, 1972, 1, 46-54
- 10 Radwan, S, *Ann Univ Mariae Curie Sklodowskac*, 1976, 31, 227-235
- 11 Lair, N, *Hydrobiology*, 1980, 73, 153-160
- 12 Arora, H C, *Hydrobiol*, 1966, XXVII, 146-159
- 13 Radwan, S and Paleolog, S, *Hydrobiology*, 1983, 104, 307-309
- 14 Sreenivasan, A, Ananthanarayanan, R and Kalaimani, N, *Indian J Environ Health*, 1979, 21, 287-288
- 15 Olah, J, *Ann Inst Biol Tichany*, 1969, 36, 185-195
- 16 Pourriot, R, *Arch Hydrobiol Beih*, 1977, 8, 243-260
- 17 Thresh, J C, Suckling, H V and Beal, J F, *The Examination of Water Supplies* (ed Taylor, E W), 1949
- 18 Moyle, J H, *J Wildl Manage*, 1956, 20, 303-320
- 19 Snedecor, G W and Cochran, W G, *Statistical Methods*, 6th edn, Oxford and IBH Publishing, New Delhi, 1967, pp, 593

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## Estimation of arsenic in geological samples by atomic absorption spectrometry

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An indirect method for estimation of arsenic is described. Arsine liberated from sample solution is passed through dilute silver nitrate. The precipitated silver arsenide is filtered, washed with ammonium hydroxide and dissolved in concentrated nitric acid. The amount of silver proportional to arsenic is determined by atomic absorption spectrometry. The method is simple and accurate.

DIRECT determination of arsenic by atomic absorption spectrometry is not accurate and precise due to matrix interferences<sup>1</sup>. Hydride generation technique also cannot be applied to samples which contain arsenic in percentage levels. The life of the hollow cathode lamps of arsenic being short<sup>2</sup> the electrodeless discharge lamp requires a separate power supply<sup>3</sup>. The resonance line of arsenic (193.7 nm) is nearer to vacuum UV range and therefore difficulties arise from the strong absorption of light by air in the light path and from the flame gases<sup>4</sup>.

Though methods like conventional ICPAES, flow injection/hydride generation ICPAES and nondestructive

activation analysis can be used to determine arsenic in minor/major levels in geological samples, sophisticated instruments are required. Isolation of arsenic from the matrix is essential for accurate determination. There are several ways of isolating arsenic from matrix like solvent extraction<sup>5,6</sup>, coprecipitation<sup>7-9</sup> and widely used arsine generation<sup>10,11</sup>. These techniques require special reagents and equipment. Arsine is passed through a dilute solution of silver nitrate, the precipitated silver arsenide washed with ammonium hydroxide and the silver in silver arsenide determined by atomic absorption spectrometry.

The reagents used were: 20% KI solution, 1% SnCl<sub>2</sub> (AR grade) in HCl, 1.5% AgNO<sub>3</sub> (AR grade), saturated bromine water, zinc pellets (AR grade), 2% ammonia (AR grade) solution and potassium pyrosulphate (AR grade). Silver nitrate (0.787 g) was dissolved in 50 ml of deionized water diluted to 1 litre with 1% (v/v) HNO<sub>3</sub> and preserved in an amber glass bottle. The resulting solution weighed 500 µg/ml. Standard silver solution of 0.2, 0.5, 1.0, 2.0, 3.0, 4.0 and 5 µg/ml was prepared by simple dilution of stock solution (500 µg/ml) maintaining 1% nitric acid concentration.

### Digestion of sample and evolution of arsine

(i) *For sulphide samples*, one gram of sample finely ground to -200 mesh is taken in a 100 ml beaker, and 5 ml of bromine water and 100 ml of concentrated nitric acid are added, the beaker is covered and the water bath kept for an hour, the cover removed and allowed to