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# AN INVESTIGATION ON ABUNDANCE OF MACRO-INVERTEBRATES IN RELATION TO WATER QUALITY OF SONE RIVER, SAHAR, ARRAH

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**KEYWORDS**

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## ABSTRACT

An attempt was made to investigate the abundance of macro-invertebrates in relation to water quality of Sone River, Sahar, Arrah. In this study, the average value of atmospheric temperature, water temperature, pH, dissolved oxygen, total alkalinity, hardness, total dissolved solid, chloride, nitrate and sulphate was calculated to be $24.902 \pm 6.464^0$C, $21.830 \pm 6.155^0$C, $7.272 \pm 0.155$, $7.026 \pm 0.93$ mg/L, $259.483 \pm 11.948$mg/L $132.108 \pm 5.294$ mg/L, $407.408 \pm 56.856$ mg/L, $21.401 \pm 3.162$mg/L, $2.723 \pm 0.48$ mg/L and $44.883 \pm 8.131$mg/L respectively. Macro invertebrate analysis showed the presence of 8 genera of phylum-Annelida belonging to two classes: Ologochaeta and Hirudinea, 10 genera of class Crustacea belonging to two sub-classes: Branchiopoda and Malacostraca, 7 genera of class-Insecta and 12 genera of phylum Mollusca belonging to two classes: Gastropoda and Pelecypoda respectively. Among macro invertebrates, annelida contributed the largest share of 49.31% of total macro invertebrate fauna, followed by 32.98% of Arthropoda and 17.69% of Mollusca. The benthic macro-invertebrates population was higher during winter season followed by monsoon and summer season. Statistical analysis showed that temperature, dissolved oxygen, chloride and total dissolved solid are the major deciding factors for abundance of most of macro invertebrates.

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## INTRODUCTION

Macro-invertebrates are animals lacking backbones and spines, visible to the unaided eye and can be captured by a 500 ìm net. Aquatic macro-invertebrates live on under and around rocks and sediment on the bottoms of lakes, rivers, and streams. As a result of their habitat choice, macro-invertebrates are often regarded as benthos. Macro-benthic invertebrates can be used as bio-indicators because of their extended residency period in specific habitats. The abundance of benthic fauna depends on physical and chemical properties of their habitat as they respond more quickly if any changes occur in water quality.

A large number of investigations have been made to study the physicochemical properties of water of different rivers (Maruthi *et al.,* 2010; Deshmukh and Urkude, 2014). Investigation on distribution and assessment of macro-benthic resources in the riverine systems has been well discussed in different parts of the country (Sharma *et al.,* 2011; Santhosh *et al.,* 2011) but few in Bihar (Roy, 2007). Such information of macro-invertebrates in relation to physicochemical nature of water of studied region is probably lacking.

Therefore, an attempt has been made to the abundance of macro-invertebrates in relation to water quality of Sone River, Sahar, Arrah.

## MATERIALS AND METHODS

Samples were collected fortnightly between 10.00am to 2.00pm from January 2013 to December 2014 at the selected site of Sone River, Sahar, Arrah. The samples were brought to the Laboratory of Department of Zoology of VKS University, Arrah.

Some of the parameters, such as, atmospheric temperature, water temperature, pH, dissolved oxygen, total alkalinity and hardness were analyzed at the site of collection, while, others namely, total dissolved solid, nitrate and sulphate were analyzed in the laboratory following the standard methods of APHA (2005).

The samples of benthos were collected with the use of an Ekman dredge and transferred to enamel buckets and were sieved with the help of water through sieve no. 40 which retained macro-organisms. Obtained materials were preserved in 10% formalin for making a detailed analysis. Macro invertebrates were identified by the works of Needham and Needham (1970) and APHA (2005). The number of benthos per unit area was represented as Org/$m^2$.

Data recorded on a predesigned Performa were entered in a Microsoft Excel spreadsheet. The results were expressed in mean and standard deviation for each group. Then data were tested for statistical significance by a two way correlation,

## RESULTS AND DISCUSSION

### Physico chemical parameters

Atmospheric temperature is one of the most important ecological factors controlling the physiological behavior and distribution of aquatic life. It varies as one move

vertically upwards from the earth's surface. Atmospheric temperature ranged from 14.46 ± 5.90 to 32.76 ± 7.38ºC with an average of 24.902 ± 6.464ºC (Table 1) at Sone River, Sahar, Arrah. A range of 21.0 to 35.7ºC of atmospheric temperature around various water bodies of Bihar had also been observed by Rai *et al*. (2013) and Mishra and Hasan (2013).

Similarly, the mean water temperature of 21.830 ± 6.155ºC was found in the range of 12.70 ± 4.23 to 30.07 ± 5.09ºC at this place. Karla *et al*. (2012) Rai *et al*. (2013) and Mishra and Hasan (2013) reported similar range from 17.6 to 33.0ºC of water temperature at different water bodies of Bihar. As the solubility of oxygen in water is inversely proportional to temperature, dissolved oxygen of water at a higher temperature would be reduced.

pH is one of the important environmental factors of natural water. pH of water was in the range of 6.89 ± 0.63 to 7.42 ± 0.92 in this study with an average of 7.272 ± 0.155 (Table 1). A range of 6.2 to 8.9 of pH of water of various water bodies of Bihar had also been observed by Karla *et al*. (2012), Rai *et al*. (2013), Singh and Choudhary (2013) and Mishra and Hasan (2013).

Dissolved oxygen is an important parameter to support aquatic life. In this work, dissolved oxygen of water ranged from 5.38 ± 0.50 to 8.02 ± 0.38mg/L showing a mean of 7.026 ± 0.93mg/L (Table 1). Karla *et al*. (2012), Rai *et al*. (2013), Mishra and Hasan (2013), Singh and Choudhary (2013) reported a wide range from 3.0 to 9.7 mg/L of dissolved oxygen of water of selected water bodies of Bihar.

Alkalinity is important for aquatic life because it protects them from rapid changes in pH. Average total alkalinity of water was found 259.483 ± 11.948mg/L with a range of 238.4 ± 42.3 to 275.6 ± 24.6mg/L (Table 1). A wide range of 114.0 to 298.0mg/L of total alkalinity of various water bodies of Bihar had been observed by Karla *et al*. (2012), Mishra and Hasan (2013) and Rai *et al*. (2013).

In this work, hardness of water ranged from 120.6 ± 10.2 to 138.2 ± 15.8mg/L with a mean of 132.108 ± 5.294mg/L (Table 1). Karla *et al*. (2012), Singh and Choudhary (2013) and Rai *et al*. (2013) reported a very wide range of 90.0 to 290.0mg/L of hardness of water of selected water bodies of Bihar.

Total dissolved solid of water showed average of 407.408 ± 56.856mg/L and range of 321.8 ± 32.2 to 458.4 ± 42.7mg/L (Table 1). A wide range of 143.0 to 872.0mg/L of total dissolved solid of various water bodies of Bihar had been observed by Karla *et al*. (2012) and Rai *et al*. (2013).

Chloride occurs naturally in all types of water. In natural fresh water, however, its concentration remains quite low. Average value of chloride of water was observed 21.401 ± 3.162 mg/L with a range of 7.86 ± 2.8to 26.68 ± 5.9mg/L (Table 1). A range from 14.0to 70.0mg/L of chloride of water of various water bodies of Bihar had been observed by Karla *et al*. (2012), Rai *et al*. (2013) and Mishra and Hasan (2013). But, Singh (2010) reported the mean value of chloride ranged between 8.2to 81.5mg/L in River Ganga in Varanasi.

Nitrate content of water is of great importance for algal growth and to judge organic pollution. In this work, nitrate of water was observed in the range of 2.14 ± 0.28to 3.37 ± 0.50mg/L and average of 2.723 ± 0.48mg/L (Table 1). A range of 0.021

**Table 1: Certain Physico-Chemical parameters of water of Sone River, Sahar, Arrah during 2013-2014**

| | Atmospheric Temperature (ºC) | Water Temperature (ºC) | pH | Dissolved Oxygen (mg/L) | Total Alkalinity (mg/L) | Hardness (mg/L) | Total Dissolved Solid (mg/L) | Chloride (mg/L) | Nitrate (mg/L) | Sulphate (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 14.46 ± 5.90 | 12.88 ± 3.76 | 7.40 ± 0.71 | 7.86 ± 0.69 | 265.8 ± 27.4 | 137.8 ± 16.3 | 352.6 ± 30.8 | 19.54 ± 2.3 | 2.14 ± 0.28 | 32.4 ± 2.9 |
| FEB | 17.08 ± 7.02 | 15.87 ± 3.88 | 7.30 ± 0.75 | 7.84 ± 0.54 | 262.3 ± 27.8 | 138.2 ± 15.8 | 434.5 ± 40.2 | 20.28 ± 1.8 | 2.38 ± 0.23 | 42.8 ± 1.8 |
| MAR | 23.71 ± 7.63 | 19.04 ± 5.02 | 7.29 ± 0.91 | 7.43 ± 0.32 | 273.8 ± 28.3 | 135.4 ± 13.7 | 435.8 ± 25.4 | 22.14 ± 1.3 | 2.39 ± 0.28 | 47.9 ± 1.9 |
| APR | 28.64 ± 7.86 | 23.26 ± 4.73 | 7.42 ± 0.92 | 6.74 ± 0.44 | 275.6 ± 24.6 | 132.8 ± 12.2 | 466.1 ± 40.3 | 25.53 ± 5.8 | 2.42 ± 0.14 | 51.2 ± 1.7 |
| MAY | 32.76 ± 7.38 | 30.07 ± 5.09 | 7.38 ± 0.94 | 6.38 ± 0.60 | 270.2 ± 22.8 | 134.3 ± 12.8 | 454.3 ± 52.8 | 26.49 ± 6.4 | 2.88 ± 0.19 | 55.4 ± 1.6 |
| JUN | 31.41 ± 4.51 | 29.42 ± 3.79 | 7.26 ± 0.96 | 6.18 ± 0.72 | 264.8 ± 27.9 | 133.9 ± 12.4 | 458.4 ± 42.7 | 26.68 ± 5.9 | 3.24 ± 0.51 | 44.3 ± 3.1 |
| JUL | 30.18 ± 4.03 | 27.14 ± 3.51 | 7.14 ± 0.88 | 5.82 ± 0.48 | 260.4 ± 32.7 | 135.4 ± 14.9 | 457.6 ± 40.1 | 21.58 ± 1.2 | 3.28 ± 0.59 | 41.9 ± 2.8 |
| AUG | 29.38 ± 5.47 | 26.16 ± 4.22 | 7.19 ± 0.91 | 5.38 ± 0.50 | 258.1 ± 34.2 | 120.6 ± 10.2 | 432.2 ± 46.4 | 20.07 ± 1.4 | 3.31 ± 0.57 | 57.8 ± 2.7 |
| SEPT | 28.32 ± 4.98 | 25.82 ± 4.01 | 6.89 ± 0.63 | 6.82 ± 1.23 | 238.4 ± 42.3 | 133.8 ± 12.1 | 416.8 ± 50.3 | 19.44 ± 1.1 | 3.37 ± 0.50 | 52.5 ± 1.6 |
| OCT | 26.76 ± 4.38 | 22.18 ± 2.74 | 7.18 ± 0.48 | 7.93 ± 0.29 | 241.6 ± 42.8 | 124.6 ± 10.7 | 324.4 ± 32.6 | 18.62 ± 2.6 | 2.82 ± 0.38 | 37.5 ± 53.0 |
| NOV | 20.63 ± 8.31 | 17.42 ± 5.79 | 7.39 ± 0.42 | 7.91 ± 0.32 | 248.5 ± 50.3 | 128.7 ± 08.8 | 321.8 ± 32.2 | 17.86 ± 2.8 | 2.27 ± 0.42 | 35.4 ± 1.9 |
| DEC | 15.49 ± 6.08 | 12.7 ± 4.23 | 7.42 ± 0.54 | 8.02 ± 0.38 | 254.3 ± 42.9 | 129.8 ± 07.9 | 334.4 ± 35.4 | 18.58 ± 2.2 | 2.18 ± 0.38 | 39.5 ± 0.6 |
| Average | 24.902 ± 6.464 | 21.830 ± 6.155 | 7.272 ± 0.155 | 7.026 ± 0.93 | 259.483 ± 11.948 | 132.108 ± 5.294 | 407.408 ± 56.856 | 21.401 ± 3.162 | 2.723 ± 0.48 | 44.883 ± 8.131 |

**Table 2: Monthly/seasonal variations shown by macro invertebrates in Sone River, Sahar, Arrah during 2013-2014**

| | Annelida | Crustacea | Insecta | Mollusca | Total | Percent |
|---|---|---|---|---|---|---|
| January | 576 | 31 | 232 | 167 | 1006 | 10.45 |
| February | 415 | 27 | 218 | 160 | 820 | 08.52 |
| March | 247 | 23 | 186 | 152 | 608 | 06.31 |
| April | 229 | 12 | 87 | 157 | 485 | 05.04 |
| May | 194 | 12 | 89 | 142 | 437 | 04.54 |
| June | 218 | 10 | 88 | 132 | 448 | 04.65 |
| July | 232 | 03 | 281 | 131 | 647 | 06.72 |
| August | 368 | 04 | 298 | 130 | 800 | 08.31 |
| September | 454 | 07 | 449 | 123 | 1033 | 10.73 |
| October | 593 | 35 | 390 | 134 | 1152 | 11.97 |
| November | 640 | 37 | 348 | 135 | 1160 | 12.05 |
| December | 584 | 47 | 261 | 140 | 1032 | 10.72 |
| Total | 4750 | 248 | 2927 | 1703 | 9628 | |
| Percent | 49.31 | 2.58 | 30.40 | 17.69 | | |

**Table 3: Correlation coefficient of physico-chemical parameters and macro-benthic invertebrates in Sone River, Sahar, Arrah during 2013-2014**

| | Atmospheric Temperature ($^0$C) | Water Temperature ($^0$C) | pH | Dissolved Oxygen (mg/L) | Total Alkalinity (mg/L) | Hardness (mg/L) | Total Dissolved Solid (mg/L) | Chloride (mg/L) | Nitrate (mg/L) | Sulphate (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Annelids | -0.697** | -0.697** | 0.057 $^{NS}$ | 0.714** | -0.680* | -0.311 $^{NS}$ | -0.949*** | -0.872*** | -0.443 $^{NS}$ | -0.657* |
| Crustaceans | -0.803*** | -0.837*** | 0.515 $^{NS}$ | 0.913*** | -0.234 $^{NS}$ | -0.062 $^{NS}$ | -0.844*** | -0.564* | -0.802*** | -0.721** |
| Insects | -0.1911 $^{NS}$ | -0.196 $^{NS}$ | -0.627* | 0.236 $^{NS}$ | -0.908*** | -0.402 $^{NS}$ | -0.581* | -0.855*** | 0.192 $^{NS}$ | -0.236 $^{NS}$ |
| Molluscs | -0.574* | -0.586* | 0.655* | 0.459 $^{NS}$ | 0.646* | 0.539 $^{NS}$ | 0.018 $^{NS}$ | 0.111 $^{NS}$ | -0.761** | -0.282 $^{NS}$ |

(NS = Not Significant, * = Significant, ** = Moderately Significant, *** = Highly Significant)

to 3.20mg/L of nitrate of water at different water bodies of Bihar had been observed by Karla *et al.* (2012), Singh and Choudhary (2013) and Mishra and Hasan (2013) respectively. Singh (2010) reported the mean value of $0.3885 \pm 0.3735$ mg/L of nitrate ranged between 0.015 to 0.762 mg/L in River Ganga in Varanasi.

Almost all natural water contains sulphate ion but its concentration varies according to mineral content of the earth. In this work, the average value of sulphate was observed $44.883 \pm 8.131$mg/L with a range of $32.4 \pm 2.9$to $55.4 \pm 1.6$mg/L (Table 1). A range of 32.0 to 90.0 of sulphate of water at different places of Bihar had been observed by Karla et al., (2012) and Rai *et al.* (2013).

From the above discussion, it may be inferred that the values of these physicochemical parameters are with the permissible range and supportive to the growth and distribution of benthic macro invertebrates.

**Benthic macro invertebrates**:

As far as the quantitative nature of macro-invertebrate was concerned, a total of 9628 individuals were collected from Sone River, Sahar, Arrah. Of these, Annelida contributed the largest share constituting 4750 (49.31%), followed by 3175 (32.98%) of Arthropoda (2927{30.40%} of insecta and 248 {2.58%} of Crustacea) and 1703 (17.69%) of Mollusca. Thus, the monthly/seasonal variation of these macro invertebrates ranges from 437 (04.54%) during the month of May to 1160 (12.05%) during November (Table 2). In this work, Annelida contributed the largest share of 51.06% of total macro invertebrate fauna, followed by 32.26% of Arthropoda and 16.68% of Mollusca.

In a work, analysis of numerical superiority of macro invertebrates Dhembare (2012) revealed that mollusca was dominant (48.10%) followed by Arthropoda (39.70%) and Annelida (12.20%) at Ashvi reservoir, Maharashtra. Sharma *et al.* (2013) reported benthic macro invertebrates belonging to Annelida, Arthropoda and Mollusca with the respective share of 17.1%, 42.1% and 44.8%. The present observation is showing opposite trend probably due to differences in ecological and geological factors when compared with the works of Dhembare (2012) and Sharma et al., (2013).

**Relationship between physico-chemical parameters & benthic macro invertebrates**

Relationship between physico-chemical parameters and macro invertebrate community structure has been the subject of numerous investigations (Garg *et al.,* 2009; Mohan *et al.,* 2013; Sharma *et al.,* 2013).

A significant and negative correlation was found between atmospheric /water temperature and annelids, crustaceans and molluscs but insignificant with insects. It indicates that abundance of annelids, crustaceans and molluscs got decreased significantly with the increase of atmospheric/water temperature.

The correlation was significant and negative between pH and insects, but the insignificant and positive with annelids and crustaceans and significant and positive relationship with molluscs. It shows that abundance of mollusca are significantly affected by the fluctuation of pH. Garg *et al.* (2009) and Mohan *et al.* (2013) also observed a significant positive correlation with molluscs.

A highly significant and positive correlation was determined

between dissolved oxygen and annelids and crustaceans but insignificant and positive with insects and molluscs. It indicates that abundance of annelids and crustaceans are significantly affected by the fluctuation of dissolved oxygen. Mohan et al., (2013) calculated also an insignificant positive relationship of dissolved oxygen of water with annelids and molluscs.

Total alkalinity showed a significant negative relationship with annelids and insects but positive and significant relationship with molluscs along with an insignificant negative relationship with crustaceans. Therefore, abundance of annelids, crustaceans and molluscs are significantly affected by the fluctuation of total alkalinity. Mohan *et al*. (2013) observed an insignificant positive correlation of water temperature with annelids, arthropods and molluscs. Garg et al., (2009) also calculated also moderate positive relationship of total alkalinity with molluscs.

But, hardness gave an insignificant negative relationship with annelids crustaceans and insects but an insignificant positive relationship with molluscs. It gives the idea that abundance of annelids, crustaceans and insects are significantly by fluctuation of hardness. Sharma *et al*. (2013) observed an insignificant negative correlation of total hardness of water with annelids and arthropods.

Total dissolved solid also established a significant negative relationship with annelids, crustaceans and insects but an insignificant positive relationship with molluscs. It indicates that abundance of annelids, crustaceans and insects are significantly affected by the fluctuation of total dissolved solid.

Chloride showed a significant negative relationship with annelids, crustaceans and insects but an insignificant positive relationship with molluscs. It means that abundance of annelids, crustaceans and insects are significantly affected by the fluctuation of chloride. Mohan *et al*. (2013) and Sharma *et al*. (2013) observed an insignificant/significant negative correlation of chloride of water with annelids, arthropods and molluscs.

Nitrate showed a significant negative relationship with crustaceans and molluscs but an insignificant negative relationship with annelids along with an insignificant positive relationship with insects. It infers that abundance of crustaceans and molluscs are significantly affected by the fluctuation of nitrate. Mohan *et al*. (2013) observed an insignificant/significant negative correlation of nitrate of water with annelids, arthropods and molluscs.

But, sulphate also showed a significant negative relationship with annelids and crustaceans but an insignificant negative relationship with insects and molluscs. It indicates that abundance of annelids and crustaceans are significantly affected by the fluctuation of sulphate. Mohan et al., (2013) observed an insignificant negative correlation of sulphate of water with annelids, arthropods and molluscs (Table 3).

It may be concluded that temperature, dissolved oxygen, chloride and total dissolved solid are the major physicochemical factors for abundance and distribution of most of the groups of macro invertebrates.

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