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Indexing water quality to determine suitability of inland fisheries of the river Ganges

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Abstract
Indexing is done based on data of water qualities of different sampling centers of the lower Ganges and gradation of waters of different centers for fisheries point of view are made. The same is performed by representing a stacked bar diagram which shows the suitability of different river based fisheries. Higher the stacked bar diagram more the suitability for fish assemblage. As we know higher value of dissolved oxygen always may indicate better fisheries whereas values all other water quality parameters should be higher for plankton growth and may be lower values for fisheries,

Keywords: Indexing water quality, Lower stretches, Riverine fisheries, Inland fisheries, Natural fish seeds

1. Introduction
A study has been made to derive water quality indexing which reveals that water qualities can be indexed to determine conducive fisheries areas in river Ganges. Data comprising forty-nine variables of water quality parameters of fisheries importance of the river lower Ganges from four sampling locations (Berhampur, Palta, Dakshineswar and Uluberia) during the period of four years (2002-2006), three seasons (winter, summer and rainy seasons), two positions (middle and side of the river) are studied using principal component analysis (PCA). Six factors of component matrix extracted by PCA and eight major controlling variables are identified. Water quality indexing is done for linear and weighted means of such eight controlling variables based on location, season and position. Through indexing waters of different locations, seasons, positions of the river are represented in the form of various stacked bars that differentiated suitability in fisheries.

2. Materials and Method
Assessment of primary production by statistical analysis of water-quality data was done and principal component analysis was carried out over water quality parameters of The River Elbe, Germany (Petersen and Callies, 2002) [2]. An index of biological integrity (IBI) was developed for streams in the Hudson, Delaware, and Susquehanna River drainages in the northeastern United States based on fish assemblage data from the Mohawk River drainage of New York. The relationships between the IBI and other indicators of environmental quality are examined using data on assemblages of fish and benthic macro-invertebrates and on chemical and physical stream characteristics obtained during 1993-2000 by the U.S. Geological Survey's National Water Quality Assessment Program in these three river basins. A principal components analysis (PCA) of chemical and physical variables from 27 sites resulted in an environmental quality gradient as the primary PCA axis (Daniels, 2002). Water sampling of water quality parameters were done to determine water pollution of river Detroit (Vaughan and Harlow, 1965) [3] are also mentioned.

3. Results and Analysis
Data of forty-nine water quality parameters over four locations, three seasons, two positions and four years of the river lower Ganges which are collected by Water Quality Monitoring Laboratory, BCKV, Kalyani under National River Conservation Directorate, Ministry of Environment and Forests, Govt. of India, are analyzed using SPSS. Maximum data value of the sampling frame comparing different sampling centre with seasonality and (Table 2) over four years is considered. Statistical tool like PCA is applied to find the component matrix (Table 1). Major parameters identified using the variable selection technique like MDS i.e.

minimum data set. All MDS parameters are taken for indexing using MS Excel. Factors or components are extracted (**Table 1**) corresponding Eigen values more than one. Considering at least 5% of total variance explained maximum 6 factors were subjected for minimum data set, MDS. Factor wise positively loaded variables which are in contrast to negatively loaded variables.

Within each factor the highest loaded variables along with variables uncorrelated to this highest loaded variable, if any will construct the MDS where only 10 % reduction in highest loading was considered to study such correlations among all selected variables within that factor. Major MDS variables Dimethoate, Endosulfan-S, Endo-1, Ammonium nitrogen, Chlorine, Mn, BOD, DO are identified based on principal component analysis (PCA) and their indexing are done. There are four locations, three seasons, two positions of sampled water quality parameters for their maximum values calculated over the years and their serials in different combinations are mentioned in following (Table 2.) Water quality indexing is done based on the linear score of minimum data sets where the except DO and BOD all other variable are ranked in such a fashion that the minimum values is best and for DO, BOD maximum values are best. Weighted linear score were also calculated and on the basis of variance explained by principal component. Linear scores and weighted linear scores of each MDS parameters were further represented in bar diagram (Fig I-VIII) for better understanding of each sample point and also for comparing each season, location and position.

Table 1: Component matrix extracted by Principle Component Analysis and whose Factors or components are having corresponding Eigen values as more than one.

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
W.Temp.	0.64	0.68	-0.05	-0.11	-0.05	0.10
Ph	-0.29	0.20	-0.15	-0.27	0.34	-0.38
DO	-0.91	-0.25	0.10	-0.05	-0.07	0.04
BOD	-0.35	-0.20	-0.48	0.48	0.36	0.21
COD	0.33	-0.53	-0.48	0.38	0.17	-0.15
Turbidity	0.79	-0.26	0.08	0.15	-0.28	-0.06
Sulphate	-0.11	0.43	-0.20	-0.19	-0.17	-0.32
Conduct.	-0.79	-0.21	-0.20	0.33	0.07	0.00
Chloride	-0.04	0.07	-0.39	0.52	0.36	-0.46
Na	0.38	-0.14	-0.18	-0.11	0.05	0.22
Ca	0.59	-0.17	0.16	0.29	-0.12	0.46
Mg	-0.73	0.39	0.10	0.09	-0.06	-0.01
Alkali	-0.86	0.26	0.06	0.27	0.04	-0.03
Tot.hardnes	-0.73	0.17	0.08	0.38	-0.06	-0.06
Phospate	-0.52	-0.29	-0.24	0.49	-0.04	0.13
NH4 –N	0.17	0.85	0.08	0.20	-0.09	-0.10
Nitrate N	-0.14	0.12	-0.31	0.36	-0.02	0.46
Total_N	-0.63	0.02	-0.19	-0.12	0.01	0.05
TotColiform	0.61	-0.09	-0.44	-0.09	0.47	0.22
FaecalColi	0.72	-0.10	-0.37	-0.06	0.46	0.14
Total plates	0.85	-0.10	-0.33	0.12	0.22	0.11
Entero	0.80	-0.07	-0.39	0.04	0.23	0.19
Fe	0.89	-0.01	-0.13	0.19	-0.11	-0.01
Mn	0.31	-0.15	-0.06	0.23	-0.59	0.04
Zn	-0.34	-0.43	-0.35	-0.37	-0.04	-0.20
Cu	-0.13	-0.27	-0.11	0.10	-0.27	0.36
Cd	0.67	0.59	0.04	0.06	-0.14	0.03
Cr	0.41	0.43	-0.11	0.06	0.13	-0.31
Ni	0.09	-0.39	0.07	-0.27	-0.40	-0.13
Pb	0.70	0.40	0.32	-0.01	-0.05	-0.16
HCH1	0.33	-0.35	0.62	0.37	0.17	-0.30
HCH2	-0.17	0.81	0.05	-0.01	0.42	0.13
HCH3	0.38	-0.45	0.39	0.31	0.32	-0.13
HCH4	0.04	-0.35	0.59	0.03	0.46	-0.02
Total HCH	-0.17	0.80	0.05	0.02	0.43	0.11
pp DDE	0.23	-0.32	0.51	0.32	0.06	0.05
opDDD	-0.18	0.59	0.44	0.13	-0.15	0.29
opDDT	-0.14	0.02	-0.12	-0.29	0.37	-0.14
Pp DDT	-0.26	-0.26	0.01	0.42	0.30	-0.40
Total DDT	-0.03	0.22	0.62	0.23	0.00	0.26
Endo-1	0.24	-0.32	0.71	0.20	0.14	-0.16
Endo-2	-0.35	-0.12	0.15	-0.09	0.21	0.36
Endo-S	-0.27	-0.12	0.02	-0.17	0.40	0.54
Tot_endo	0.08	-0.32	0.70	0.18	0.26	0.06
Tot_OC	-0.19	0.78	0.18	0.04	0.39	0.13
Dimethoite	-0.01	0.35	-0.18	0.56	-0.31	0.39
M.parathion	0.44	0.56	0.18	-0.05	-0.01	-0.21
Malathion	-0.02	0.12	-0.39	0.59	-0.18	-0.26
Total OP	0.09	0.57	-0.17	0.51	-0.17	-0.27

Table 2: Sampling frame of four locations, three seasons, two positions of sampled water quality parameters over the years and their serials number in different combinations are mentioned

Serial No	Location	Season	Position
1	Berhampur	Winter	Middle
2	Berhampur	Winter	Side
3	Berhampur	Summer	Middle
4	Berhampur	Summer	Side
5	Berhampur	Rainy	Middle
6	Berhampur	Rainy	Side
7	Palta	Winter	Middle
8	Palta	Winter	Side
9	Palta	Summer	Middle
10	Palta	Summer	Side
11	Palta	Rainy	Middle
12	Palta	Rainy	Side
13	Dakshineswar	Winter	Middle
14	Dakshineswar	Winter	Side
15	Dakshineswar	Summer	Middle
16	Dakshineswar	Summer	Side
17	Dakshineswar	Rainy	Middle
18	Dakshineswar	Rainy	Side
19	Uluberia	Winter	Middle
20	Uluberia	Winter	Side
21	Uluberia	Summer	Middle
22	Uluberia	Summer	Side
23	Uluberia	Rainy	Middle
24	Uluberia	Rainy	Side

Location: 1 Berhampur, 2 Palta, 3 Dakskineswar, 4 Uluberia; Season : 1 Winter, 2 Summer, 3 Rainy; Position : 1 Middle, 2 Side

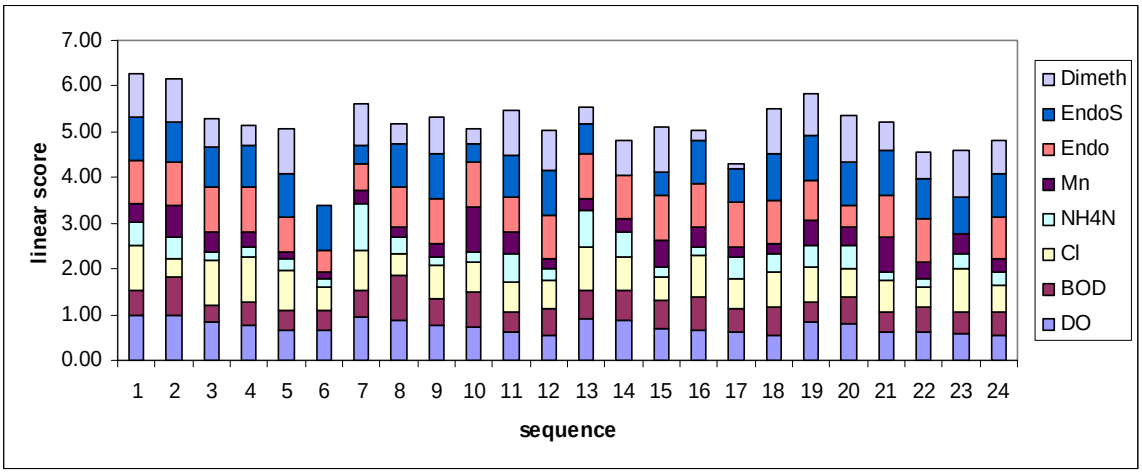

Fig 1: Linear score of controlling MDS parameters.

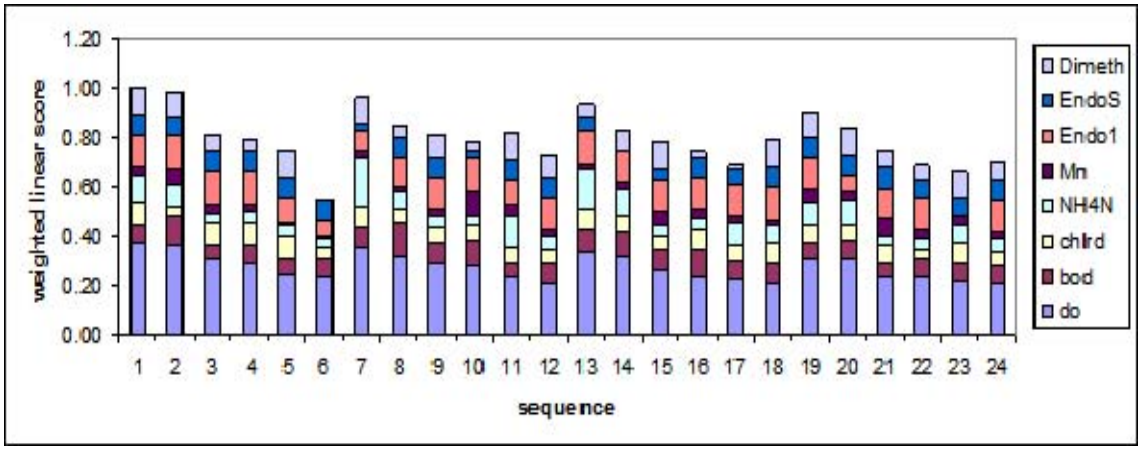

Fig 2: Weighted linear score of controlling MDS parameters.

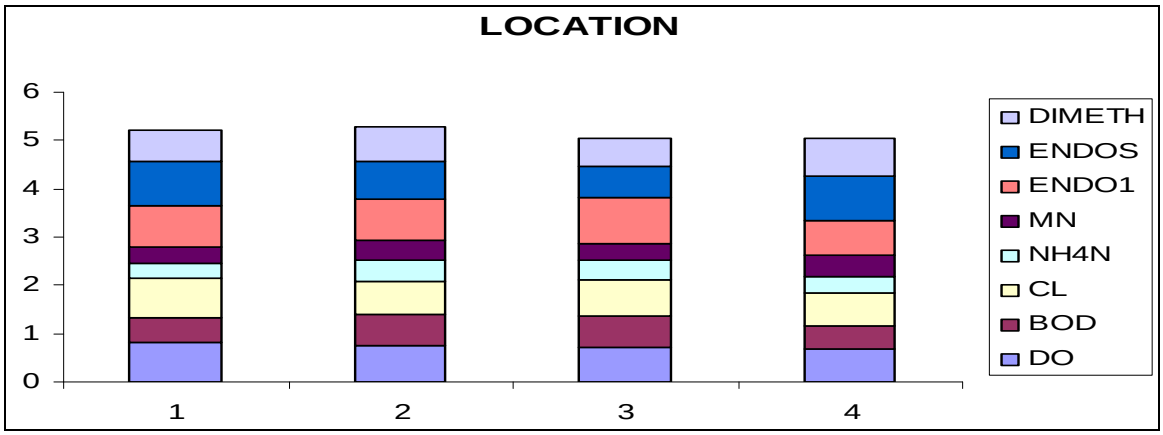

Fig 3: Linear score on of controlling MDS parameters on location.

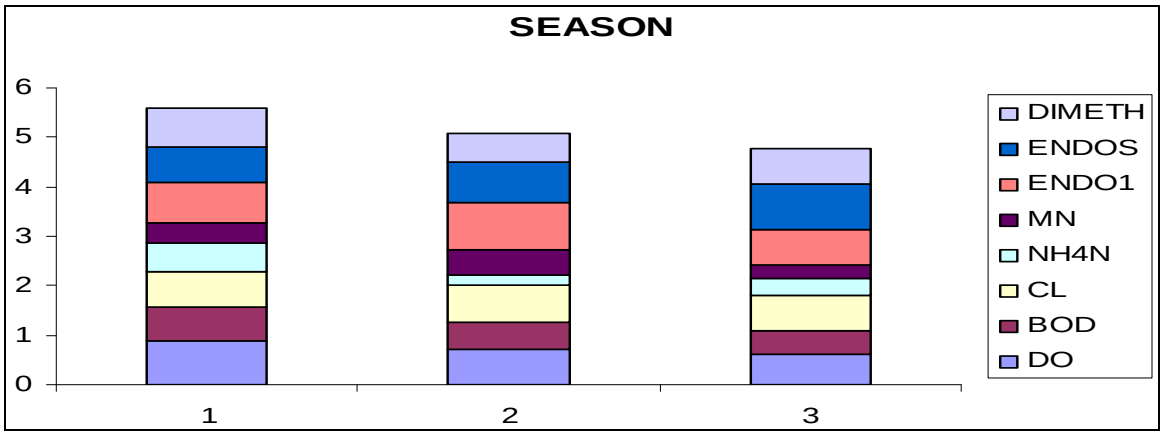

Fig 4: Liner score of controlling MDS parameters on seasons.

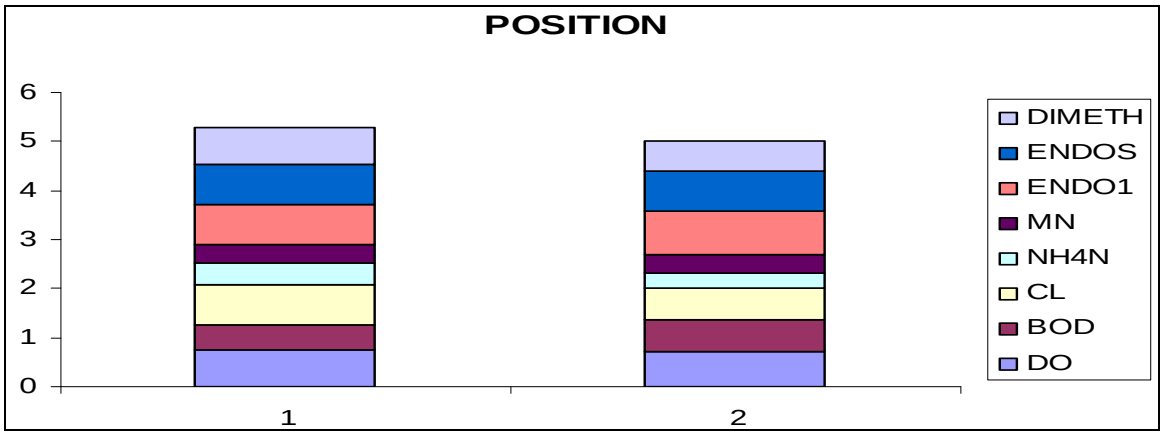

Fig 5: Liner score of controlling MDS parameters on positions

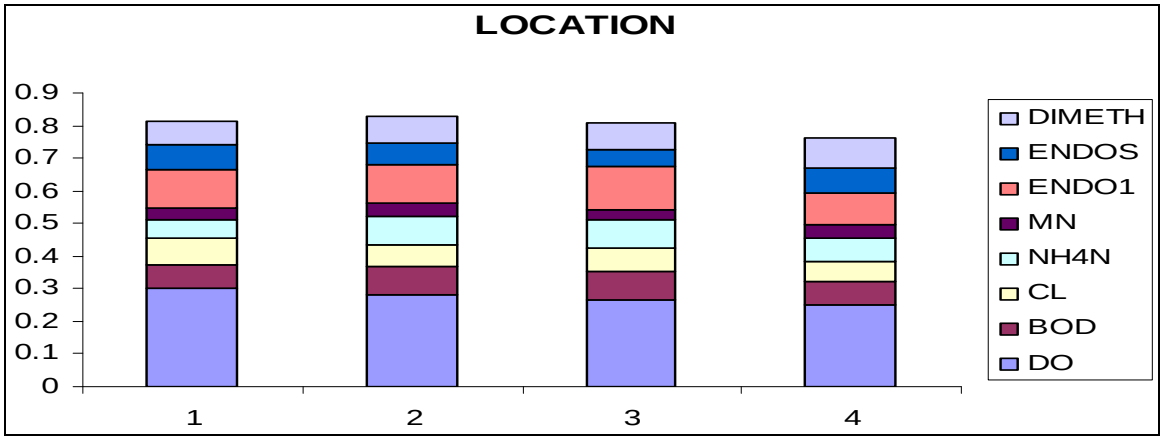

Fig 6: Weighted score on of controlling MDS parameters on location

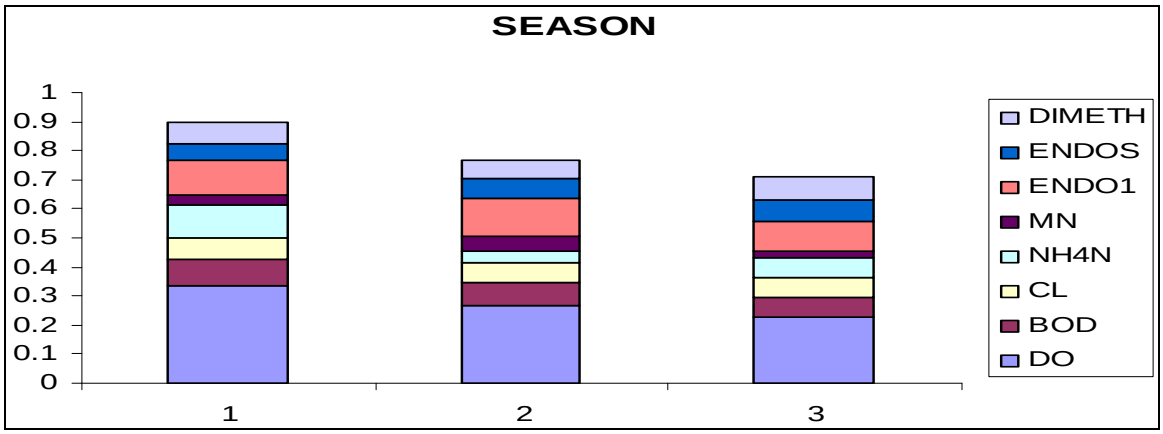

Fig 7: Weighted score of controlling MDS parameters on seasons

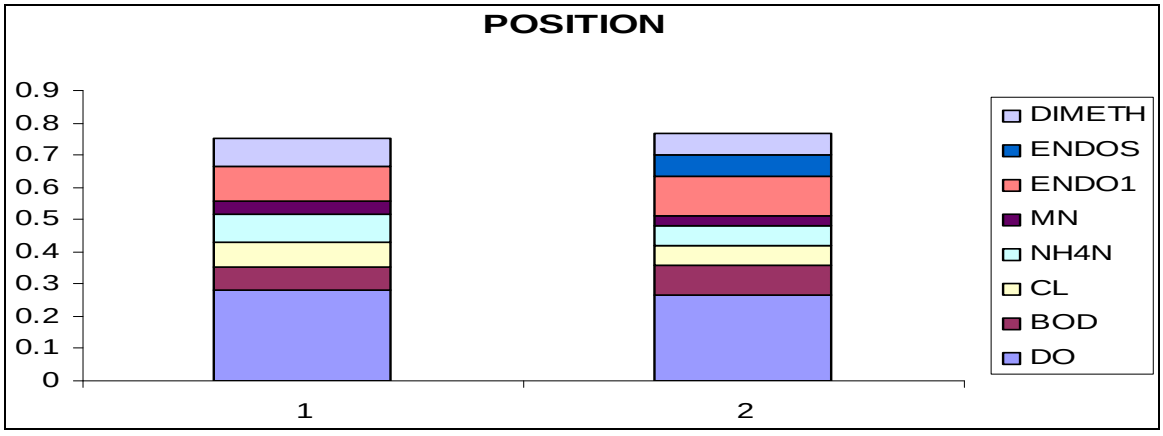

Fig 8: Weighted score of controlling MDS parameters on positions.

4. Conclusion

It is concluded that, in all figures, higher stacked bar indicated better water qualities for inland fisheries in the respective zones of the lower stretches of the river Ganges and also to avail enriched fish seeds as a source, fisheries recruitment once depleted.

5. Acknowledgments

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