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A NON - STATISTICAL POLLUTION EVALUATOR INDEX FOR COASTAL AQUATIC ECOSYSTEMS BASED ON ABIOTIC ENVIRONMENTAL PARAMETERS.

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Abstract :

The present paper describes a Pollutrion Evaluator Index (PEI) for coastal aquatic ecosystems. It is based on parameters of water and sediment. For calculating the PEI, the average values of the parameters are compared with their standard limit values for unpolluted ecosystems (described by researchers) and percent variation from the limit values is calculated. Accordingly positive or negative points are given for the variation towards healthy or polluted conditions respectively. The basis of calculation of PEI method is flexible and can be suitably modified for the other dquatic ecosystems (or even the terrestrial ecosystems). The calculation is explained using the 1999-2000 data on Thane creek and the advantages and the limitations of the index are discussed.

Introduction :

Pollution is a major problem affecting the natural ecosystems around the world. Dybern (1973) defined pollutant as a substance whcih brings about negative changes in natural environment. Various methods are used to study the changes taking place in the ecosystem. Many scientists have suggested different statisctical and biologtical indices to determine the extent of pollution. Some of the popular statistical tests and indices include average, standard deviation,'t' and 'Z' tests, correlation coefficients, etc. while the commonly used biological indices are Shannon-Weaver index, Margalef's index. Menhinick's index, Richness indices, Evenness index, diversity indices, etc. The later are based on occurrence, dominance and variety of organisms and have a major advantage that they become helpful to asess pollution status even by studying single or a few samples. However sometimes they fail to evaluate, mainly because of different r esponse of different organisms to pollution stress. Their calculation and interpretation requires the biologist to seek help of a statistician or acquire adequate knowledge of statistics. This problem has been tackled by some workers by evolving relatively easy indices such as Nygaard's index, Palmer's algal genus/species index, Raffaeli Mason's Nematode/Copepod index (for aquatic ecosystems), Lampshed's K-dominance curve, Warwick's ABC curve, etc. But in practice these also prove difficult like statistical and biological indices. Hence a new non-statistical Pollution Evaluator Index (PEI) has been suggested to assess the health of coastal aquatic ecosystems. It is based on the standrd limits of different water and soil (abiotic) parameters of an unpolluted coastal ecosystem that are suggested by various researchers. The index however can be modified as per the need for fresh water ecosystems.

Table 1. Standard limit values for water and soil parameters of coastal aquatic ecosystems.

Parameter	**Standard limit value for unpolluted environment used for calculating PEI**	**Reference**
pH	pH 8 - indicates normal marine water, due decomposition or respiration pH reduces to b 7.5; during photosynthesis it rises to over 9	Levinton, 1982
Suspended solids	Limit value not available Hence presently 1.7 g/I was used as it was an average of Thane cr in 1981 - 82, when pollution was lower.	Tandel, 1984; Pejaver 1984
Dissolved Oxygen	2.5 mg/ I - In nutrient enriched waters dissol oxygen below 2.5 mg/I is considered hypoxi	Laponite and Clark, 1992
PO4-P	0.9 mg/l - maximum limit for unpolluted wat	Ryther and Dunstan, 1971
NO3-N	1.26 mg/l - is considered as semihealthy cond	Raman and Ganapati, 1986.
Soil Eh	+ 200 mv - is considered as weakly reduce condition	Varshin in and Rozanov, 1983.
Soil Organic	1.22% - organic carbon below this level is considered as healthy condition	Raman and Ganapati, 1983

Table 2. Point assigning scheme based on percent variation from limit values of different parameters.

Parameter	Limit value considered for PEI Calculation*	Decided percent variation for assigning ± 1 point
pH**	8	1%
Suspended solids ***	1.703 g/l	100%
Dissolved Oxygen	2.5 mg/l	10%
PO4-P	0.09 mg/l	25%
NO3-N	1.26 mg/l	25%
Soil redox potential Eh	200 mv	25%
Soil Organic Carbon	1.22 %	25%

* One can change / modify the limits / scheme for fresh water lentic and lotic ecosystems.

** Grading for pH should be reconsidered if pH increases beyond 9.5 as it would not be healthy condition and should be given negative marks.

*** Limit value based on average of 1981-82 data on Thane creek (Tandel, 1984; Pejaver, 1984) when the creek water was relatively healthy. The value may be taken as 1 g/l.

For evolving the Pollution Evaluator Index (PEI), Thane creek ecosystem has been used as a model, hence the index is mainly for coastal water bodies. The PEI is based on the standard limit values for the rameters of unpolluted ecosystem, described by different researchers, (Table 1). The method for calculating the PEI is as below -

- The stationwise annual average values of the parameters are obtained and considered for calculating the PEI.
- The limit values of unpolluted water (Table -1) are treated as 100% for the respective parameters.
- The average value of a parameter is compared with the corresponding limit value in Table 1 and percent increase or decrease from the limit value is calculated e.g. Limit value for dissolved oxygen is given. 2.5 mg/l and average 2mg/l shows 20% decrease from the limit value.
- For a fixed percent increase or decrease (variation) from the limit value, positive or negative points are assigned. The extent of percent variation considered for giving points varies with the parameter, as shown in table 2.

Table 3. Standard wise averages of various parameters of Thane creek and calculated Pollution Evaluator Indices (PEI)

Station wise average values of different parameters used to calculate the Pollution Evaluator Index (PEI)

Parameters	**Stn. 1**	**Stn. 2**	**Stn. 3**	**Stn. 4**	**Stn. 5**	**Stn. 6**	**Stn. 7**	**Stn. 8**	**Stn. 9**	**Stn. 10**	**Stn. 11**	**Stn. 12**	**Aver-age**
pH HT	7.37	7.41	7.62	7.73	7.74	7.84	7.74	7.77	7.81	7.75	7.75	7.7	7.69
pH LT	7.6	7.53	7.64	7.9	7.71	7.88	7.88	7.71	7.81	7.77	7.71	7.7	7.74
SS HT	3.08	4.05	6.7	6.43	10.13	4.35	3.88	3.9	6.23	4.43	5.5	5.17	5.32
SS LT	7.47	5.75	1.9	6.88	10.17	8.17	4.28	9.52	9.88	6.75	5.35	6.98	6.93
DO HT	2.73	1.13	1.47	2	2.16	2.98	2.52	2.21	2.9	2.29	2.75	3.11	2.35
DO LT	4.02	2.04	1.88	2.05	1.36	2.09	2.09	3.62	2.1	2.94	2.01	3.12	2.44
PO4- PHT	0.18	0.45	0.354	0.4	0.398	0.34	0.255	0.213	0.204	0.172	0.21	0.1	0.273
PO4-P LT	0.179	0.314	0.337	0.288	0.323	0.294	0.308	0.238	0.245	0.206	0.21	0.17	0.254
NO3-N HT	0.987	0.893	0.945	0.97	0.976	1.073	1.029	0.863	0939	1.022	1.108	0.836	0.97
NO3-N LT	0.865	0.905	0.922	1.184	0.784	0.995	0.863	1.046	0.914	0.878	0.918	1.102	0.948
Soil EH	-30.15	-23.58	-30.49	-29.56	-27.75	-28.87	-23.33	-26.57	-22.35	-27.4	-23.68	-24.07	-26.48
Soil OC	2.61	3.9	2.76	2.63	3.46	2.38	2.73	2.1	2.41	2	2.23	2.14	2.63
Points allotted after calculating the % difference from the Pollution limit values.													
pH HT	-8	-7	5	3	3	-2	-3	-3	2	3	-3	-4	-4
pH LT	-5	-6	-5	-1	-4	-2	-2	-4	-2	-3	-4	-4	-3
SS HT	-1	-1	-3	-3	-5	-2	-1	-1	-3	-3	-2	-2	-2
SS LT	-3	-2	-1	-3	-5	-4	-2	-5	-5	-3	-2	-3	-3
DO HT	1	-5	-4	-2	-1	2	1	-1	2	-1	1	2	-1
DO LT	6	-2	-2	-2	-5	-2	-2	4	-2	2	-2	2	-1
PO4- PHT	-4	-16	-12	-14	-14	-11	-7	-5	-5	-4	-5	-1	-8
PO4-P LT	-4	-10	-11	-9	-10	-9	-10	-7	-7	-5	-5	-1	-7
NO3-N HT	1	1	1	1	1	1	1	1	1	1	1	1	1
NO3-N LT	1	1	1	1	2	1	1	1	1	1	1	1	1
Soil EH	-5	-4	-5	-5	-5	-5	-4	-5	-4	-5	-4	-4	-5
Soil OC	-5	-9	-5	-5	-7	-4	-5	-3	-4	-3	-3	-3	-5
Total (PEI)	-26	-60	-51	-45	-56	-37	-33	-28	-30	-26	-27	-16	-37

For e.g. pH change is usually in small range,
while in case of nutrient PO4-P or suspended solids the fluctuations are usually large. Hence for every 1% variation in pH from the limit value 1 point is allotted; whereas the same 1 point is assigned for every 25% change in PO4-P and 100% change in suspended solids.

- Positive points are allotted for the change towards healthy conditions and negative points
  for the ones indicating more deterioration of the environment. For e.g. if average dissolved oxygen at a station is 4 mg/l then it is a relatively healthy condition as composed to the limit value 2.5 mg/l. So the station will get positive points. Whereas a station with average dissolved oxygen 1mg/l will get negative points.

- Finally the points assigned for all the parameters are totaled and accordingly the healthiness or pollution of an ecosystem is evaluated

- The ecosystem is said to be healthy when the total is a positive number, stressed when the total to zero or close to zero and polluted when the total is a negative number.

- The extent of healthiness or pollution can be judged on the magnitude of the positive or negative total.

Calculation of PEI for the model ecosystem :

The authors were studying Thane creek ecosystem ecology at 12 different stations along its 26 km stretch during year 1999-2000. The hydrological parameters were studied during low tide and high tide whereas sediment parameters were assessed during low tide. Using the average values for different parameters pollution evaluator indices were calculated for all the stations and for overall averages of Thane creek (Table 3). It was noticed that the pollution status of different stations indicated by different indices matched with the on ground status.

The PEI based on overall averages of all 12 stations was -37 indicating high level of pollution in Thane creek. Station wise PEI indicated the upstream stations 2 to 6 to be more polluted. This is supported by the visual observational facts that the upstream stretch is relatively shallow and faces maximum anthropogenic pressure by way of solid waste disposal , construction activities, reclamation, release of effluent and domestic sewage. On the contrary the pollutant load gets diluted in the lower (downstream) streatcg; hence PEI indices of the downstream stations were lower. Stn 12 being near open sea showed the minimum PEI. The upsteam Stn. 1 is close to be junction of Thane creek with Ulhas river. Hence at this station the pollutants get diluted. The station had relatively lower PEI than the other upstream stations.

The PEI can be thus used to evaluate and compare the pollution status of the ecosystem and it can be calculated with minimum mathematical skill. It is not necessary that one must have data on many parameters. Even less number of parameters can give an idea regarding the pollution status. However more parameters will give a better evaluation. One can compare pollution status of two or more studies by calculating their PEI based on the available average values of the parameters. It is essential that the parameters studied are common equal in number. For e.g. for comparison of the pollution status of Thane creek in year 1979-80, 84-85 and 1999-200, the data available had only five environmental parameters common, namely pH, dissoved oxygen, PO4-P, NO3-N and sediment - organic carbon. When the PEI were calculated (Table 4) they clearly indicated relatively healthy creek conditions in year 1979-80 (PEI = +8) which deteriorated in the following years as indicated by PEI - 11 in 84-85 and -16 in 1999-2000. Thus, using the PEI calculated from the available data, one could point out the changing patterns in an ecosystem and determine the levels of deterioration. However it must be

Table 4. Pollution Evaluator Indices calculated for the past data of Thane Creek.

Study period	**1979-80**		**1984-85**		**1999-2000**	
Parameters	**Average Data**	**Calculated values PEI**	**Average Data**	**Calculated values PEI**	**Average Data**	**Calculated values PEI**
pH	7.85	-2	7.45	-7	7.72	-3
DO	5.67	+12	4.09	+6	2.40	-1
PO4-P	0.174	-4	0.163	-3	0.264	-8
NO3-N	0.185	+4	2.047	-2	0.959	+1
OC	1.81	-2	2.85	-5	2.63	-5
Total	–	+8	–	-11	–	-16
pH	7.85	-2	7.45	-7	7.72	-3

noted that PEI shoud not be based on only one or two parameters; data on at least 5 parameters would be optimum. If more parameters are included, the conclusion drawn will be more reliable

Discussion :

From the above examples based. on the data on Thane creek it becomes evident that the PEI values fluctuate between positive to negative depending on the status of the ecosystem. The index is inversely related to the degree of pollution. i.e. for highly polluted environment the PEI will be more negative value (low) and a healthier environment will give more positive (high) PEI. As the PEI is based on abiotic parameters i.e. the parameters of water and sediment, it has certain advantages and limitations.

Advantages

i) The most significant advantage of the present PEI is its simplicity. A person with optimum mathematical knowledge of calculation of % change can calculate PEI.

ii) As PEI is based on water and sediment parameters, it can depict correctly the status of pollution.

iii) There is no need to study biotic parameters hence a non-biologist can use the index.

iv) One can modify PEI method suitably for other aquatic ecosystems such as pond, lake, river, etc. for which one will have to specify limit values and the percent variation considered for giving points.

Limitations :

i) PEI may fail to evaluate exact pollution status if the results of single sample study are considered. Hence for application of PEI it is ideal to have average values obtained by studying many samples.

ii) The comparison of PEI indices of two ecosystems is possible only if data is available for some common parameters.

Thus the new PEI is an added tool to assess and compare pollution status. It can be modified as per need and thoughtfully used considering its limitations.

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