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A Study on the Pollution due to Dissolved Copper and Chromium in the Water Column of Muvattupuzha River

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Abstract: ***Various methods have been used for estimating the pollution in water columns. But there exist uncertainty in the quality criteria employed and the vagueness in the input data leads to the vague output values. Fuzzy set theory has been successfully used for the analysis of vague and imprecise information. This paper presents a study on the pollution due to dissolved trace metals ofCopper and Chromium in the water column of Muvattupuzha River using modified fuzzy synthetic evaluation approach.***

Keywords: fuzzy synthetic evaluation, modified fuzzy operator

1. Introduction

Rivers are the major source of dissolved and particulate materials to the oceans and are there by the primary contributors to the geochemical composition of both ocean water and marine sediments. Muvattupuzha river is one of the major perennial rivers in Central Kerala having, a length of 121km, a catchment area of 1554km^2, annual sediment load input of 1,57,000 tons and an annual run off of 4780 million m^{3}of fresh water flows in to the Vembanad lake and thus to the Arabian Sea. The water stored in Idukki dam is being diverted to muvattupuzha river after generation of electricity. The agricultural areas and urban township located on the river banks of Muvattupuzha discharge untreated agricultural and domestic effluents in to the river. Trace metals get added to the riverine environment from both natural and anthropogenic sources [3]. Data on trace metal partitioning between dissolved and suspended particulate phases are scarce because only a few such measurements have been made in Indian riverine environments. Geo chemical assessment of trace metal enrichment in aquatic sediments is an important component in understanding environmental pollution and its impact on the ecosystem. Since the measurements of this involve vagueness we can suitably apply fuzzy theory for better evaluation.

2. Fuzzy Synthetic Evaluation

The concept of fuzzy sets was introduced by Zadeh in 1965 and has been applied throughout the world in decision making and evaluation process in imprecise environment. Lu et al. (2000) applied fuzzy synthetic evaluation techniques for accounting fuzzy information. Modified fuzzy operator is a simple fuzzy synthetic evaluation tool capable of overcoming the uncertainties existing in the sampling and analyzing methods.

3. Modified Fuzzy Operator

Fuzzy operator is a simple fuzzy synthetic evaluation technique for interpreting uncertainties of real world phenomena. Here fuzzy operator method is modified to obtain better results. Fuzzy operator utilizes the max-min operator (Zadeh) as a tool to perform fuzzy synthetic evaluation. If the relationship between ith parameter and jth data is represented by {λij} , a fuzzy number, thenthe modifiedfuzzy operator gives the relative impact of the problem as an interval ($\max_i \min_j \{\lambda ij\}$,$\min_i \max_j \{\lambda ij\}$).

4. The bimonthly data on dissolved trace metal Cu and Cr in the water column at 18 stations of the Muvattupuzha river:[5]

Station Position	July		September		November		January		March		May	
	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)
S_1	1.548	0.755	1.384	0.666	1.146	0.534	1.095	0.688	1.058	0.445	1.065	0.366
S_2	1.557	0.756	1.448	0.676	0.975	0.521	1.158	0.629	0.985	0.455	0.948	0.345
S_3	1.298	0.661	1.585	0.714	0.869	0.531	1.036	0.619	1.028	0.434	0.986	0.356
S_4	1.345	0.619	1.698	0.628	0.885	0.496	0.866	0.565	0.728	0.479	0.685	0.254
S_5	1.448	0.595	1.564	0.615	0.975	0.497	0.985	0.548	0.733	0.469	0.758	0.276
S_6	1.857	0.628	1.345	0.577	0.936	0.513	1.098	0.526	0.814	0.488	0.787	0.284
S_7	1.556	0.645	1.378	0.521	1.047	0.517	0.898	0.523	0.834	0.474	0.897	0.326
S_8	1.356	0.744	1.452	0.777	1.078	0.554	0.978	0.536	1.061	0.529	1.045	0.405
S_9	1.298	0.726	1.656	0.719	1.226	0.562	1.197	0.523	1,065	0.518	1.066	0.408
S_{10}	1.365	0.676	1.661	0.663	1.223	0.541	0.838	0.498	0.975	0.388	0.936	0.340
S_{11}	1.788	0.626	1.384	0.682	1.198	0.536	0.937	0.480	1.086	0.378	0.968	0.352
S_{12}	1.235	0.616	1.434	0.684	0.998	0.602	0.995	0.438	1.061	0.425	1.019	0.370

S_{13}	1.857	0.512	1.507	0.585	1.028	0.584	0.818	0.556	0.814	0.518	0.787	0.284
S_{14}	1.246	0.524	1.356	0.521	1.087	0.579	0.987	0.543	0.866	0.514	0.894	0.325
S_{15}	1.684	0.666	1.230	0.673	0.985	0.546	0.878	0.414	0.801	0.414	0.765	0.278
S_{16}	1.665	0.567	1.216	0.661	0.845	0.575	0.898	0.569	1.028	0.452	0.986	0.357
S_{17}	1.395	0.657	1.531	0.663	0.987	0.528	1.078	0.561	1.046	0.513	1.038	0.365
S_{18}	1.538	0.721	1.637	0.658	1.056	0.548	1.088	0.546	1.148	0.529	1.087	0.468

5. Bimonthly mean values and standard deviations of dissolved trace metalCu and Cr in the water column of Muvattupuzha river

Month	dCu (ppb)		dCr (ppb)	
July 2005	1 .502	0.203	0.650	0.073
Sept 2005	1.470	0.144	0.649	0.066
Nov 2005	1.030	0.115	0.542	0.030
Jan 2006	0.990	0.112	0.542	0.065
Mar 2006	0.959	0.127	0.468	0.048
May 2006	0.929	0.124	0.470	0.034

Thus the dissolved copper content in water column varies between 0.685 to 1.857ppb and the dissolved copper average is 1.15ppb during the months of July 2005 to May 2006. The dissolved Cu averages 0.22ppb of the Muvattupuzha river isvery much lower than the maximum permissible limits for human consumption 2000pbb[9],1500pbb [1],1500pbb[4]. The dissolved copper averages reported for the Indian river Kali is 1.34pbb[7] higher than that of Muvattupuzha river

The dissolved chromium content in water column varies between0.378 to 0.777 ppb during the months of July 2005 to may 2006 .The dissolved chromium averages 0.55 ppb of the Muvattupuzha river is very much lower than the maximum permissible limit of 50ppb for human consumption [1],[4],[9].

6. Evaluation of dissolved trace metalCu and Cr in the water column of Muvattupuzha river using modified fuzzy operator

Station Position	July		September		November		January		March		May	
	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)	Cu (ppb)	Cr (ppb)
$\min_j \lambda ij$	1.235	0.512	1.216	0.521	0.845	0.496	0.818	0.414	0.728	0.378	0.685	0.254
$\max_j \lambda ij$	1.857	0.756	1.698	0.777	1.226	0.602	1.197	0.688	1.148	0.529	1.087	0.468

Relative impact of Dissolved Copper

$\max_i \min_j \{\lambda ij\}=$

$\max_i\{1.235, 1.216, 0.845, 0.818, 0.728, 0.685\}$

=1.235 ppb

$\min_i \max_j \{\lambda ij\}=$

$\min_i\{1.857,1.698, 1.226, 1.197, 1.148,1.087\}$

=1.087ppb

The dissolved copper in the Muvattupuzhariver shows a variation from 1.087 to 1.225ppbusing modified fuzzy operator method and the dissolved copper average is 1.15ppb.

Relative impact of Dissolved Chromium

$\max_i \min_j \{\lambda ij\}=\max_i\{0.512,0.521,0.496,0.414,0.378,0.254\}$

= 0.521ppb

$\min_i \max_j \{\lambda ij\}=$

$\min_i\{0.756, 0.777, 0.602, 0.688, 0.529, 0.468\}$

=0.468ppb

Thus the dissolved Chromium in the Muvattupuzha river shows the variation from 0.468ppb to 0.521ppb using modified fuzzy operator and thedissolved chromium average is 0.55 ppb.

7. Conclusion

The modified fuzzy operator method reveals that the dissolved Cu and Cr in the river lies in the interval(1.087,1.235)ppb and(0.468,0.521)ppb respectively while the dissolved average of Cu and Cr calculated using mean and standard deviation methods shows a variation (0.085pbb ,1.705pbb) and (0.477pbb , 0.723pbb) respectively. Thus the fuzzy approach is shown to provide a better evaluation method.

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