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Spectral Analysis of River Ramganga Hydraulics using Discrete Wavelet Transforms

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Abstract

In the forecasting of something whatever it may be weather forecasting or results of the share marketing, etc. trend of raw data has an important role. In a given signal, trend is the most important part and also slowest part of a signal. In wavelet analysis terms, this corresponds to the greatest scale value. Discrete Meyer Wavelet (dmey) is orthogonal and compactly supportive and therefore, it is useful for multiresolution analysis of a signal. To sustainable management of freshwater ecosystems and understanding of the basic physical, chemical and biological components, there functions and interrelationship are necessary. We analyzed the unknown trend of the time series of TDS (Total Dissolved Solids) and EC (Electrical Conductivity) of river Ramganga water of the time period from 2005 to 2008 by discrete Wavelet transforms. In the present paper an attempt has been made to evaluate the selected parameters by applying Wavelet analysis techniques to diagnose the water quality problems. In order to carry out in-depth investigation 9 sampling stations at different segment of river Ramganga are selected on the basis of varied topographical conditions, agricultural, social patterns and on the locations of various large and small scale industries and also on the basis of human settlements.

1. Introduction

In India a number of studies have been made to describe the hydrochemistry of several stream and rivers. Kulwinder Singh Parmar et al. [1] studied the water quality parameters by using Daubechies wavelet (db5). Also the impacts of hydrological conditions of the water on biological community of the water body have been documented (Pathak et al.) [2, 3. 4]. In India as a developing country, industrial pollution is one of the main causes of water pollution has been investigated in several major rivers. The necessity to efficiently conserve and manage freshwater resources is becoming more and more urgent. This is as a result of growing world population and economic activities with the subsequent degradation of freshwater resources as a result of anthropogenic pollution.

Wavelet is a new development in the emerging field of data analysis for Physicists, Engineers, Environmentalists and Mathematicians [5, 6]. It represents an efficient computational algorithm under the interest of a broad community. Fourier sine's extracts only frequency information from a time signal, thus losing time information, while wavelet extracts both time evolution and frequency composition of a signal.

Wavelet is a special kind of the functions which exhibits oscillatory behaviour for a short time interval and then dies out. In wavelet we use a single function and its dilation and translation to generate a set of orthonormal basis functions to represent a signal. Number of such functions is infinite and we choose one that suits to our application. The range of interval over which scaling function and wavelet function are defined is known as support of wavelet. Beyond this interval (support) the functions should be identically zero.

There is an interesting relation between length of support and number of coefficients in the refinement relation. For orthogonal wavelet system, the length of support is always less than no. of coefficients in the refinement relation. A wavelet function is defined as

$$\psi_{a,b} = \frac{1}{\sqrt{|a|}}\psi\left(\frac{t-b}{a}\right)$$

Where a is scaling parameter which gives the dilate or compressed version of wavelet function and b is a parameter gives a translated version of wavelet function called translation parameter. If we choose $a = 2^{-j}$ and $b/a = k$, we get discrete wavelet

$$\psi_{j,k}(t) = 2^{j/2}\psi\left(2^j t - k\right)$$

The wavelet transform of a signal captures the localized time frequency information of the signal. Suppose we are given a signal or sequences of data $s = \{s_n\}_{n\in\mathbb{Z}}$ sampled at regular time interval $\Delta t = \tau$. S is split into a "blurred" version a_1 at the coarser interval $\Delta t = 2\tau$ and "detail" d_1 at scale $\Delta t = \tau$. This process is repeated and gives a sequence S_n, a_1, a_2, a_3, a_4,…..of more and more blurred versions together with the details d_1, d_2, d_3, …….removed at every scale ($\Delta t = 2^m\tau$ in a_m and d_{m-1}). Here $a_{m's}$ and $d_{m's}$ are approximation and details of original signal. After N iteration the original signal S can be reconstructed as $S=a_N+d_1+d_2+d_3+d_4+d_5+\ldots\ldots+d_N$.

2. Study Area

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River Ramganga is the most important tributary of Holy River Ganga. The river navigates through varied catchments covered with forestland, agriculture field and human settlements with various types of industrial setups. The study area of the river catchments lie between North latitude 29o29'42" and 28o49'32" and east latitude 78o45'37" and 78o47'53". The catchment area in downstream is inhabited on alluvial deposits of Quartz energy period. The alluvial deposits has been drained and transported from the Himalayas ranges by the Ganga river system and specially the river Ramganga. In order to carry out in depth investigation, nine sampling stations at different segments of river Ramganga were selected on the basis of varied topographical conditions, agricultural, social pattern and on the locations of various large and small-scale industries and also on the basis of human settlement.

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Table: 1. Sampling Spots in downstream River Ramganga

1	Kalagargh
2	Bhutpuri
3	Seohara
4	Mishripur
5	Agwanpur
6	Jigar Colony
7	Lalbhagh
8	Jamamasjid
9	Kathgargh

3. Methodology

3.1 Water Analysis

The river Ramganga was thoroughly surveyed physically as well as with the help of topographic maps keeping in view of the objectives of the present study. A detail survey of catchment area of the river along the stretch of about 110 km from upstream to downstream was conducted. The electrical conductivity and total dissolved solids were analyzed with the help of Hanna meters.

3.2 Spectral Analysis

Wavelet extracts both time evolution and frequency composition of a signal. Meyer wavelet is a frequency band limited function whose Fourier transform is smooth. This smoothness provides a much faster asymptotic decay in time. Discrete Meyer wavelet or dmey is a FIR (Finite Impulse Response) based approximation of the Meyer Wavelet [7, 8]. it is orthogonal and compactly supported and therefore it is useful for multi resolution analysis. Wavelet function and scaling function of dmey are shown in figure 1.

A multiresolution analysis for $L^2(\mathbb{R})$ introduced by Mallat [9, 10] and extended by other researchers [11, 12] consists of a Sequence $V_j : j \in \mathbf{Z}$ of closed subspaces of $L^2(\mathbb{R})$. Let $f(x)$ be a function in $L^2(\mathbb{R})$. We can write $f(x)$ in V_{j+1} space, i.e.,

$$f(x) = \sum c_{j+1,k}\phi_{j+1,k}(x)$$

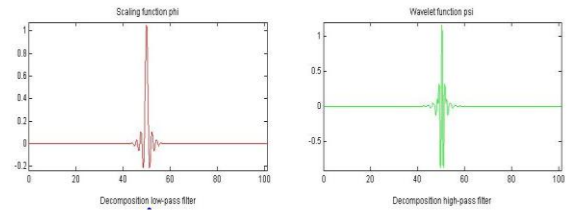

Fig: 1. Scaling and Wavelet function of dmey

Since $V_{j+1} = V_j \oplus W_j$, where

$V_{j+1} = span\left(\phi_{j+1,k}(x)\right)$,

$V_j = span\left(\phi_{j,k}(x)\right)$ and

$W_j = span\left(\psi_{j,k}(x)\right)$.

Therefore

$$f(x) = \sum_k c_{j,k}\phi_{j,k}(x) + \sum_{j_0}^{j}\sum_k d_{j,k}\psi_{j,k}(x)$$

Where

$$C_{j,k} = \langle f, \phi_{j,k} \rangle = \int f(x)\phi_{j,k}(x)dx \quad , \forall k \in \mathbf{Z}$$

and

$$d_{j,k} = \langle f, \psi_{j,k} \rangle = \int f(x)\psi_{j,k}(x)dx \quad , \forall k \in \mathbf{Z}$$

are collectively known as approximation and detailed coefficients.

Here we have a signal of length $2^j \approx 324$ or *j=8.* Hence maximum 8 level are possible. Thus given signal takes place a new six version such as

$$f(1) = a_1 + d_1$$
$$f(2) = a_2 + d_2 + d_1$$
$$f(3) = a_3 + d_3 + d_2 + d_1$$
$$f(4) = a_4 + d_4 + d_3 + d_2 + d_1$$
$$f(5) = a_5 + d_5 + d_4 + d_3 + d_2 + d_1$$
$$f(6) = a_6 + d_6 + d_5 + d_4 + d_3 + d_2 + d_1$$
$$f(7) = a_7 + d_7 + d_6 + d_5 + d_4 + d_3 + d_2 + d_1$$
$$f(8) = a_8 + d_8 + d_7 + d_6 + d_5 + d_4 + d_3 + d_2 + d_1$$

Here a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8 are approximation signals and d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8 are details of signal at various scale or time frames. Since maximum 8 level are possible therefore, f(8) will be combined into a zero frequency component a_8 as well as 8 frequency components d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8.

i.e.

$$f(1)=\sum_k c_{1,k}\phi_{1,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(2)=\sum_k c_{2,k}\phi_{2,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(3)=\sum_k c_{3,k}\phi_{3,k}(x)+\sum_k d_{3,k}\psi_{3,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(4)=\sum_k c_{4,k}\phi_{4,k}(x)+\sum_k d_{4,k}\psi_{4,k}(x)+\sum_k d_{3,k}\psi_{3,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(5)=\sum_k c_{5,k}\phi_{5,k}(x)+\sum_k d_{5,k}\psi_{5,k}(x)+\sum_k d_{4,k}\psi_{4,k}(x)+\sum_k d_{3,k}\psi_{3,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(6)=\sum_k c_{6,k}\phi_{6,k}(x)+\sum_k d_{6,k}\psi_{6,k}(x)+\sum_k d_{5,k}\psi_{5,k}(x)+\sum_k d_{4,k}\psi_{4,k}(x)+\sum_k d_{3,k}\psi_{3,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(7)=\sum_k c_{7,k}\phi_{7,k}(x)+\sum_k d_{7,k}\psi_{7,k}(x)+\sum_k d_{6,k}\psi_{6,k}(x)+\sum_k d_{5,k}\psi_{5,k}(x)+\sum_k d_{4,k}\psi_{4,k}(x)+\sum_k d_{3,k}\psi_{3,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$
$$f(8)=\sum_k c_{8,k}\phi_{8,k}(x)+\sum_k d_{8,k}\psi_{8,k}(x)+\sum_k d_{7,k}\psi_{7,k}(x)+\sum_k d_{6,k}\psi_{6,k}(x)+\sum_k d_{5,k}\psi_{5,k}(x)+\sum_k d_{4,k}\psi_{4,k}(x)+\sum_k d_{3,k}\psi_{3,k}(x)+\sum_k d_{2,k}\psi_{2,k}(x)+\sum_k d_{1,k}\psi_{1,k}(x)$$

4. Results and Discussion

In present study, concentration of TDS was fluctuating from season to season at different sampling stations. Higher value of TDS is the indication of high mineralization making it unsuitable for various purposes. Observations indicate that the value of TDS have increased from upstream to downstream. The study revealed that TDS and conductivity at upstream sampling stations were relatively low as compared to downstream sampling stations may be due to the low salt content in the water of upper reaches. Higher value of conductivity in summer month may be due to the high concentration of salts attributed of evaporation of water. Water at Lalbagh sampling station had maximum conductivity of 1800 μS/cm because of high load of metal ions in the river. At this station ash of metal was washed by the people in a very large quantity which rose metal concentration and hence conductivity. In present investigation strong positive correlation of EC has been recorded with TDS. Both of these variables show positive relationship with various chemical parameters.

The trend represents the slowest part of the signal. In wavelet analysis terms, this corresponds to the greatest scale value. As the scale increases, the resolution decreases, producing a better estimate of the unknown trend. In order to perform a more detailed investigation, we perform a discrete wavelet transform of the time series of signal, TDS, and EC. The decomposition is chosen as maximum level. For this purpose we used 'db 8' Wavelet transform. The decompositions of time Series TDS and EC are shown in Figure 2 and 3 respectively. Successive approximations possess progressively less high-frequency information.

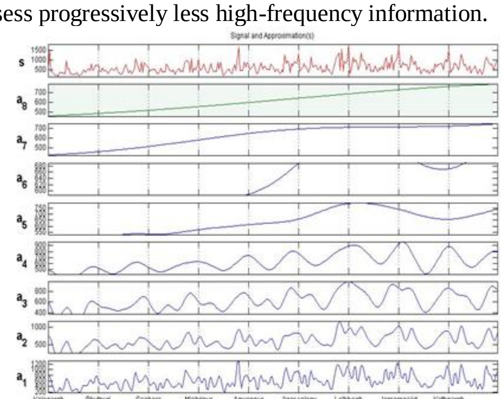

Fig: 2. Successive Approximations for EC Time Series

In figures 2 and 3, successive approximations are shown as a_1, a_2, a_3, a_4, a_5, a_6, a_7, and a_8. In each figure, it is observed that the trend becomes more and clearer with each approximation, a_1 to a_8. In this 8-level analysis, the trend is apparent clearer in approximation a_8. The trend of EC is in upward direction that means it is minimum in Kalagargh and than increases from 500 to 700 at Kathgargh.

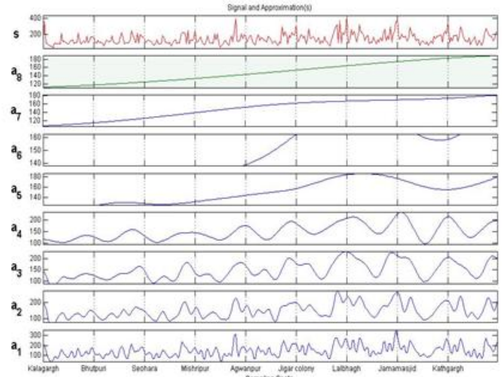

Fig: 3. Successive Approximations for TDS Time Series

Figure 3 shows that the value of EC is varying by the value 120 to 180 in upward direction minimum in Kalagargh and than Kathgargh.

5. Conclusion

Increasing trend of conductivity and total dissolved solids towards downstream was observed. The trend become more sharp and clear after applying the wavelet transforms and make easy to reduce the noise in the primary data. The increasing trend of the parameters towards downstream is mainly due to the large quantity of inorganic salts present in the effluent discharged from electroplating unit of brass industries. Very strong positive correlation of EC has been recorded with TDS.

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References

[1] P. K. Singh, B. Rashmi, Analysis of Water Parameters Using Daubechies Wavelet, American Journal of Mathematics and Statistics, 2(3), 2012, 57-63
[2] J. K. Pathak, Evaluation of limnological characteristics and its trophic status of river Ramganga of western Uttar Pradesh". FTR submitted to DST, Government of India, 2008
[3] S. Kumar, A. Kumar, R. Kumar, J. K. Pathak, Mohd. Alam, Spectral Analysis of Biochemical Oxygen Demand in River water: An Analytical Approach to Discrete Wavelet Transform, American Journal of Mathematics and Statistics, 4(2), 2014, 107-112
[4] M. Alam, J. K. Pathak, Running water environment: A case of Ramganga basin, Lambert Academic Publications, Scholars Press Germany, 2013, 260
[5] J. P. Antoine, Wavelet analysis: A new tool in Physics, Wavelets in Physics, Van Der Berg, J. C., ed., 2004, 9-21
[6] C. K. Chui, An introduction to wavelets, Academic Press, New York, 1992

[7] Y. Meyer, Wavelets and Operators, Cambridge University Press, Cambridge, 1992
[8] Y. Meyer, Ondelettes et operateurs II: Operators de Calderon-Zygmund, Hermann, Paris, 1990
[9] S. G. Mallat, Multiresolution Approximations and Wavelet Orthonormal Bases of L^2 (R), Trans. Amer. Math. Soc., 315, 1989, 69-87
[10] S. G. Mallat, A Theory for Multiresolution Signal Decompositio:, The Wavelet Representation IEEE Trans. On Pattern Analysis and Machine Intelligence, 11, 1989, 674-693
[11] A. Cohen, I. Daubechies, P. Vail, Wavelets on the interval and fast algorithms, Journal of Applied and Computational Harmonic Analysis, 1, 1993, 54-81
[12] R. R. Coifman, M. V. Wickerhauser, Entropy based algorithms for best basis selection, IEEE Trans. Inform. Theory, 38 (2), 1992, 713-718