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OPTIMIZATION OF POLLUTION POTENTIAL EMPIRICAL EQUATION FOR RIVER WATER CONTAMINATION

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ABSTRACT

Water quality estimation functions are very useful in the assessment of river water contamination. Several water quality functions or water quality empirical equations have been developed in the last two decades. Of all the water quality empirical equations developed so far, not even a single equation caters to the need of all kind of river water contamination. This work is an attempt in the direction of optimization of water quality empirical equations with a view to consider several/all water quality parameters. The optimized equation may find its application in various kind of water quality assessment.

Keywords :* *Wqi, Water Quality Parameters, Optimization, Water Contamination

I. INTRODUCTION

Water is one of the precious gifts of nature which is vital for all kinds of living organisms. On earth, water holds almost 70% of the area. Only 2.5% of the total water of earth is fresh and is meant for drinking [1, 2]. Pollution of river is a recurring problem. Pollutants are those substances which are built up in water to an extent such that it starts polluting water and causes problem to aquatic life and humans. Drinking water is one of the most important resource in many minor and major sectors like industry, agriculture and households[3]. Scarcity of pure and clean water is prevailing on earth. As time is passing, the industrial activities and rapid urbanization is becoming the reasons for the pollution of water. Thus cleaning the polluted water/river for the purpose of drinking is now the major challenges for today.

The water plants have objects to purify the polluted water so that it can be made fit for drinking purpose and for various human consumptions by deleting and killing all the pathogenic organisms. Safe drinking water implies no major or significant risk to human health.

Water Quality Index (WQI) is basically a mathematical formula which estimates the state of water to determine whether it is fit for the intended use or not. It is a rating that reflects the influence of various water quality parameters which is taken into account to calculate the value of water quality index (WQI) [4 -6]. This value of water quality index becomes the powerful factor to inform various public or policy makers and water quality management agencies about the state of water.

The water quality index can be divided into four categories: Public Indices, Specific Consumption Indices, Designing or Planning Indices and Statistical Indices[7]. The Public Indices ignore the water type consumption and are used for general water quality. It's example is National Sanitation Foundation WQI [7]. The Specific Consumption Indices are related to specific purpose which can be drinking, industrial and ecosystem etc. Designing or Planning Indices act as a tool or instruments in planning water quality management projects. The first three types of indices are called as Expert Opinion Approach because they have different weight for same variables given by the experts like Delphi technique [8]. The fourth type of WQI is Statistical Indices that do not include any kind of personal opinion and is used for evaluating data using statistical methods. This type of indices is very beneficial in determining the significance of important parameters in water quality analysis[7]. Objectives of water quality index are: Determine the quality of water of different water bodies, Identification of the pollutants, Extraction of information about the toxic substances which results into the pollution and to develop different water quality indices that could help to determine the quality of water of similar water bodies[3].

WQI equations are very much specific to the particular application area. There is not any universal water quality empirical equation. This paper is an attempt to optimize the water quality empirical equations for the consideration of various water quality parameters which will lead to a generic equation.

II. COMPARATIVE STUDY OF FUNCTIONAL/EMPIRICAL EQUATIONS

In the literature, various functional equations leading to water quality indices have been developed. Of all the empirical equation developed so far, the most popular water quality index equations are-National Sanitation foundation quality index, Oregon water quality index, Bhargava water quality index, British Columbia water quality index, Canadian water quality index and Smith water quality index[7].

In the year 1970 the National Sanitation Foundation Water Quality Index (NSFWQI) [9] was developed by the Brown et al. and this index is the most comprehensive work in calculating the water quality index. It made use of nine parameters-dissolved oxygen, faecal coliform, pH, BOD, Temperature, total phosphate nitrate, turbidity, total solids. The author used Delphi method and logarithmic transforms to convert water quality variable results into sub index values [10]. This index come under the category of public indices which ignore the type of water consumption and is used for the general water quality.

In the same year i.e. 1970 a new water quality index was developed called as Oregon Water Quality Index (OWQI) by Curtis Cude [11] (Oregon department of Environment Quality). It was actually updated so many times because of its versatality [7]. The original OWQI was stopped being in use in 1983 because it required various different resources to calculate the values. In the year 1995, two new parameters temperature and total phosphorus were added and thus finally it included total eight parameters- temperature, DO, BOD, pH, total solid, ammonia and nitrate nitrogen, total phosphorus and faecal coliform [12]. Like NSFWQI, it also belongs to the category of public indices that make use of expert opinion approach.

In 1989, Bhargava method [13] was developed which basically focused on the sensitivity of the variables [7, 14]. The technique they used was that they divided the parameters in four groups. First group was of coliform organism represented bacterial quality of drinking water. Second group included the heavy metals and toxicants. Third group considered the physical parameters like colour, odour, turbidity etc. and the fourth group was of organic and inorganic substances like sulphate and chloride etc.

Later, Smith index was developed in 1990 [15]and was based on the expert opinion as well as water quality standard. This water quality index considers FC, pH, colour, turbidity, BOD, dissolved reactive phosphorus, dissolved inorganic nitrogen as

water quality parameters. The selection of parameters were done by the Delphi method and also further creating sub indices and assignment of the weights to them were also done by the Delphi technique itself [8].

In 1995, British Columbia water quality index [16] was developed by the Canadian Ministry of Environment which has the major advantage of representing the measurement of a variety of parameters as a single index, thereby reducing complexity [10]. This water quality index considers the objectives and frequency of the objectives and time period for calculation. They are extremely sensitive to sampling design and are highly dependent on the specific application of water quality objectives.

Similarly, Canadian Council of Ministers of Environment water quality index [17] was developed after British Columbia water quality index by the Canadian Ministry of Environment for simplifying the complex and water quality data in the year 2001. It considers the scope, frequency and amplitude to calculate the value that will tell the water quality status of water of one site related to the chosen benchmark or target [10]. The benchmark could be like protection of aquatic life. It removes the various limitations of the British Columbia water quality index like running regression analysis. The value 1.732 in the respective formula is used so that the result of calculation range lies within the 1-100 [7].

III. OPTIMIZATION OF EMPIRICAL EQUATIONS

The optimization of a mathematical equation depends on various factors such as the order of equation, variables of the equation and the application for which the equation has been developed [18-21].

3.1 Parameters considerations

There are many vital water quality parameters such as DO, Faecal Coliform, pH, BOD, temperature, heavy metals ions(arsenic, fluoride, nitrate), turbidity, solid contents, metals and toxicants , organic and inorganic substances (sulphate and chloride) which are considered for the development of functional equation leading to water quality index[22 -24]. The accuracy of the functional equation depends on the no. of parameters considered. The more the no. of parameters, the better will be the classification of water samples from the contamination point of view. Of all the aforementioned water quality parameters, various researchers have come up with different kind of functional or empirical equations depending upon the parameters considered [1, 9, 11, 13, 15 -17].

3.2 Linear vs Polynomial equations

The degree of any polynomial equation has a significant impact on the accuracy of the mapping/ analysis of that function. The higher the degree of polynomial equation is, the higher the associated errors are[25].
Consider the various equations of various orders e aras given below:

y= A(x) -- (1)
y= ax+b ------------- (First order equation) ------ (2)
y= ax2+bx+c--------- (Second order equation) ------ (3)
y= ax2+bx2 +cx+d-----(Third order equation) ------ (4)

It can be seen that the first order equation as given in equation 2 that it involves just twovariables 'a' and 'b'. Likewise, the equations 3 and 4 have 3 and 4 variables respectively. It is a well known fact that the variables associated as coefficients of higher order parts in equations lead to more errors because of highly transient states of higher order polynomial equations. Therefore, we propose to have a linear equation as described below:
y= f(water quality parameters) ------------------(5)
y=a(DO) + b(fecal coliform) + c(PH) + d(BOD) + e(Temperature) + f(Heavy metal ions) + g(turbidity) + h(solid contents) + i(metals and toxicants) + j(organic and inorganic substances) -----------------------------(6)
Where 'a' to 'j' are coefficients which decide the relative importance of various water quality parameters. Water Quality Index equations should be as linear as it can be because all water quality parameters involved in the development of the equations have got equal roles to play. Though there are provisions to assign different ratings to different parameters in order to give different importance to different parameters depending upon the purpose for which water quality index value is to be estimated. But, we propose to have a generic equation so we prefer that a linear equation will be more justified [25].

IV. CONCLUSION

Different water quality empirical equations have been developed for different purposes such as drinking, industrial applications, domestic applications, agriculture applications and so on. Though it would be unrealistic to assume that all kind of water quality parameters would be present in all the water samples, nevertheless, developing a generic equation will cater to the kinds of various water applications. So, even if some water quality parameters are not present in water samples then the generic equation will take care of it by nullifying their effects. So far very little has been done in the area of generic equation development that is being shown in equation 5 & 6 above in water quality index. As a result there is a tremendous amount of scope in the research works related to the optimization of empirical equations thereby developing generic equations.

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