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A new Model for evaluating the water quality of Kai Tak Nullah

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Abstract

Rivers are a small component of the world's current water and are one of the essential sources of water for various uses, including agriculture, drinking and industry. On the other hand, sufficient information and awareness of the quality of water resources is crucial in conserving these resources as well as in planning and managing water resources. Wastewater discharge to surface water sources around the world has caused various environmental catastrophes. In this regard, these problems and risks can be partially controlled by examining the water quality of the rivers. The water quality of rivers in different countries is assessed in different ways. In France and Germany, for example, water quality is based on the interaction of various factors and factors, and is stable in the United States based on BOD, DO, ammonia, and salmon biological tests. In some countries, such as the United Kingdom and Canada, water quality is measured using a water quality index system. One of the methods of water quality assessment is the use of expert opinions. The statistical population of the research includes water industry experts and experts are in the Kai Tak Nullah area. The statistical sample in this research includes 100 experts based on questionnaires with complete and usable answers. Finally, a framework for evaluation of water quality of Kai Tak Nullah River is presented.

Keywords: River, Quality, Kai Tak Nullah, water quality.

1. Introduction:

Water is a vital source for any biological and human phenomenon and is one of the most important basic resources for developing countries [1]. A small proportion of water resources (about 1%) include running water, surface wetlands and lakes that can be directly exploited and used by humans. Therefore, the decline in the quality of the current water, such as rivers and streams, which are severely affected by humans. One of the concerns now is. Rivers are one of the main sources of water supply for agriculture, drinking and industrial use [2]. On the other hand, over time, human societies have expanded and consequently increased use of water resources, abnormal seizures and changes in river water quality conditions have increased. River pollution is one of the most important problems in today's world, especially in developing countries [3]. Increasing water demand, increasing living standards and expanding water pollution caused by the expansion of agricultural, urban, and industrial activities have created an environmental disadvantage and exacerbated the pollution of water resources and made rational and complex management difficult. Having clean water resources is an essential prerequisite for environmental protection, economic, political, social and cultural development [4]. Unfortunately, in our country since the beginning of agricultural fertilizers and pesticides and plant diseases in the field of agricultural production, there was no balance between demand and consumption, so the excessive use of chemicals in agriculture, increases the severity of pollution of water resources [5]. As environmental change is impacted by the reduction or increase of chemicals, therefore the need for a well-developed strategy and program to conserve water resources and control its pollution is an important issue in management [6]. Therefore, the control and monitoring of surface water for its various uses is necessary to make water of appropriate quality available for different uses. One of the simplest and non-complex mathematical and statistical methods that can predict water quality conditions and be used as a powerful advanced tool for decision making is the use of water quality index. Water quality indicators are methods that can be used to manage water quality by simplifying and reducing raw information, in addition to expressing the quality of water, monitoring trends in water quality over time and place, and identifying areas that are contaminated. Most are threatened, identified and managed [7]. The usual water quality index used by the National Health Foundation was developed in 1970 by Brown et al [2].

2. Literature Review

Sufficient water and good quality are essential for human life. The development of health and environmental protection is always dependent on the provision of safe water. Since the beginning of human civilization, human beings have always lived on the banks of rivers, lakes or springs [5]. Prevention of many diseases such as diarrhea, cholera, typhoid and para typhoid, infectious hepatitis, and amoebic and basil diarrhea, healthy water and hygiene is of great importance [6]. Until biological, chemical, and medical sciences were developed, there were no methods to determine the quality of water and its effects on human health. Early humans only assessed water quality through physical senses such as sight, taste and smell. There are several theories on water pollution, including the one expressed at the March 1961 Geneva Conference [7]: Water is considered to be contaminated when human activities have directly or indirectly altered its composition or properties. To the extent that, as a result of these changes, water becomes undesirable for uses previously used in the natural state.

In fact, with the industrial development and the excessive increase in the use of synthetic organic materials, serious negative consequences have been had on freshwater resources. As each decade, a new problem of water pollution in developed countries comes to the minds of experts [8]. Groundwater and groundwater are at risk due to the contamination of pesticides and agricultural pesticides [9]. The optimum physical and chemical quality of water is essential from the point of view of its acceptability to the consumer, maintaining consumer health and maintaining the water network system. In some areas, controlling the concentration of certain pollutants is necessary to ensure public health, such as performing chemical tests on water sources [10]. Physical parameters are those properties of water that can be distinguished by visual, tactile, taste or olfactory senses. Suspended solids, turbidity, color, taste, odor and temperature fall into this category [11]. Solids are one of the physical impurities of water. This parameter can play a major role in water contamination by protecting microorganisms from direct contact with disinfectants such as chlorine, as well as increasing the amount of disinfectant consumed. The presence of suspended substances is aesthetically damaging to water and can provide sites for the adsorption of chemicals and biological [12].

Another physical parameter is turbidity water, which is a measure of the amount of light absorbed or scattered by suspended matter [13]. Much of the turbidity in surface water comes from the erosion of colloidal materials such as clay, silt, crumbs and metal oxides. Turbidity colloids provide surfaces to absorb biological organisms or harmful chemicals or unpleasant taste and odor factors [14]. Disinfection of the opaque water is difficult because of the absorption properties of some colloids and also because solids may protect microorganisms against disinfectants [15]. Also, light absorption turbidity prevents light from entering the water, thus indirectly; it is a factor of water pollution [16]. The chemical properties of water can be hard to pinpoint, which in excessive amounts can have many negative effects such as increased soap consumption, stains on dishes, delayed cooking of vegetables, boilers bursting, etc. Have. For each of these parameters, certain values are specified in the Hong Kong and World standards [17].

3. Materials and Methods

To analyze and interpret the kinds of parameters measured along the range of a river, there are various mathematical methods that are used such as water quality index. It is one of the simplest methods with wide applications. In this method a considerable amount of data resulting from measurements of water quality are converted to a single and dimensionless number in a rated scale with interpreted quality and conception. In general, water quality indices are divided into five main groups [18]:

A) Public indices: in this category, the indices ignore the kind of water consumption in the evaluation process, such as NSFWQI.

B) Specific consumption indices: in this category, classification of water is conducted on the basis of the kind of consumption and application (drinking, industrial, ecosystem preservation etc). The most important and applicable of these indices are the Oconer, Oregan and British Columbia indices.

C) Statistical indices: in these indices statistical methods are used and personal opinions are not considered.

D) Designing indices: this category is an instrument aiding decision making and planning in water quality management projects.

Among the public water quality indices, NSF is the most applicable index in this regard [19]. On the other hand, the parameters considered in this index are mostly the parameters that are measured in the river water quality monitoring programmers and environmental assessment [20].

Also, the British Columbia index is a more appropriate index as it considers water usage criteria. This index has been used in this research on river water quality assessment for drinking and agricultural consumptions.

4. Mathematical Structure of Quality Indices

Two main and primary forms exist for indices [21]:

- Indices whose index number increases with increases in the pollution level and are known as pollution indices.

- Indices whose index number decreases with increases in the pollution level and are known as qualitative indices.

In a general framework, calculating an index has two main stages: (1) estimating sub-indices based on water quality variables used in the index and (2) summing these sub-indices to obtain a general index.

5. British Columbia Water Quality Index

British Columbia quality index was developed by the Canadian Ministry of Environment in 1995 as increasing index to evaluate water quality [19]. In this method, water quality parameters are measured and their violation is determined by comparison with a predefined limit [21]. This limit can includes recommended guidelines to keep to suitable levels of water utilization. One of the advantages of this method is the use of standards for each area or country and so provides possibility to make a classification on the basis of all existing measurement parameters. To calculate final index value the following equation is used [22]:

$$BCWQI = \left[\sqrt{\left(F_1^{\,2} + F_2^{\,2} + \left(\frac{F_3}{3} \right)^2 \right)} \right] \Big/ 1.453$$

F1: percentage of parameters which have been violated with respect to all parameters

F2: number of offender data with respect to all measured data

F3: maximum percentage of violation

The number 1.453 was selected to give assurance to the scale index number from zero to 100. It is important to note that repeated samplings and increasing stations increase the accuracy of British Columbia index. The disadvantages of this method are that this index does not indicate the water quality trend until it deviates from the standard limit. Also, due to using a maximum percentage of deviation, it cannot determine the number of withdrawals above the maximum limit of standard. Table 1 shows the rankings in the British Columbia water quality index.

6. NSF Water Quality Index

A Water Quality Index for the United States of America was developed by the National Sanitary Foundation (NSF) in 1970 to monitor the variation trend in river water quality [23]. It has been used throughout the USA by the executive agencies. This index represents the general water quality status of monitoring stations using 9 quality parameters [24]. This index has the capability of being estimated using existing data from water quality parameters, if data for

some parameters are lost. Parameters that are required for this index are as follows: fecal coliforms, B0D5, turbidity, pH, TSS, D0%, N03, P04 and ΔT. Measured parameters according to the sub-index of each of them are achieved on conversion curves.

Table 1- Water quality ranking for british columbia water quality index.

Rating	F_1	F_2	F_3	Index Value	Index Rank
Excellent	0 to 2	0 to 1	0 to 9	0 to 4	0 to 3
Good	3 to 14	2 to 14	10 to 45	5 to 25	4 to 17
Fair	15 to 35	15 to 40	46 to 96	26 to 62	18 to 43
Borderline	36 to 50	41 to 60	97 to 99	63 to 85	44 to 59
Poor	51 to 100	61 to 100	99.1 to 100	86 to 145	60 to 100

Table 3- Importance rate and parameters weight in NFSWQI.

Parameters	Weight
Do%	**0.17**
Fecal Coliform	**0.16**
pH	**0.11**
BOD_5	**0.11**
ΔT	**0.1**
$T.PO_4$	**0.1**
NO_3	**0.1**
Turbidity	**0.08**
TS	**0.07**

Table 2- NSF water quality index ranking.

Quality	Value
Very good	90-100
Good	70-90
Fair	50-70
Bad	25-50
Very bad	0-25

Table 4- The situation and the name of monitoring stations in the study areas.

Name of stations	Elevation (m)	Distance from downstream(Km)
After the Coincidence of Gavrood and Gheshlagh (S1)	1326	0
Dare Koole station (S2)	1293	1.8
Darvishan Tributary (S3)	1302	3.25
After the Coincidence of Soo Tributary (S4)	1311	8.65
Soo Tributary(S5)	1313	10.5
Downstream of Slaughterhouse Discharge(S6)	1332	12.05
After the Coincidence of landfill leachate and Gheshlagh (S7)	1357	17.55
Downstream of Sanandaj Wastewater Treatment Plant (S8)	1362	20.95
The Coincidence of Sanandaj Wastewater and Gheshlagh (S9)	1373	22.5
Downstream of Baharan WW and Gheshlagh Coincidence (S10)	1390	26.65
Salavat Abad Tributary (S11)	1422	30.5
Gheshlagh Bridge (S12)	1419	33.45
Vahdat Fishery Upstream (S13)	1447	39.45
Gheshlagh Dam (S14)	1479	47.45
Chehelgazi Station (S15)	1567	53.35
Khalife Tarkhan Station (S16)	1574	61.2
Downstream of Hosseinabad Village (S17)	1661	72.2
Upstream of Hosseinabad Village (S18)	1687	73.63

Water quality parameters were measured over a one-year monitoring period in 2018-2019 and were sampled in September, December, March and June. In Figure 1 the values of the final index for each station have been shown separately based on measuring results in the water year considered. When considering Figure 1 it is observed that, based on comparing British Colombia index with the drinking water standards of the World Health Organization, only station No.18 as the upstream station shows suitable quality conditions. Most of the stations are within proper range. Stations 2 and 4 are located in the middle range.

According to the British Columbia quality index for agricultural consumption (Fig.2), stations 1, 2, 3, 5, 11, 12, 13, 15, 16 and18 are located in an excellent range for agricultural purposes and stations 6, 7 and 8 which are located within an area of industrial concentration are not proper for agricultural purposes. Station 9 is the most polluted area for agricultural use due to the discharge of urban wastewater into the river.

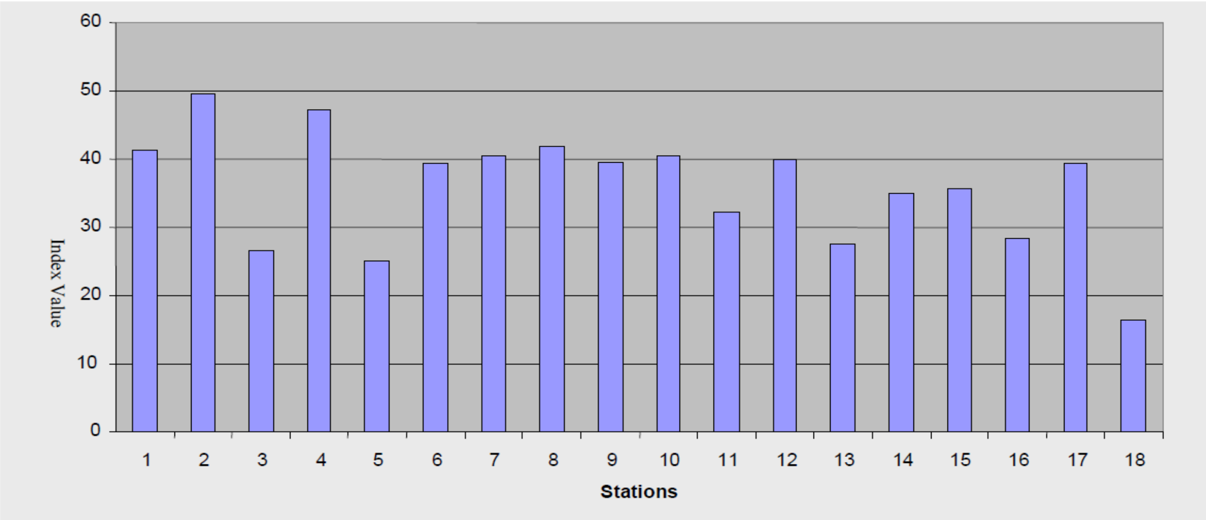

Figure 1. Diagram of British columbia WQI for 2008-2009 for drinking water consumption.

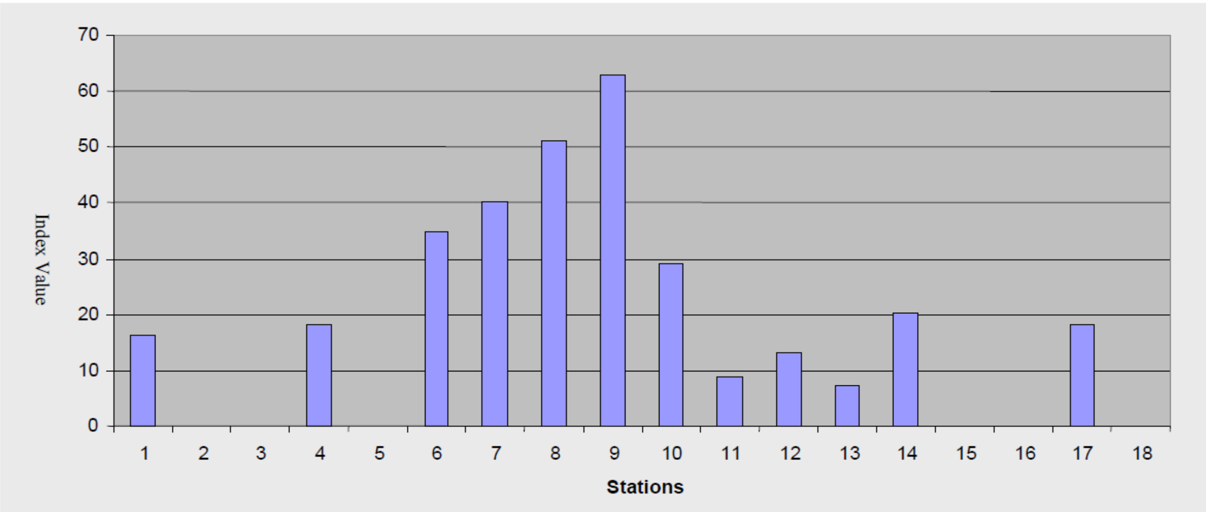

Figure 2. British columbia water quality index for 2008-2009 for agricultural consumption.

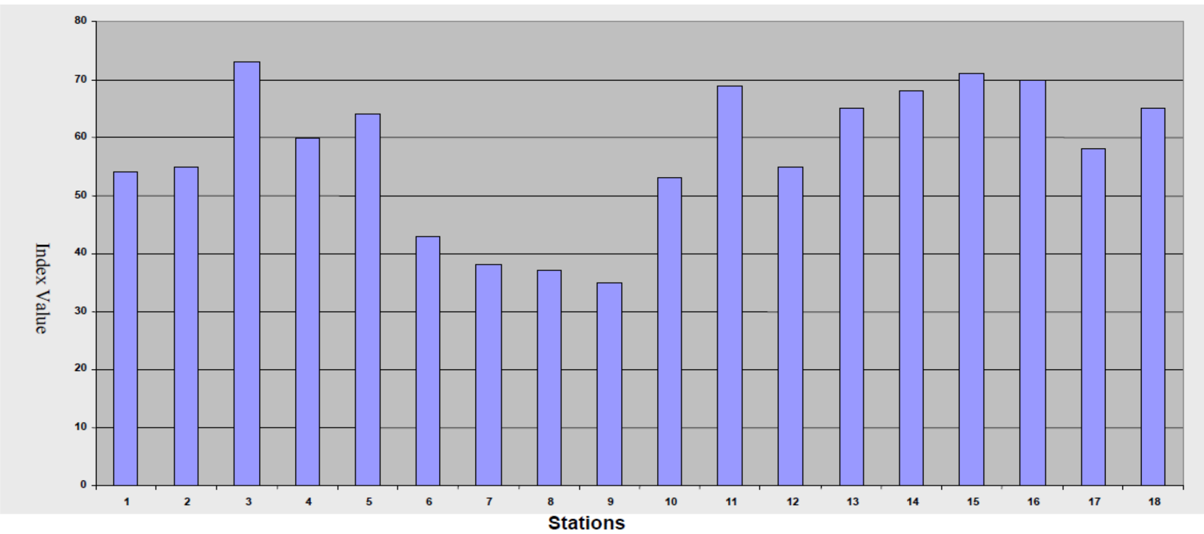

Figure 3. NSFWQI diagram for the dry season (summer).

7. Hypotheses

1. The water quality of the Kai Tak Nullah is suitable for children.
2. The water quality of the Kai Tak Nullah is suitable for middle-aged people.
3. The water quality of the Kai Tak Nullah is suitable for adults.

8. The method, target population and sample:

The statistical population of the research includes water industry experts and experts are in the Kai Tak Nullah area. The sample size formulas and procedures used for categorical data are very similar, but some variations do exist. Since the data are qualitatively and the number of statistical community is unlimited, so the sample size calculation formula is as follows:

$$n = \frac{Z\alpha_{/2}{}^{2} p_0(1-p_0)}{\varepsilon^2} \qquad (1)$$

In this study, researcher has set the alpha level a priori at .05, plans to use a proportional variable, has set the level of acceptable error at 5%, and has estimated the standard deviation of the scale as .5. Cochran's sample size formula for categorical data and an example of its use is presented here along with explanations as to how these decisions were made.

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.1^2} = 96.04 \qquad (2)$$

Where $Z\alpha_{/2}$ = value for selected alpha level of .025 in each tail = 1.96.

(The alpha level of .05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

Where (p)(q) = estimate of variance = .25.

(Maximum possible proportion (.5) *1-Maximum possible proportion (.5) produces maximum possible sample size).

Where ε = acceptable margin of error for proportion being estimated = .1

(Error researcher is willing to except).

According to the formula at least 97 samples are needed. Therefore, 100 questionnaires were sent between experts and were collected.

9. Analysis of information

The statistical sample in this research includes 100 experts based on questionnaires with complete and usable answers. 47% of these experts have a master's degree, 34% have Ph.D.

degrees and 19% have a bachelor's degree. 81% of these experts are male and 19% are female.

We used SPSS 19.0 to analyze the data. In following the results of test hypotheses are offered:

9.1. Testing Hypothesis H1. The water quality of the Kai Tak Nullah is suitable for children.

The results of SPSS are shown below:

Table. 5. One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
H1	100	6.6058	1.02867	.10287

Table. 6. One-Sample Test

	Test Value = 5					
					95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
H1	15.611	99	.000	1.60580	1.4017	1.8099

9.2. Testing Hypothesis H2. The water quality of the Kai Tak Nullah is suitable for middle-aged people.

The results of SPSS are shown below:

Table. 7. One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
H2	100	6.8078	1.09900	.10990

Table. 8. One-Sample Test

	Test Value = 5					
					95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
H2	16.449	99	.000	1.80780	1.5897	2.0259

9.3. Testing Hypothesis H3. The water quality of the Kai Tak Nullah is suitable for adults. The results of SPSS are shown below:

Table. 9. One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
H3	100	6.2250	1.01915	.10191

Table. 10. One-Sample Test

	Test Value = 5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
H3	12.020	99	.000	1.22500	1.0228	1.4272

10. Conclusions

Drinking water quality includes examination of chemical, physical and microbiological parameters of water. Drinking water quality is a critical indicator of the health of water consumers. For this purpose, the measurement of all water cations and anions including the following parameters is performed for a specific purpose. As much as water quantity is concerned, water quality is also an indicator that needs more attention. Water quality is one of the issues that is directly related to the health, personal and public health of the community. The necessity of water monitoring and the provision of hygienic and standard conditions for drinking has made it important to control the quality of drinking water. The quality of drinking water is used to control the quality of drinking water and to determine its quality level. Water quality index is a tool that converts complex information on basic parameters of water quality control into a simple index number to better understand officials and ordinary people. Most quality indices are calculated based on the standard or expected value of each parameter. Given the amount of impact each parameter can have in turn on health or other consumption, a weight factor is assigned to it. Finally, water quality is interpreted as good to bad. The Water Quality Index has the ability to critique water quality variables to describe water quality that is not easily understood by the general public. Supplying quality drinking water is of particular importance, however human interference with the nature and development of technology and the production of various pollutants have had negative effects on the quality of drinking water. Every year, with the sampling and testing of surface and groundwater, a great deal of information is obtained on qualitative parameters such as pH, temperature, turbidity, soluble solids and other parameters. Since the volume of such data is large and there is no suitable tool for the non-expert community to know the quality of water used, it is used to better understand and express the results of water quality indices. In this paper, a framework for evaluation of water quality of Kai Tak Nullah River is presented.

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