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REVIEW ON PERFORMANCE EVALUATION OF WATER TREATMENT PLANT AND WATER QUALITY INDEX

Er. Devendra Dohare *, Er. Vyoma Gupta
* Assistant Professor, CE-AMD, SGSITS, Indore, M.P, India
PG Student, M.Tech. (Environmental Engg.), CE-AMD, SGSITS, Indore, M.P, India

ABSTRACT

Human body contains about 60 % of water and water is being used in most of human activities in different ways. Therefore it is observed that early human civilization had spread along the river banks. The degradation of water quality in water body creates adverse condition so that water cannot be used various purposes including bathing, recreation and as a source of raw water supply. According to Central Pollution Control Board (2008), out of total water supplied to the town and cities in India, 90% is polluted, and out of which only 1.6% gets treated. Therefore, water quality management is fundamental for the human welfare. Safe water supply is required in adequate quantity at convenient points and at reasonable cost to the consumers. Therefore performance of water treatment plants needed to be evaluated and monitored by analysis of various physico-chemical and bacteriological parameters (IS: 10500-2012). A water quality index is a numerical value which is developed to interpret overall water quality as well as to identify water pollutants at certain location and time, based on several water quality parameters.The present paper is reviewed for water quality Index from 2007 to 2013 and for water treatment plant performance evaluation from 2003 to 2014.

KEYWORDS: Performance evaluation, water quality index, water treatment plant, drinking water.

INTRODUCTION

Water is precious commodity for all living beings on earth. Most of the earth water is sea water and onlyabout 2.5% of the water is fresh water that does not contain significant levels of dissolved minerals or salts and 2/3 of that is frozen in ice caps and glaciers. Therefore in total 0.01 % of the total water of the planet is accessible for consumption (Baroniya et al.2012).

Drinking water is the most vital natural resource since it serves industrial, domestic and agricultural sectors. Clean and safe drinking water is very scarce on earth. Every day due to industrialization and uncontrolled urbanization the source of pure water are getting polluted. Cleaning the polluted water and making it safe for drinking is main challenge in today's world.

The main objective of the water treatment plants is to purify the polluted water and make it fit for the human consumption through the removal of objectionable parameters and killing of organism (pathogenic organism), along with taste, odour, unpalatable brownish discharge, some of the excess of dissolved metals and a range of other items as per relevant standards. (Mohammed et al.2012). Safe drinking-water means no significant risk to health over a lifetime of consumption, including different sensitivities thatmay occur between life stages.

Study of performance of water treatment plant is essential to be assessed with all aspects and considerations including physical, chemical and bacteriological so as to determine its efficiency and to produce quality water. A typical water supply scheme consists of intake, transmission, treatment and distribution. The physical, operational and environmental conditions for water treatment plant must be analysed for all parameters (Baroniya et al.2012).

Pure water is colourless, tasteless, and odourless. It is an excellent solvent that can dissolve most minerals that come in contact with it. Therefore, in nature, water always contains chemicals and biological impurities i.e. suspended and dissolved inorganic and organic compounds and microorganisms. These compounds may come from natural sources and leaching of waste deposits. However, Municipal and Industrial wastes

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also contribute to a wide spectrum of both organic and inorganic impurities in water. Inorganic compounds, in general, originate from weathering and leaching of rocks, soils, and sediments which principally are calcium, magnesium, sodium and potassium salts of bicarbonate, chloride, sulphate, nitrate, and phosphate. Besides lead, fluoride, copper, arsenic, iron and manganese may also be present in traces. Organic compounds originate from decaying of plants and animal matters and from agricultural runoffs, which constitute natural humic material to synthetic organics used as detergents, pesticides, herbicides and solvents. These constituents and their concentrations level in water influence the quality and use of the natural water. (Status of water treatment plants in India, CPCB)

There is no single measure that can describe overall water quality for any water body.Although there is no globally accepted composite index of water quality but some countries and regions have used or are using aggregated water quality data in the development of water quality indices. Lots of variations in the calculation of water quality index were reported [Horton (1965),Delphi, NSF(1970), Prati(1971), Harkin(1974), Serbian Water Quality Index (1976),Bhargava (1983, 1998, 2006), Smith's index(1987)British Columbia(1995), Canadian Water Quality Index(1995) Oregon, Overall index of Pollution (OIP)(2003)].Most water quality indices rely on normalizing or standardizing data parameter by parameter according to expected concentrations and some relative interpretation of 'good' versus 'bad' concentrations. Parameters are often weighted according to their perceived importance to overall water quality and the index is calculated as the weighted average of all observations. (Global Drinking Water Quality Index Development and Sensitivity Analysis Report, UNEP, 2007)

In many countries in the world, to assess water quality, separate water quality parameters were analysed and compared with the defined national standards of different uses. Water quality Index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. It is an aggregation parameter calculated on many water quality parameters according to a defined method. WQI is scaled from 0 (the worst water quality) to 100 (the best water quality).The suitability of water sources for human consumption or other user has been described in terms of Water Quality Index (WQI)(Global Drinking Water Quality Index Development and Sensitivity Analysis Report, UNEP, 2007). WQI is a way for précising large amounts of water quality data into simple expressions (i.e poor, marginal, fair, good, excellent) for reporting to concerned citizens and policymakers in an effective manner. Different water quality parameters are expressed in different units. (Sthiannopkao et al. 2011)

The purpose of water quality index: -

Water quality is a complex subject, which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations. From the consumer's point of view, the term "Water Quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example, drinking water should be pure, wholesome and potable. Similarly, for irrigation dissolved solids and toxicants are important, for outdoor bathing pathogens are important and water quality is controlled accordingly. Textiles, paper, brewing and dozens of other industries using water, have their specific water quality needs (Water quality monitoring guidelines, CPCB, 2008) hence required assessment of the water quality is to be used for specific purpose.

Objectives of water quality index (Sthiannopkao et al. 2011):-

- To interpret water qualities of various water bodies (surface water and ground water)
- To identify water pollutants(Organic Nutrients, particulates and bacteria)
- To provide additional information, particularly on toxic substance contributing to water pollution
- To apply the developed water quality indices to evaluate the water quality of similar water bodies.

Water quality is the condition of the water body or water resource in relation to its designated use. It can be defined in qualitative and/or quantitative terms. Parameters in defining water quality can also be grouped into three broad categories: physical, chemical, and biological.

Physical factors include temperature, sediment and bed material, suspended sediments, turbidity, colour, dissolved solids and odour. Chemical factors consist of the major and minor elements and other chemical

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parameters such as pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The major elements include agro-nutrients such as Nitrogen and Phosphorus; Minor elements include elements such as arsenic (As), lead (Pb), and mercury (Hg), etc. which may be toxic when exceeds above standard permissible concentration. Biological Constituents include Fecal Coli-form and *E. coli* (Website:http://www.waterefficiency.net/WE/Articles/The_Introduction_to_the_Water_Quality_Index_15374.aspx)

REVIEW

Performance Evaluation of Water Treatment Plant:-

M.A. EIDib and **Mahmoud A. Azeem Elbayoumy (2003)** inspected a water treatment plant (400 L/s, 35 MLD) at Meet Fares of Dakahlia (**Egypt**) from all aspects and considerations including Engineering, Chemical, Biological, Bacteriological, Organic pollutant, Tri-halomethane (THM), Heavy metal

Authors described the process of water treatment plant and outlined different operating and design problems, which were found and concluded for modifications and considerations. This WTP consisted of Intake, Prechlorination, coagulation and sedimentation, sand filter, storage and other facilities. Through treatment processes, the turbidity was reduced from 14-28 NTU to 0.1-0.6 NTU. Tri- halomethane compounds and Heavy metals were reported within the range of their referred standards.

Dr. Abbas A. Al-Jeebory and **Dr. Ali H. Ghawi (2009)** investigated 96 MLD Al-Dewanyia water treatment plant in **Iraq,** built in 1973, from all aspects and considerations including: engineering, chemical, biological, and bacteriological to determine water treatment plants efficiency and produced water quality. Authors defined design and operating problems and difficulties and recommended proper revision of all aspects to define the suggested recommendations to be considered in designs and operating conditions. This WTP consisted of Intake, prechlorination, coagulation and sedimentation, sand filter and Storage and other facilities. Some charts were prepared for turbidity variation on monthly basis, in treated water after sedimentation tanks, in treated water after filter tanks, in finally treated water. (Table 1)

Table 1: Comparison of Water quality Criteria between IRAQ and U.S. EPA:-

Items		Water Quality Criteria	Water Quality Target Value	U.S. EPA Criteria
Taste and Odour	Sensory Evaluation	No Taste/ Odour	< 3 Ton	< 3 Ton
	Geosmin, MIB	-	< 10 ng/L	-
Pathogenic Microbes	Giardia	3 log	5 log	5 log
	Cryptosporidium	-	3.5 log	3-3.5 log
	Turbidity, NTU	5	0.1	0.1
	Particles	-	50/mL	-
Disinfection By-Products (DBPs)	TOC, % removal	-	35	15-50
General Items	NH_4^+ ,mg/L	0.5	0.5	-
	Fe , mg/L	0.3	0.3	0.3
	Mn, mg/L	0.3	0.05	0.05
	pH	5.8-8.5	7.5-8.0	6.5-8.5

Nephelometric turbidity (average) between each of the unit process:-

Unit Process	Raw water, before coagulation	After Flash Mixing	After Clariflocculator	After Rapid Filtration
Turbidity (NTU)	75	70	40	20

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A.N. Burile and **Dr. P.B. Nagarnaik (2010**) studied Water Treatment Plants in Nagpur (Maharashtra, **India**) and stated that for providing continuous and good quality of water to all regions in Maharashtra throughout the year, Govt. of Maharashtra had constructed new water treatment plants during the past few years. Performance of water treatment plants is an essential parameter to be monitored and evaluated for the better understanding of design and operating difficulties in water treatment. They analysed and compared seven parameters (pH, turbidity, dissolved oxygen, total solids, suspended solids, total coliformand fecal coliform) between raw water & treated water. Samples were collected from intake and from all water treatment plant's units of Gorewada Pench Phase-II plant and results were determined in accordance to the Standard Methods of American Water works Association (AWWA) manual, 21st addition (2009) and CPHEEO manuals. It was revealed that pH, Turbidity and Dissolved oxygen came to be within the limit but chlorine dose was not adequate and should be increased.

R. Makungo, J.O. Odiyo and **N. shidzumba(2011**) reviewed some literature and assessed the performance of 16 MLD Mutshedzi water treatment plant situated in Limpopo Province in **South Africa** using the compliance of pH, electrical conductivity, turbidity and all chemical parameters (calcium, chloride, magnesium, manganese, iron, zinc, nitrate, sulphate, phosphate and fluoride) of concern for domestic water use in raw and treated water and computed compliance of raw and treated water analyses.All parameters were compared with DWAF (Department of Water Affairs and Forestry) guidelines.These small plants supply water to rural villages, faced problem of cost recovery, water wastages, limited size and semi- skilled labour
Authors recommended that the treatments of turbidity and fluoride should form critical functions of the plant to ensure the quality of final water for domestic use and should always kept safe from any harmful substances or disease causing pathogens. Water samples for both raw and treated water were collected from Mutshedzi Dam and Mutshedzi water treatment plant. The standard solutions were prepared by extracting a known volume of a stock solution (100 ppm) and diluting it to 100 ml with deionised water. All glassware used was washed with tap water and rinsed with acidified water and deionised water.
The results obtained from interviewing the plant operators and Department of water Affairs regional officials indicated the lack of monitoring of quantity of water supplied to each village, dosage of treatment chemicals, the treatment capacity of the WTP, monitoring the quality of treated water and lack of proper management were some of the factors that limit the quantity and quality of the final water from plant. The results of this study showed that this WTP, through moving towards full compliance of the final water analysis, was still not producing adequate quality of water.

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Ali Ahmed Mohammed and **Alaa A. Shakir (2012**) described the process of Al-wahdaa Project Drinking water treatment plant in **Iraq** which consists of intake and purification process (rapid mixing basins, sedimentation basins, filtration basins, disinfection stage, and flocculation stage).
Authors calculated turbidity removal efficiency for sedimentation basin and filtration basin and provided relationship between

- Removal efficiency of turbidity in sedimentation basin and date of test
- Removal efficiency of turbidity in filtration basin and date of test
- pH and date of test
- Temperature with date
- Concentrations of total dissolved salts with date of test.

The duration of test was from 05/12/2005 to 23/01/2006.It was found that the average value of the removal of turbidity in sedimentation basin was about (46%) and the (R^2= 0.902) which was obviously low due to the absence of the permanent maintenance and the continuous clean out for the sedimentation basin. The removal efficiency of turbidity in filtration basin was as high as (75%) and the (R^2= 0.445) comparatively with the removal efficiency of the sedimentation basin.

Arshad Ali, HashimNisarHashmi, NaseemBaig, Shahid Iqbal and **KhurramMumtaz (2012)** evaluated the treatability performance of SG-WTP (Sangjani Water Treatment plant) and SM-WTP (Simly Water treatment Plant) for a period of 12 months in Islamabad- **Pakistan**. The 51 MGD SG-WTP consists of coagulation with alum dose, flocculation, sedimentation, rapid gravity filtration and chlorination. The 42 MGD SM-WTP also consists of coagulation, flocculation, sedimentation, rapid gravity filtration and chlorination. They analysed, compared and calculated removal efficiencies of selected parameters (pH, turbidity (NTU), electrical

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conductivity, total dissolved solids, nitrates, sulphates, chlorides, total coliform, and fecal coliform) between SG-WTP and SM-WTP. Authors analysed water quality for both WTP on upstream side of filtration plant then compared physicochemical characteristics and evaluated them economically.

Their results revealed that the most of the water quality parameters were within the limits of WHO drinking water quality guideline, except the turbidity and microbial contents and the water samples collected on the upstream side of filters were highly contaminated with total coliform and fecal coliforms.

Ashish R. Mishra and **Prashant A. Kadu (2014**) analysed water treatment plant at Yavatmal, Maharashtra (**India**) for chemical, physical and bacteriological characteristics. All experiments were conducted and results were determined in accordance to the Standard Methods of American Water Works Association. They compared parameters (pH, odour, turbidity, alkalinity, total solids and total hardness) between raw water, treated waterand permissible & desirable limits according to IS: 10500-2012. Authors developed chart for monthly wise removal of turbidity in each unit (aeration, flash Mixer, clariflocculation, filtration, and chlorination). This research paper gave information related to the various process of water treatment plant which consists of intake, raw water sump and pump house aeration, flash mixer, clarrifloculator, filter beds, chemical house, chlorination, pure water sump, pump house, and wash water tank.

Water quality Index:-

Nguyen Van Hop, Thuy Chau To, Truong Quy Tung, TuVongNghe,YutaYasaka (2007) computed the water quality index of Huong, Thach Han and KeinGaing rivers (**Central Vietnam**) by Bharagava Model. The temperature, pH, conductivity (EC), salinity, turbidity (TUR), DO, COD, BODs, nitrate, ammonia, phosphate, total solids (TS), hardness, total dissolved iron, total coliform (TC), fecal coliform (FC) and sodium adsorption ratio (SAR) of water samples were analysed.
Water quality index developed by Bhargava (Bhargava-WQI) was modified and applied to assess water quality of the above mentioned rivers. Based on Bhargava-WQI, the classification and zoning of the rivers for beneficial uses were carried out.
The results obtained showed that the water quality index can be used as an efficient tool for the water quality management and water pollution control of the rivers. By using WQI, anyone can easily inform the community and decision makers about water quality. There is lot of advantage in using WQI, however, WQI is still a limitation on eclipsing the WQ parameter of poor quality.

Santosh W. Avvannavar and **S. Shrihari (2008)** selected eight stations for sample collection along the stretch of River Netravathi (Dakshina Kannada District, Karnataka, **India**) basin to determine water quality index (WQI) using six water quality parameters: dissolved oxygen (DO), biochemical oxygen demand (BOD), most probable number (MPN), turbidity, total dissolved solids (TDS) and pH. Rating curves were drawn based on the tolerance limits of inland waters and health point of view. Bhargava WQI method and Harmonic Mean WQI method were used to find overall WQI along the stretch of the river basin.(Table 2)

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Table 2 : Rating curves were drawn based on the Class A, B and C tolerance limits of inland waters (IS: 10500 – 1982 and IS: 2296–1982)

Characteristics	Class A		Class B	Class C
	Desirable	Permissible		
pH	6.5-8.5	9.2	6.5-8.5	6.5-8.5
Turbidity, NTU	5.00	10.00	-	-
DO, mg/L	-	-	6.00	4.00
BOD5 20°C	-	-	2.00	3.00
Total coliform organism MPN/100 ml	1.00	-	50.00	5000.00
TDS, mg/L	500	3000	500	1500

Authors described effects of all the parameters: pH, dissolved oxygen, BOD, Turbidity, Micro-organisms, and TDS. Water quality matrix based on Bhargava water quality method and Harmonic Mean water quality index methods and Rating scale for WQI based on Harmonic Mean water quality index method. The simplified model for WQI for a beneficial use is given

Harmonic Mean of water quality index method was

$$WQI = [\eta^n i = 1 \quad f_i(P_i)]^{1/n} \times 100$$

used to determine the overall water quality index along the different sampling stations. It was used because, if the quality index of the parameter is less, then the weightage to that parameter should be higher. To determine the water quality index following equation was used.

$$WQI = \frac{1}{\frac{1}{n_p}\sum_{i=1}^{n}\frac{1}{\phi_i}}$$

Where i=1, 2…n

X_I = the element of the matrix of the each row

N_p = number of water quality parameters

Five point rating scale was used to classify water quality in each of the study areas. It was found that the water quality of Netravathi varied from Excellent to Marginal range by Bhargava WQI method and Excellent to Poor range by Harmonic Mean WQI method. It was observed that the impact of human activity was severe on most of the parameters. The MPN values exceeded the tolerable limits at almost all the stations. It was claimed that the main cause of deterioration in water quality was due to the lack of proper sanitation, unprotected river sites and high anthropogenic activities.

Avnish Chauhan and **Suman Singh(2010)** estimated water quality index (WQI)) for National river (Ganga) of India at Rishikesh for drinking, recreation and other purpose by considering eight water quality parameters turbidity, DO, BOD, COD, Free CO_2, TS, TSS and TDS.

Ganga Action Plan program was launched by Government of India in April 1985 in order to reduce the pollution load on the river Ganga, but it failed to decrease the pollution level in the river, after spending more than 9 billion rupees over a period of 15 years.

The Water Quality Index for the river Ganga was determined which was based on formula given below:-

Water Quality Index (WQI) = $\sum q_i w_i$

Where

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q_i (water quality rating) = 100 X (V_a-V_i) / (V_s-V_i),

when

V_a = actual value present in the water sample

V_i = ideal value (0 for all parameters except pH and DO which are 7.0 and 14.6 mg l-1 respectively).

Vs = standard value.

If quality rating q_i =0 means complete absence of pollutants,

While 0 < q_i< 100 implies that, the pollutants are within the prescribed standard.

When q_i>100 implies that, the pollutants are above the standards (Mohanty, 2004).

W_i (unit weight) = K / S_n

Where K (constant) =

$$\frac{1}{1/Vs_1 + 1/Vs_2 + 1/Vs_3 + 1/Vs_4 \ldots\ldots + 1/Vsn}$$

Sn = 'n' number of standard values.

According to Sinha et al. (2004), if, Water quality index (WQI) is less than 50 such water is slightly polluted and fit for human consumption,

WQI between 51 - 80 – moderately polluted,

WQI between 50 -100-excessively polluted and WQI-Severely polluted.

Analysis of river Ganga water at Rishikesh during study period proved that the water of dam is not suitable for drinking purpose. These results indicated that water of river Ganga is completely unsuitable for human being, wild animals and cattle.

Kavita Parmar and **Vineeta Parmar(2010)** measured six water quality parameters: Dissolved Oxygen (DO), Biochemical oxygen Demand (BOD), Most Probable Number (MPN), Turbidity, Total Dissolved Solids (TDS) and pH at five different stations along the River Subernarekha (Singhbhum District, Jharkhand, **India**) basin and then developed water quality index (WQI) from November 2006 to November 2007.

Rating curves were drawn based on the tolerance limits of inland waters and health point of view. Bhargava WQI method was used to find overall WQI along the stretch of the river basin. (Table 3)

Table 3:

Parameters	pH	DO mg/L	BOD mg/L	Turbidity NTU	TDS mg/L	MPN / 100 ml
Station 1	6.8	6.87	1.2	6.8	256	1200
Station 2	7.4	7.2	0.8	5.7	240	800
Station 3	6.9	7.4	2.9	4.2	178	670
Station 4	6.6	6.2	1.57	3.8	308	950

Five point rating scale was used to classify water qual ity in each of the study areas. It was found that the wa ter quality of Subernarekha varied from Excellent to Marginal range by Bhargava WQI method. It was observed that the main cause of deterioration in water quality was due to the lack of proper sanitation, unprotected river sites, high anthropogenic activities and direct discharge of industrial effluent in River.

Pham Thi Minh Hanh, SuthipongSthiannopkao, Dang The Ba and Kyoung-Woong Kim (2011) developed water quality indexes to evaluate the surface water and to identify water pollutants in **Vietnam**.

Following were the objectivesof theirstudy:

1) To develop water quality indexes for evaluating surface-water quality and identifying water pollutants in Vietnam.
2) To apply the developed WQIs to evaluate the water quality of important water bodies in Vietnam by using the national surface water monitoring data from 1999 to 2007.

Twenty Seven physcio-chemical parameters at 100 stations (sites including lakes, rivers and streams) had been monitored : pH, dissolved oxygen (DO), water temperature (Tw), turbidity, conductivity, suspended solids (SS), total dissolved solids (TDS), chloride (Cl-), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total coliform (T. coli), Fecal coliform, ammonium-nitrogen (NH_4^+ -N),

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nitratenitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), orthophosphatephosphorus (PO_4^{3-} -P), total phosphorus, oil and grease, heavy metals [Iron (Fe), Lead (Pb), Cadmium (Cd), Mercury (Hg), Zinc (Zn), Copper (Cu), Nickel (Ni), Chromium (Cr)], and pesticides. Water quality index were developed in three steps:

1) Parameters selection
2) Rating Curves building with inclusion of Vietnam's surface-water standards.
3) Aggregation of sub indexes using a hybrid aggregation function of additive and multiplicative forms.

In this method, the original variables were transformed into new uncorrelated variables, called the principal components (PC). The PC can be expressed as

Where

$$z_{ij} = a_{i1}x_{1j} + a_{i2}x_{2j} + a_{i3}x_{3j} + \cdots + a_{im}x_{mj}$$

z = component score;

a = component loading;

x = measured value of variable;

i = component number;

j = sample number; and

m = total number of variables.

Water quality monitoring data show that among 27 parameters, eight parameters (SS, turbidity, DO, COD, BOD5, PO_4^{3-}-P, NH_4 -N, and T. coli) were the most frequently observed and these were important for water quality evaluation because their measured concentrations often exceed the Vietnamese surface-water standards. The toxic parameters such as cyanide, heavy metals, phenols, and pesticides along with pH, water temperature were also of concern, although they had been less monitored.Rating curves for all the water quality variables included in the list of Vietnamese surface-water quality standards were developed. On the basis of these rating curves, parameter concentrations received final scores between 1 (the worst case) and 100 (the best case).Water quality then was classified on the basis of the WQI_B or WQI_O score as follows:

91 to 100 is excellent water quality,

76 to 90 is good water quality,

51 to 75 is fair,

26 to 50 is marginal, and

1 to 25 is poor water quality.

The two newly developed water quality indexes can serve as such tools. The WQI_B can be effectively used to evaluate the spatial and temporal variations of surface-water quality, to identify water pollutants, and to reflect the impacts of socioeconomic development on surface-water quality.

The WQI_O can provide additional information, particularly on toxic substances contributing to water pollution. Together the indexes can well serve the objective of informing policy decisions for sustainable water-resources management in Vietnam.

The study observations indicates that surface-water quality in the northern and central parts was poor, containing organic matter, nutrients, and bacteria, whereas water in the southern part was primarily polluted by bacteria. Drainage systems, lakes and stretches of rivers close to urban areas had extremely poor water quality. This raises alarms about the impacts of discharging untreated wastewater on the quality of surface water in big cities. Analysis of water quality trends shows some possible negative impacts of socioeconomic development on surface-water quality in the provinces studied. The implementation of water quality indexes can well serve the objective of sustainable water-resources management in Vietnam.

Kavita Parmar and **Smriti Priya (2013)** evaluated the ground water quality of Jamshedpur, Jharkhand **(India**) by Bhargava Method (Bhargava, 1983; Bhargava, 1998; Bhargava, 2006). Some parameters like pH, electrical conductivity, odour, taste, temperature, turbidity, total dissolved solids, chloride , alkalinity, total hardness, sulphates, nitrates, fluoride, DO, BOD were analysed in this study and the results were compared with water quality standards of WHO and water quality index was determined. The samples were collected during the month of July 2011.

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Table 4 : Some of the parameter values of the study are as follows:

S.No.	Parameters	WHO standards
1	Colour	Acceptable
2	Odour	Unobjectionable
3	Taste	Agreeable
4	Turbidity	5 NTU
5	pH	7 - 8.5
6	Electrical conductivity	1000 µmhos/cm
7	Total Dissolved Solids	500
8	Chloride	250
9	Alkalinity	120
10	Hardness	300
11	Sulphate	200
12	Nitrate	45
13	Fluoride	1
14	Dissolved Oxygen	5
15	BOD	3

The water quality parameters were estimated through physic-chemical studywhich stated that all drinking water quality parameters except alkalinity & hardness were found well within limit for all studied water samples prescribed by WHO.

From the results, it was evident that, the chemical parameters such as colour, taste, odour and turbidity and chemical parameters were well within suitable limits. Therefore the water from all Bore-wells were suitable for drinking as per specifications. WQI of all the eight sites had been found to be below 100 which prove that quality of ground water of the city was satisfactory for drinking purposes.

Shweta Tyagi, Bhavtosh Sharma, Prashant Singh, RajendraDobhal (2013) explained water quality index by four models:

- National Sanitation Foundation (NSF) WQI
- Canadian Council of Ministers of the Environment (CCME) WQI
- Oregon WQI
- Weight Arithmetic WQI

Water Quality Rating as per different Water Quality Index are in Table 5 :

Table 5 :

National Sanitation Foundation Water Quality Index (NSFWQI)	
WQI value	**Rating of Water Quality**
91-100	Excellent water quality
71-90	Good water Quality
51-70	Medium water quality
26-50	Bad water quality
0-25	Very bad water quality
Canadian Council of Minters of the Environment Water Quality Index (CCME WQI)	
95-100	Excellent water quality
80-94	Good water quality
60-79	Fair water quality
45-59	Marginal water quality
0-44	Poor water quality
Oregon Water Quality Index (OWQI)	
90-100	Excellent water quality
85-89	Good water quality
80-84	Fair water quality
60-79	Poor water quality
0-59	Very poor water quality

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Table 6 : Water Quality Rating as per Weight Arithmetic Water Quality Index Method

WQI value	Rating of Water Quality	Grading
0-25	Excellent water quality	A
26-50	Good Water Quality	B
51-75	Poor water quality	C
76-100	Very Poor water quality	D
Above 100	Unsuitabble for drinking purpose	E

Table 7 : Merits and Demerits of Selected Water Quality Index Methods:-

S.No.	Merits	Demerits
1	National Sanitation Foundation (NSF) WQI	
	1. Summarizes data in a single index value in an objective, rapid and reproducible manner. 2. Evaluation between areas and identifying changes in water quality. 3. Index value relate to a potential water use. 4. Facilitates communication with lay person.	1. Represents general water quality, it does not represent specific use of the water. 2. Loss of data during data handling. 3. Lack of dealing with uncertainty and subjectivity present in complex environmental issues
2	Canadian Council of Ministers of the Environment (CCME) WQI	
	1. Represent measurements of a variety of variables in a single number. 2. Flexibility in the selection of input parameters and objectives. 3. Adaptability to different legal requirements and different water uses. 4. Statistical simplification of complex multivariate data. 5. Clear and intelligible diagnostic for managers and the general public. 6. Suitable tool for water quality evaluation in a specific location 7. Easy to calculate 8. Tolerance to missing data 9. Suitable for analysis of data coming from automated sampling. 10. Combine various measurements in a variety of different measurement units in a single metric.	1. Loss of information on single variables. 2. Loss of information about the objectives specific to each location and particular water use. 3. Sensitivity of the results to the formulation of the index. 4. Loss of information on interactions between variables. 5. Lack of portability of the index to different ecosystem types. 6. Easy to manipulate (biased). 7. The same importance is given to all variables. 8. No combination with other indicators or biological data. 9. Only partial diagnostic of the water quality. 10. F1 not working appropriately when too few variables are considered or when too much covariance exists among them.
3	Oregon WQI	

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	1. Un-weighted harmonic square mean formula used to combine sub-indices allows the most impacted parameter to impart the greatest influence on the water quality index. 2. Method acknowledges that different water quality parameters will pose differing significance to overall water quality at different times and locations. 3. Formula is sensitive to changing conditions and to significant impacts on water quality.	1. Does not consider changes in toxics concentrations, habitat or biology. 2. To make inferences of water quality conditions outside of the actual ambient network site locations is not possible. 3. Cannot determine the water quality for specific uses nor can it be used to provide definitive information about water quality without considering all appropriate physical, chemical and biological data. 4. Cannot evaluate all health hazards (toxics, bacteria, metals, etc.).
4	Weight Arithmetic WQI	
	1. Incorporate data from multiple water quality parameters into a mathematical equation that rates the health of water body with number. 2. Less number of parameters required in comparison to all water quality parameters for particular use. 3. Useful for communication of overall water quality information to the concerned citizens and policy makers. 4. Reflects the composite influence of different parameters i.e. important for the assessment and management of water quality. 5. Describes the suitability of both surface and groundwater sources for human consumption.	1. WQI may not carry enough information about the real quality situation of the water. 2. Many uses of water quality data cannot be met with an index. 3. The eclipsing or over-emphasizing of a single bad parameter value 4. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. 5. WQI based on some very important parameters can provide a simple indicator of water quality.

CONCLUSION

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. A properly designed plant is not only a requirement to guarantee safe drinking water, but also skillful and alert plant operation and attention to the sanitary requirements of the source of supply and the distribution system are equally important. Performance of any water treatment plant is an essential parameter to be evaluated to understand its operation, working and efficiency. This study concluded that only after performance evaluation of any water treatment, the defects and problems can be known and can lead to further betterment of the plant.

The water quality of any water body is deteriorated due to domestic and industrial discharges without treatment. To analyse the condition of any water body, water quality index claimed suitable term to evaluate variations in quality of water.

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