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Assessment of Water Quality Parameters: A Review

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ABSTRACT:
Water is the most important in shaping the land and regulating the climate. It is one of the most important compounds that profoundly influence life. The quality of water usually described according to its physical, chemical and biological characteristics. Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and depletion of aquatic biota. Due to use of contaminated water, human population suffers from water borne diseases. It is therefore necessary to check the water quality at regular interval of time. Parameters that may be tested include temperature, pH, turbidity, salinity, nitrates and phosphates. An assessment of the aquatic macro invertebrates can also provide an indication of water quality.
Keywords: Alkalinity, Dissolved Oxygen (D.O.), Eutrophication, Biochemical Oxygen Demand (BOD), Water Quality Index (WQI)

CONTENTS:

I. INTRODUCTION

India is facing a serious problem of natural resource scarcity, especially that of water in view of population growth and economic development. Most of fresh water bodies all over the world are getting polluted, thus decreasing the potability of water. All life is depend on water and exists in nature in many forms like ocean, river, lake, clouds, rain, snow and fog etc. However, strictly speaking chemically pure water does not exist for any appreciable length of time in nature.

A lake is a large body of water surrounded by land, inhabited by various aquatic life forms, for all practical purpose, pure water is considered to that which has low dissolved or suspended solids and obnoxious gases as well low in biological life. Such high quality of water may be required only for drinking purposes while for other uses like agriculture and industry, the quality of water can be quite flexible and water polluted up to certain extent in general sense can be regarded as pure. The health of lakes and their biological diversity are directly related to health of almost every component of the ecosystem. Lakes are also subjected to various natural processes taking place in the environment like the hydrologic cycle, with unprecedented development activities; human beings are responsible for choking several lakes to death. Storm water runoff and discharge of sewage into the lakes are few of the common causes where various nutrients enter the aquatic ecosystems resulting in their death.

Of all the water quality issues facing lakes everywhere, eutrophication is of great concern. Eutrophication is a term used to describe the aging of a lake, resulting due to the accumulation of nutrients, sediments, silt and organic matter in the lake from the surrounding watershed. The role of vegetation and sediments as sources and sink of nutrients has been demonstrated. It describes the biological reaction of aquatic systems to nutrient enrichment, the eventual consequence of which is the development of primary production to nuisance proportions. The main cause is excessively adding of phosphorus and nitrogen resulting in high algal biomass, dominance by cyanobacteria and loss of macrophytes.

II. LITERATURE REVIEW

2.1 GENERAL

Various technical papers on Assessment of water quality for lake have been presented at research level from which I referred many papers for study. These papers are presented below.

2.2 REVIEW OF LITERATURE

P. J. Puri , M. K. N. Yenkie, et al [01] have studied water quality index (WQI) has been calculated for different surface water resources especially lakes, in Nagpur city, Maharashtra (India), for the session January to December 2008; comprising of three seasons, summer, winter and rainy season. Sampling points were selected on the basis of their importance. Water quality index was calculated using water quality index calculator given by National Sanitation Foundation (NSF) information system. The calculated (WQI) for various studied lakes showed fair water quality in monsoon season which then changed to medium in winter and poor for summer season. Gorewada lake showed medium water quality rating in all season except monsoon season. Futala, Ambazari and Gandhisagar lake has also declined in aesthetic quality over past decade following invasion of aquatic weeds such as hydrilla and water primrose, so the reasons to import water quality change and measures to be taken up in terms of surface water (lakes) quality management are required.

B. N. Tandel, Dr. J. Macwan, C. K. Soni [02] have studied, the water quality index is a single number that expresses the quality of water by integrating the water quality variables. Its purpose is to provide a simple and concise method for expressing the water quality for different usage. The present work deals with the monitoring of variation of seasonal water quality index of some strategically selected surface water bodies. The index improves the comprehension of general water quality issues, communicates water quality status and illustrates the need for and the effectiveness of protective practices. It is found that in all cases the change in WQI value follow a similar trend throughout the study period. The lake water is found of good quality (WQI - 67.7 to 78.5) during both seasons. However, it is found that water quality of lake deteriorates slightly from winter to summer season on account of the increase in microbial activity as well as increase in pollutants concentration due to water evaporation.

S. Chandra, A. Singh and P. K. Tomar [03] have described, lake water is a source of drinking and domestic use water for rural and urban population of India. The main goal of the present study was to assess drinking water quality of various lakes i.e. Porur lake Chennai, Hussain Sager Hydrabad Vihar lake Mumbai in India. For this, lakes water samples were collected from six different sites and composite sample prepared were analyzed for pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH)and calcium hardness (Ca-H), chemical oxygen demand(COD), biochemical oxygen demand (BOD), dissolved oxygen (D.O.), sulphate (as SO_4^{2-}), nitrate (as NO_3) and chloride (Cl^-) levels .Some heavy metals like Iron, Zinc, Cadmium, Mercury, Nickel and Chromium were also analyzed in these samples. There were variations for EC (141-1041 "#$%&), turbidity (2-9 NTU), TDS (107.1–935.8 mg/L), SO_4^{2-} (4–8 mg/L), TA (42–410 mg/L), TH (41-280 mg/L), Ca–H (14-10 mg/L), BOD (5-9mg/L), COD (4–32 mg/L) NO_3(1.1-3.6 mg/L) and Cl^- (49-167 mg/L) levels at different sites. Water pollution indicates that these parameters were manifold higher than the prescribed limit by the WHO & BIS standard.

Wu-Seng Lung, A. M. Asce [04] has studied, a two-layer time-variable model is developed to quantify seasonal variations of pH and alkalinity levels in acidic lakes. The model incorporates the CO2/ HCOJ/ CO5 equilibria with internal sources and sinks of alkalinity and acidity in the water column. External alkalinity and C02 acidity loadings are also incorporated. The modeling framework is applied to the Bickford Reservoir in Massachusetts and to Woods Lake and Panther Lake in Adirondack Park, New York. In general, in-lake alkalinity generation by reduction processes in the Bickford Reservoir during the summer months is simulated by the model. The observed response to snowpack release in Woods Lake and Panther Lake during the spring months is also reproduced by the model. All three model applications are efficiently run on a personal computer system.

T. M. Heidtke, A. M. Asce and W. C. Sonzogni [05] have studied, results from a study of water quality planning and management alternatives for the Great Lakes are used to identify cost-effective pollution control strategies. Mathematical models and other systems analysis techniques are applied to estimate pollutional loadings, specific water quality problem areas, costs and pollutant reductions offered through alternative management strategies. A determination of how these alternatives may be expected to achieve water quality objectives for the Great Lakes is made. Data from a diversity of Great Lakes research efforts are compiled, integrated, and used to project local and lake wide water quality conditions over the next twenty years. A set of management tools, including a near shore water quality index and a series of environmental quality maps, are developed to promote communication and interpretation of Great Lakes water quality data among technical and nontechnical interests. Findings from the study support a staged approach to pollution control, whereby the most cost effective programs are implemented and their results assessed before more expensive control measures are undertaken.

V. Pradhan, M. Mohsin, B. H. Gaikwad [06] have studied, water quality of Chilika Lake was determined during the month of January 2012. It was observed that all the parameters are above permissible limit except at the sample site S2. The results are discussed in the light of findings of other workers.

Dr. M. K. Mahesh, B. R. Sushmitha, H. R. Uma [07] have explained, a water quality index (WQI) developed by the Canadian Council of Ministers of the Environment (CCME) was applied to Hebbal lake of Mysore, Karnataka State, India, to study its impact on aquatic life, livestock and to know whether it is suitable for recreation, irrigation and drinking. The index of the lake is rated as poor with respect to drinking, recreation and livestock, marginal with respect to Aquatic life and excellent for irrigation purpose. The overall water quality is rated as poor. The water quality is almost always endangered or deteriorated and the conditions often deviate from natural levels. Anabaena and Microcystis aeruginosa form blooms, Phacus pleuronectes is also recorded and the lake water is unsuitable to protect aquatic life. Incidence of Fish kill occurred in 2011 due to contamination of water.

M. S. Islam, B. S. Ismail, et al [08] have studied, the purpose of this study was to assess the hydrological properties and water quality characteristics of Chini Lake in Pahang, Malaysia. A total of seven sampling stations were established at the main Feeder Rivers of Chini Lake for measurement of stream flow. A total of 10 monitoring stations covering the study area were selected for water sampling. Fourteen water quality parameters were analyzed based on in-situ and ex-situ analysis for two seasons and laboratory analyses were carried out according to the HACH and APHA methods. Stream flow from the seven Feeder Rivers into the Chini Lake was relatively slow, ranging from 0.001 to 1.31 m/s 3 or an average of 0.21 m /s. According to the INWQS (Interim National Water Quality Standards, Malaysia) 3 classification, the temperature was within the normal ranges; conductivity, total suspended solids (TSS), nitrate, sulphate and total dissolved solids (TDS) were categorized under class I, while turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen and phosphate came under class II and pH under class III. Furthermore water quality in Chini Lake varied temporally and spatially and the most affected parameters were pH, TSS, turbidity, DO, ammoniacal nitrogen, phosphate and conductivity. Based on the Malaysian Water Quality Index (WQI), the water in the Chini Lake was classified under class II, meaning it is suitable for recreational activities and safe for body contact.

V. B. Y. Sheikh, P. R. Bhosale, B. N. Nagargoje [09] has explained, Physical, chemical, ionic, biological studies were conducted at (Maharashtra State, India). It is positioned on south east corner of Maharashtra. Nagzari dam is situated at Nagzari village of Kinwat quality of Nagzari dam. Water is to determine the nutrient status of the water with reference to drinking water quality as well as irrigational purpose. Also observe the seasonal variations of selected water parameters and identify the pollution sources dam. The physical and chemical parameters were analyzed as per APHA revealed that there were fewer variations in the physicochemical, ionic, heavy metals analysis of the present water quality parameters undertaken and results received through the entire one year of study showed that the status of water quality is quite normal and within the permissible limit as mentioned with ISI. Basically this entire premises of the study area is in the remote and tribal also natural area, hence, the pollution load is minimum. The Nagzari dam in the rural region is relatively clean are main source of water pollution. There is no industrial pollution in this area. As this study deals with the social and other important aspects like drinking, domestic, agricultural, irrigation and fishing etc.

S. Hussaina, V. Maneb, et al. [10] have studied, In the present work we are reported the Physico chemical properties like pH, conductivity, Turbidity, TDS, DO, fluoride, chloride, Sodium, Sulphate, etc. and the values are compared for treated and untreated water samples. The samples were collected from treatment plant of Ahmedpur, Dist Latur. The values changes apparently after the treatment of water.

R. W. Gaikwad, V. V. Sasane [11] has explained, the present work is aimed at assessing the water quality of the groundwater in and around Lonar Lake. Water quality has been determined by collecting groundwater samples and subjecting the samples to a comprehensive physiochemical analysis. For assessing water quality, pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulphate, total dissolved solids, iron, manganese and fluorides have been considered. The higher values has been found to be mainly for Iron, Total hardness, chloride, fluoride, calcium and magnesium, many literature shown that groundwater quality in Lonar Taluka has been badly affected by nitrate contamination. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination. Many different options are now in progress for treatment of water locally. Various community based programs have been tried in the past, but only few of these purely community run plants are successful. The future lies in providing safe drinking water in rural areas with a mixture of these options so that the objectives of providing safe water at low cost for sustaining over a long time and reaching to maximum number of people is achieved.

S. N. Thitame and G. M. Pondhe [12] have studied, in present investigation an attempt was made for assessment of Seasonal Variation in Physico-chemical Characteristics and Quality of Pravara River Water for Irrigation during year 2008. The study reveals that most of the physicochemical parameters of river water at five selected sites show moderate variation in their concentration for all seasons. However site 3 and 4 stands evidence of discharge of waste water from the city in the river. This intern indicated the quality of water for irrigation in the study area. The Sodium absorption ratio and Residual sodium carbonate values show good water quality for irrigation. However at site 3 and 4 the values of Kelly's index and Soluble Sodium Percentage exceed their standards in monsoon season indicating doubtful quality of water for irrigation.

M. Pejaver and M. Gurav [13] have explained, the two lakes namely Kalwa and Jail lake of Thane city are eutrophicated and hence the study were done to find the quality of water for the period of 6 months for various physico-chemical parameters to study the pollution status of the lakes. The Jail lake is found to be relatively more organically polluted and greater degree of eutrophication the Kalwa lake. Among water quality parameters, a positive correlation was found between chlorophyll and temperature, suspended solids, pH, dissolved oxygen (not with chlorophyll c), Co2 (only with chlorophyll C). A negative correlation was seen between Chlorophyll and light penetration. The Chlorophyll a and b showed negative correlation with Co2 silicates and Phosphates.

R. M. Khan, M. J. Jadhav, I. R. Ustad [14] have explained, in order to understand the water quality of Triveni Lake, Physico-chemical parameters were studied and analyzed for the period of one year i.e. December 2010 to November 2011. Various physicochemical parameters, such as water temperature, air temperature, pH, humidity, conductivity, free Co2, total solid, dissolved oxygen, Total alkalinity, Total hardness, caco3, ca++, mg++ were studied. The results revealed that there was significant seasonal variation in some physicochemical parameters and most of the parameters were in normal range and indicated better quality of lake water. It has been found that the water is best for drinking purpose in winter and summer seasons.

III. ASSESSMENT OF WATER QUALITY:

3.1 GENERAL

Due to increase in population, industrialization and urbanization, large quantities of sewage and industrial wastewater are discharged into lake has significantly contributed to the pollution of the lake. Water quality assessment studies on the Lake were conducted from time to time for the last two decades by several agencies and implemented pollution control measures to rejuvenate the lake. The objective of the present study was to assess drinking water quality of various lakes in India.

3.2 PARAMETERS TO BE ANALYZED

For the assessment of water pollution status of the water bodies, the following water quality parameters were analyzed: (1) pH (2) Specific Conductance (3) Temperature (4) Total dissolved solid (TDS) (5) Total Solids (TS) (6) Total Alkalinity (7) Dissolved oxygen (DO) (8) Chemical oxygen demand (COD) (9) Biochemical oxygen demand (BOD) (10) Total Hardness.

3.3 WATER QUALITY PARAMETERS INCLUDED IN LAKE ASSESSMENTS

Monitoring lakes requires many different parameters to be sampled. The parameters analyzed in this assessment include:

3.3.1 pH

pH is the measure of the acidity of a solution of water. The pH scale commonly ranges from 0 to 14. The scale is not linear but rather it is logarithmic. For example, a solution with a pH of 6 is ten times more acidic than a solution with a pH of 7. Pure water is said to be neutral, with a pH of 7. Water with a pH below 7.0 is considered acidic while water with pH greater than 7.0 is considered basic or alkaline.

3.3.2 CONDUCTIVITY

Conductivity is a numerical expression of an aqueous solution's capacity to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of the liquid. Solutions of most inorganic acids, bases, and salts are relatively good conductors. In contrast, the conductivity of distilled water is less than 1 µmhos/cm. Because conductivity is the inverse of resistance, the unit of conductance is the mho (ohm spelled backwards), or in low-conductivity natural waters, the micromho.

3.3.3 ALKALINITY

Alkalinity is the sum total of components in the water that tend to elevate the pH to the alkaline side of neutrality. It is measured by titration with standardized acid to a pH value of 4.5 and is expressed commonly as milligrams per liter as calcium carbonate (mg/L as CaCO3). Alkalinity is a measure of the buffering capacity (ability to resist changes in pH) of the water, and since pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality. Commonly occurring materials in water that increase alkalinity are carbonates, bicarbonates, phosphates and hydroxides. Limestone bedrock and thick deposits of glacial till are good sources of carbonate buffering. Lakes within such areas are usually well-buffered.

3.3.4 PHOSPHORUS

Phosphorus is an essential plant nutrient and most often controls aquatic plant (algae and macrophyte) growth in freshwater. It is found in fertilizers, human and animal wastes, and yard waste. There is no atmospheric (vapor) form of phosphorus. Because there are few natural sources of phosphorus and the lack of an atmospheric cycle, phosphorus is often a limiting nutrient in aquatic systems. This means that the relative scarcity of phosphorus may limit the ultimate growth and production of algae and rooted aquatic plants. Therefore, management efforts often focus on reducing phosphorus input to a receiving waterway because: (a) it can be managed, and (b) reducing phosphorus can reduce algae production. Two common forms of phosphorus are: Soluble reactive phosphorus (SRP) – SRP is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae and cycled very rapidly. Sources of SRP include fertilizers, animal wastes and septic systems. Total phosphorus (TP) – TP includes dissolved and particulate forms of phosphorus. TP concentrations greater than 0.03 mg/L (or 30!g/L) can cause algal blooms in lakes and reservoirs.

3.3.5 NITROGEN

Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of the atmosphere is nitrogen gas. Nitrogen gas diffuses into water where it can be “fixed” (converted) by blue-green algae to ammonia for algal use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because nitrogen can enter aquatic systems in many forms, there is an abundant supply of available nitrogen in these systems.

3.3.6 LIGHT TRANSMISSION

This measurement uses a light meter (photocell) to determine the rate at which light transmission is diminished in the upper portion of the lake’s water column. Another important light transmission measurement is determination of the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. The 1% light level is considered the lower limit of algal growth in lakes and this area and above is referred to as the euphotic zone.

3.3.7 DISSOLVED OXYGEN (D.O.)

D.O. is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. D.O. enters water by diffusion from the atmosphere and as a by- product of photosynthesis by algae and plants. The concentration of D.O. in epilimnetic waters continually equilibrates with the concentration of atmospheric oxygen to maintain 100% D.O. saturation. Excessive algae growth can over-saturate (greater than 100% saturation) the water with D.O. when the rate of photosynthesis is greater than the rate of oxygen diffusion to the atmosphere. Hypolimnetic D.O. concentration is typically low as there is no mechanism to replace oxygen that is consumed by respiration and decomposition. Fish need at least 3-5 mg/L of D.O. to survive.

3.3.8 SECCHI DISK TRANSPARENCY

Secchi disk transparency refers to the depth to which the black and white Secchi disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (soil or dead leaves) may be introduced into the water by either runoff or sediments already on the bottom of the lake. Erosion from construction sites, agricultural lands, and riverbanks all lead to increased sediment runoff. Bottom sediments may be resuspended by bottom-feeding fish such as carp, or by motorboats or strong winds in shallow lakes.

3.3.9 PLANKTON

Plankton is important members of the aquatic food web. The plankton includes phytoplankton or algae (microscopic plants) and zooplankton (tiny shrimp-like animals that eat algae). The phytoplankton is primary producers that convert light energy from the Sun to plant tissue through the process of photosynthesis. This forms the foundation of the aquatic food chain. Small microscopic shrimp-like crustaceans called zooplankton eat the phytoplankton. In turn, the zooplanktons are extremely important food for young fish. The phytoplankton are organized taxonomically largely by colour. Important phyla (groups) include: Cyanobacteria (blue-green algae), Chlorophyta (green algae), Chrysophyta (yellow-brown algae) and Bacillariophyta (diatoms). The cyanobacteria are of particular interest to limnologists and lake users because members of this group are those that often form nuisance blooms and their dominance in lakes may indicate poor water conditions. Some species of cyanobacteria are known to produce toxins.

3.3.10 CHOROPHYLL-A

The plant pigments of algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll-a is the most dominant chlorophyll pigment in the green algae (Chlorophyta) but is only one of several pigments in the blue-green algae (Cyanophyta), yellow- brown algae (Chrysophyta), and others. Despite this, chlorophyll-a is often used as a direct estimate of algal biomass although it might underestimate the production of those algae that contain multiple pigments.

TABLE 1
PHYSICOCHEMICAL CHARACTERISTICS OF LAKE WATER IN INDIA

Sr No	Parameter	BIS specification
1	Appearance	Clear
2	Colour	5 Hazen max
3	Turbity	5 NTU max
4	PH	6.5-8.5
5	EC	Not mentioned
6	Alkalinity	200 mg/L max
7	Fluoride	1 mg/L max
8	Chloride	250 mg/L max
9	Phosphate	Not mentioned
10	Sulphate	200 mg/L max
11	T H	300 mg/L max
12	Ca H	75 mg/L max
13	Mg H	30 mg/L
14	TDS	500 mg/L max
15	Silica	Not mentioned
16	FRC	0.2 mg/L
17	Hydrazine	Not mentioned
18	COD	Not mentioned
19	BOD	Not mentioned
20	DO	Not mentioned
21	SO3	Not mentioned
22	NO3	50 g/L

where EC = Electrical conductivity (EC = µS/cm), TH = Total hardness, CaH = Calcium hardness, COD = Chemical oxygen demand, BOD = Biological oxygen demand and TDS = Total dissolve solid, ND = Not detected. FRC = Free Residual Chlorine. Not mentioned results are given in mg/L.

3.4 WATER QUALITY INDEX (WQI)

WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves. Factors to be included in WQI model could vary depending upon the designated water uses and local preferences. Some of these factors include DO, pH, BOD, COD, total coliform bacteria, temperature, and nutrients (nitrogen and phosphorus), etc. These parameters occur in different ranges and expressed in different units. The WQI takes the complex scientific information of these variables and synthesizes into a single number.

Calculation of WQI: The Water Quality Index (WQI) was calculated using the Weighted Arithmetic Index method.

The quality rating scale for each parameter Qi was calculated by using this expression:

Quality rating, $Qi = 100 [(Vn - Vi) / (Vs - Vi)]$

Where, Vn : actual amount of nth parameter, Vi : the ideal value of this parameter, Vi = 0 except for pH and D.O.; Vi = 7.0 for pH; Vi = 14.6 mg/L for D.O., Vs : recommended WHO standard of corresponding parameter

Relative weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) of the corresponding parameter.

$Wi = 1 / Si$

Generally, WQI are discussed for a specific and intended use of water. In this study the WQI for human consumption is considered and permissible WQI for the drinking water is taken as 100. The overall WQI was calculated by using Equation:

Water Quality Index $= \sum (Qi)Wi \ / \ \sum Wi$

The WQI ranges have been defined as:

- 90-100 : Excellent
- 70-90 : Good
- 50-70 : Medium
- 25-50 : Bad
- 0-25 : Very Bad

By this way it defines water quality.

IV. CONCLUDING REMARK:

1. The seasonal values of WQI indicate that during summer season, lake water is more affected than during winter. This could be due to the fact that the microbial activity get reduced due to low temperature, thereby keeping DO level at a very satisfactory range during entire winter season.
2. The suggested measures to improve the lake water quality includes total ban on the activities that causes pollution.
3. Result of water quality assessment clearly showed that most of the water quality parameters slightly higher in the wet season than in the dry season.
4. Water quality is dependent on the type of the pollutant added and the nature of self purification of water.

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