A REVIEW OF NATURAL WATER PHYSICO-CHEMICAL PARAMETER TESTING

[1] **Makibar Rahman,**

[1] Assistant Professor,
[1] Department of Chemistry,
[1] Barama College, Barama, Baksa, India

Abstract : **People all over the world are in grave danger as a result of unfavorable changes in the physical, chemical, and biological properties of air, water, and soil. Water is highly polluted with various harmful contaminants as a result of increased human population, industrialization, fertilizer use, and man-made activities. Natural water pollution occurs as a result of rock weathering, soil leaching, mining processing, and other factors. The quality of drinking water must be checked on a regular basis because the human population suffers from a variety of water-borne diseases as a result of the use of contaminated drinking water. The availability of high-quality water is critical for disease prevention and quality of life improvement. It is necessary to understand the various physico-chemical parameters used for testing water quality, such as colour, temperature, acidity, hardness, pH, sulphate, chloride, DO, BOD, COD, and alkalinity. Heavy metals such as Pb, Cr, Fe, Hg, and others are of particular concern because they cause acute or chronic poisoning in aquatic animals. For the exploratory parameter study, some water analysis reports with physico-chemical parameters were provided. Guidelines for comparing the value of a real water sample have also been provided for various physico-chemical parameters.**

IndexTerms **- Biological, contaminates, heavy metals, natural water, physico-chemical, testing.**

I. Introduction

Water needs proper planning, development, and management because it is a valuable national asset, a prime natural resource, and a basic human necessity. Ecology and environmental studies, on the other hand, are generally regarded as a nuisance and are frequently viewed as "anti-development and detrimental to the overall growth and welfare of human beings." India is dealing with a severe shortage of natural resources, particularly water, as a result of population expansion and economic expansion. The water ecosystem has undergone noticeable changes in recent years due to the rapid growth of industry and agriculture. As a result, it is now vulnerable to all local disturbances, regardless of their location. For all living things on Earth to survive and thrive, water is necessary. It is among the most significant and prevalent substances in the ecosystem. An unavoidable water crisis has been brought on by the growing urbanization, industrialization, and development efforts made to deal with the population explosion. There is a direct correlation between biological diversity and lake health. Nutrients are important in freshwater bodies because excess of them causes eutrophication. The first step toward managing and conserving aquatic ecosystems is water quality monitoring. It is also true that the goal of managing any aquatic ecosystem is to preserve its habitat by keeping the water's physico-chemical quality within reasonable bounds. At the moment, 70% of Earth's surface is submerged in water. However, because of man-made activities, industrialization, the use of fertilizer in agriculture, and an increase in the human population, it has become extremely contaminated with a variety of dangerous substances. Because tainted drinking water can lead to a number of water-borne illnesses in humans, it is imperative that the quality of drinking water be monitored frequently. Since the chemistry of water explains the general hydro-biological relationship and provides a wealth of information about the metabolism of the ecosystem, it is challenging to fully comprehend the biological phenomenon.

II. Testable Parameters

It is necessary to test water using various physico-chemical parameters. Before using the water for domestic, industrial, agricultural, or drinking purposes, it must be tested. The selection of water testing parameters is contingent only upon the intended use and degree of necessity for the water's quality and purity. Numerous kinds of suspended, dissolved, floating, microbiological, and bacteriological impurities are present in water. The physical and chemical tests should be carried out for its pH, temperature, carbon dioxide, dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Electrical Conductivity (EC), alkalinity, Carbonate, Bicarbonate, Ammonia (NH_3), Sulphate, Chloride, Phosphate, Silicates, Sodium, Potassium, Calcium and Magnesium i.e., total hardness (TH) and other characteristics such as colour, odour, turbidity, total dissolved solids (TDS) etc.It needs to be tested for organic content, such as pesticide residue, heavy metal concentrations, and trace metals. It goes without saying that drinking water must pass all of these tests and have the necessary mineral content. All of these requirements are only closely observed in developed nations. Since organic pesticides and heavy metals are present in water at very low concentrations, highly sophisticated analytical equipment and skilled labor are required. To keep an eye on the quality of the water, various physical and chemical parameters are routinely tested.

- pH: When assessing how corrosive water is, pH is the most significant factor. The water is more corrosive the lower its pH value. Total alkalinity and electrical conductivity showed a positive correlation with pH (Gupta, 2009)[1]. The assimilation of carbon dioxide and bicarbonates, which ultimately cause the pH to rise, was the cause of the decreased rate of photosynthetic activity. The summer months' high temperatures and low oxygen levels were in sync. The pH of water varies due to a number of factors. The higher pH values found indicate that changes in physico-chemical conditions have a greater impact on carbon dioxide and carbonate-bicarbonate equilibrium (Karanth 1987)[2].
- Temperature: In a well-functioning system, the temperature of the water regulates the speed of all chemical reactions and has an impact on the growth, immunity, and reproduction of fish. Fish can die from sudden changes in temperature.

- Carbon dioxide: In practically all aquatic environments, carbon dioxide is the final product of the degradation of organic carbon, and its variation is frequently a measure of net ecosystem metabolism (Smith 1997[3], 1993[4], Hopkinson 1985[5]). As such, it is desirable to measure parameters that characterize the carbon dioxide system in aquatic biogeochemical studies. The most significant greenhouse gas on Earth is CO_2. One of the most significant issues in studies of global change is its fluxes across the air-water or sediment-water interfaces, which are frequently indicators of the aquatic system's net ecosystem production and metabolism. The aquatic carbon dioxide system has several easily measured parameters, including total alkalinity (TA), pH (pCO_2), and total dissolved inorganic carbon (DIC). An infrared CO_2 analyzer or a coulometer can be used to measure DIC CO_2 (Dickson 1994)[6] while the photometric method can be used to measure surface water pCO_2 (DeGrandpre 1993[7]; Wang, 2002[8]),.
- Dissolved Oxygen (DO): Summertime high DO is caused by rising temperatures and the amount of time spent in direct sunlight affects the proportion of soluble gases (O_2 and CO_2). Summertime's long days and bright light seem to speed up phytoplankton's process of using CO_2 and producing oxygen through photosynthesis. This could explain why summertime measurements of O_2 quality were found to be higher (Krishnamurthy R., 1990)[9]. Due to rising temperatures and increased microbial activity, dissolved oxygen decreased in the summer (Moss 1972[10]; Morrissette 1978[11]; Kataria 1996[12]). It is among the most crucial variables. Its relationship to the body of water provides both direct and indirect information about things like photosynthesis, bacterial activity, nutrient availability, stratification, etc. (Premlata Vikal, 2009)[13]. After five days at 293 K, DO in the sample is measured titrimetrically using Winkler's method. The amount of oxygen consumed by the bacteria during this time is indicated by the difference between the initial and final DO values. Special bottles are required for this procedure because they keep the interior environment free of outside oxygen.
- Biochemical Oxygen Demand (BOD): BOD is a measurement, expressed in mg/L, of the organic material contamination in water. The amount of dissolved oxygen known as BOD is necessary for the oxidation of some inorganic materials (such as iron and sulphites) and the biochemical breakdown of organic compounds. The BOD test is usually run over the course of five days (Milacron Marketing Co.)[14].
- Chemical Oxygen Demand (COD): Another indicator of the amount of organic material contamination in water, expressed in mg/L, is COD. The COD is the concentration of dissolved oxygen needed to oxidize organic matter in water chemically. Important markers of a surface water supply's environmental health are BOD and COD. Although they are rarely used in general water treatment, they are frequently used in waste water treatment. (Marketing Company Milacron Co.)[14].
- Electrical Conductivity (EC): Ten parameters, including temperature, pH, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, chloride, and iron concentration in water, exhibit a significant correlation with electrical conductivity. According to Navneet Kumar et al. (2010)[15], regulating the water's conductivity can be an effective way to check the quality of the study area's subterranean drinking water. This method can also be used to manage the water quality of other study areas. An EC meter, which measures the resistance provided by the water between two platinized electrodes, is used to measure it. Known conductance values measured with a standard KCl solution are used to standardize the instrument.
- Alkalinity: It is primarily composed of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-), and its alkalinity acts as a pH stabilizer. The toxicity of many substances in water is affected by alkalinity, pH, and hardness. A simple dilute HCl titration in the presence of phenolphthalein and methyl orange indicators is used to determine it. The presence of hydroxyl and carbonate ions in boiler water causes alkalinity. The presence of hydroxyl alkalinity (causticity) in boiler water is required to protect the boiler from corrosion. Other operational issues, such as foaming, are caused by excessive causticity. Excessive causticity can cause a type of caustic attack on the boiler known as "embrittlement."
- Carbonate: The presence of carbonates is indicated when the pH falls below 8.3. Titration with standardized hydrochloric acid with phenolphthalein as an indicator is used to measure it. Carbonates are converted to bicarbonates when the pH falls below 8.3. Titration can also be done using pH meters or potentiometers.
- Bicarbonate (HCO_3^-): Titration with standardized hydrochloric acid with methyl orange as an indicator is also used to measure it. Below pH 4.0, methyl orange turns yellow. Carbonic acid decomposes to give carbon dioxide and water at this pH.
- Ammonia (NH_3): It is measured spectroscopically at 425 nm radiation by using Nessler's reagent to create a colour complex. The alkaline conditions of the reaction lead to significant interference from the water's hardness.
- Sulphate: The nephelometric method is used to measure it, where the turbidity concentration is compared to a known concentration of a sulphate solution that has been artificially made. Sodium chloride is used to stop turbidity from settling, while barium chloride is used to create turbidity caused by barium sulphate and a combination of organic materials (glycerol).
- Chloride: It is determined by titrating a known volume of sample with a standardized silver nitrate solution, employing an indicator such as eosin/fluorescein solution in alcohol or potassium chromate solution in water. The former forms a reddish-coloured compound with silver as soon as the chlorides precipitate out of solution, whereas the latter is an adsorption indicator.
- Phosphate and Silicates: Spectroscopic measurements are also made of these. Strongly acidic conditions cause phosphates and silicates to react with molybdate ions, resulting in the development of the yellow colour. The amount of silicates and phosphate in the sample is directly correlated with the colour intensity. If silica complexes need strong reducing conditions like hydrazine or bisulphite, phosphate complexes can be reduced by weak reducing agents like ascorbic acid or tartaric acid. The reduced complex has a sky blue colour.
- Sodium: An instrument called a flame photometer is used to measure it. The instrument is calibrated using a known sodium ion concentration, ranging from 1 to 100 mg/litre. The dilution factor is applied to the observed values after the samples with higher concentrations have been suitably diluted with distilled water.

- Potassium: A flame photometer is also utilized in the measurement process. A potassium solution with a known concentration in the range of 1 mg to 5 mg/litre is used to standardize the instrument. The higher concentration sample is appropriately diluted using distilled water, and the observed values are adjusted for the dilution factor.
- Calcium: Under pH conditions greater than 12.0, it is measured by complexometric titration with a standard solution of ETDA using Patton's and Reeder's indicators. A fixed volume of 4N sodium hydroxide is added to achieve these conditions. The concentration of calcium in the sample is calculated by dividing the volume of the EDTA solution by the known volume of the sample.
- Magnesium: Additionally, under pH 10.0 buffer conditions, it is measured by complexometric titration using a standard EDTA solution and Eriochrome black T as an indicator. Ammonium hydroxide and ammonium chloride are used to make the buffer solution. During titration, the solution resists the changes in pH.

The standard methods recommended by APHA (1985)[16], ASTM (2003)[17], Kodarkar (1992)[18] and Trivedy and Goal (1986)[19] are used to determine the majority of the physico-chemical parameters.

III. Review of Literature

High fluctuations in the physico-chemical parameters, indicating the intensity of pollution, were observed by Rokade and Ganeshwade (2005)[20]. The chlorides ranged from 132.5 to 820.4 mg/l, the hardness was between 74 and 281 mg/l, the CO_2 was between 2.1 and 5.09, the BOD was between 4.437 and 112.432 mg/l, the sulphates were between 0.192 and 5.12 mg/l, and the nitrates were between 0.5 and 1.012. The pH was between 6.6 and 8.4. The wintertime pH value was found to be the lowest at 6.3 mg/l, and the summertime pH value was found to be the highest at 8.93 mg/l. A general decrease in pH is seen from upstream to downstream. It was discovered that CO_2 decreased to a minimum of 2.28 mg/l during the rainy season and reached a maximum of 55.44 mg/l in the summer. Based on the gathered data, it can be said that the current investigation does not support the known inverse relationship between pH and CO_2 (Sawane 2006)[21].

The groundwater quality of the industrial area of Kishangarh was investigated by Sharma Madhavi et al. (2005)[22] for a number of physicochemical parameters seasonally, both with and without the addition of marble slurry in varying amounts. The results of the study demonstrate that these parameters rise when marble slurry is added, degrading the groundwater's overall quality.

The treatment of pulp and paper mill effluent by Phanerochaete chrysosporium is reported in a study by Singhal et al. (2005)[23], and it has been compared at two different pH levels, 5.5 and 8.5. Following bioremediation, the effluent's pH, color, COD, lignin content, and total phenols all drastically decreased. At pH 5.5, however, there was more decolourization and a decrease in COD, lignin content, and total phenols.

Aftab Begum et al. (2005)[24] examined untreated fertilizer effluent analysis as well as a number of physico-chemical parameters. Fungal analysis revealed the presence of 15 species isolated on Malt Extract Agar (MEA) medium, indicating the pollutional load of the effluent. His results also showed that parameters like EC, TDS, TSS, BOD, COD, and ammonia are high compared to the permissible limits of CPCB (1995).

Dey Kallol et al. (2005)[25] examined a range of physio-chemical characteristics in samples taken from the Brahmani, Shankha, and Koel rivers. Dilution during the rainy season has been shown to significantly lower the level of metal concentration. Nonetheless, it is acknowledged that the enrichment of these metals through biomagnification and bioaccumulation in edible components produced in water has a notable impact on the water of the Brahamani River, which is deeply concerning to the public.

An investigation was conducted by Chavan et al. (2005)[26] to examine the various organic pollutants found in the water of Thane Creek. The water in the creek exhibits elevated levels of BOD and COD, in addition to detergents, alcohols, acetone, ether, and fifteen phenolic compounds that are detrimental to aquatic life. The entry of effluents from nearby industries is the primary source of these pollutants.

Ariyalur and Reddipalayam, two significant cement factories, were chosen, and the waste water that these businesses discharged was gathered and examined. The Tamil Nadu Pollution Control Board's standard values were compared to the values of various parameters. Remedial actions are recommended after the causes of the variations are examined (Gnana 2005)[27]. Of all the environmental problems facing the mineral-based industry, water pollution has caused the most havoc and presented the most difficult obstacles to taking the required corrective action. The various mineral-based industries—mining, mineral processing, integrated iron and steel plants, and nonferrous metal industries—and their sources of water pollution are discussed. There have been discussions and descriptions of a variety of physiochemical and biological methods for treating liquid wastewater. Every procedure that is being used in a commercial setting has been described. Jena and Mohanty (2005)[28].

Gupta et al. (2009)[1] examined the physicochemical properties of water samples taken from 20 Kaithal sampling locations. Samples are analyzed for things like pH, TDS, colour, odour, hardness, chloride, and alkalinity. Upon cross-referencing the findings with the drinking water quality standards established by the World Health Organization (WHO)[29] and the Indian Council of Medical Research (ICMR)[30], it is discovered that certain water samples are unfit for human consumption because of elevated levels of one or more of the parameters. Therefore, an effort has been made to ascertain whether or not the groundwater quality in and around Kaithal City town is fit for human consumption.

Premlata Vikal (2009)[13] has been researching the physicochemical properties of Pichhola lake water. He looked at air and water temperature, pH, free CO_2, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, conductivity, total dissolved solids, hardness, total alkalinity, chloride, nitrate, phosphate, and sulphate. The results revealed that conductivity, COD, and sulphate levels in water samples exceeded the standard limits. The correlation coefficient (r) between various physicochemical parameters was also calculated.

The physico-chemical characteristics of the Tamadalge water tank in Kolhapur District, Maharashtra, were examined by Manjare et al. (2010)[31]. Throughout the course of a year, changes in total hardness, chlorides, alkalinity, phosphate, nitrates, pH, total dissolved solids, transparency, turbidity, free carbon dioxide, and total hardness were all examined monthly. Every parameter was within the allowed bounds. The findings show that the tank is suitable for residential and irrigation use and is not contaminated.

In the Shimoga district of Karnataka, the Hosahalli water tank's monthly variations in a number of physico-chemical parameters were examined by Basawaraj Simpi et al. (2011)[32]. According to the study, tank water is safe for residential, agricultural, and fishing use and all parameters are within permissible limits. In their 2011 paper, Saravanakumar[33] and Ranjith Kumar[33] discuss their research on the groundwater quality in Chennai City's Ambattur industrial area. They looked at things like conductivity, pH, turbidity, total dissolved solids, sulphate, fluoride, total alkalinity, and hardness. A minor variation in the physico-chemical parameters was noted among the examined water samples. The water sample's physico-chemical characteristics were compared to WHO[29] and ICMR[30] limits, revealing that the groundwater is extremely contaminated and poses health risks to humans.

IV. RESULT & DISCUSSION

Natural water pollution affects both developed and developing nations, though the extent of the pollution varies depending on the location. The current study concludes that pollution from industry, mining, agriculture, urban areas, homes, and medical practices has led to significant physical, chemical, and bacterial pollution of natural water in India and overseas. This work also establishes a relationship between various physicochemical parameters. Temperature, photosynthesis, respiration, and turbidity are all related to the DO. Temperature, photosynthesis, dissolved carbon dioxide, and chloride all affect pH. The study also discovered that the value of DO is higher in the winter due to low temperatures and lower during the summer due to high temperatures. Therefore, temperature and DO are inversely correlated. Additionally, it has been discovered that, in some circumstances, flooding and aeration during the rainy season cause the value of DO to rise. The review also reveals a somewhat deviation-free reciprocal relationship between the DO and BOD. The deviation shows that rising pollutant and dissolved oxygen concentrations cause an increase in DO and BOD. Temperature and dissolved free carbon dioxide have a direct relationship; in the summer, high temperatures correspond with high free CO_2, and in the winter, low temperatures correspond with low free CO_2.A vital component of illness prevention and raising the standard of living is the availability of clean water. Many impurities found in natural water are brought into aquatic systems through a variety of processes, including the weathering of rocks and soils, the dissolution of aerosol particles from the atmosphere, and the mining, processing, and use of metal-based materials by humans. The government's increased use of fertilizers based on metals during the agricultural revolution may cause the concentration of metal pollution in freshwater reservoirs to rise further as a result of water runoff. Moreover, millions of people have died from waterborne diseases brought on by the faucal pollution of drinking water. Unwanted alterations in the physical, chemical, and biological properties of air, water, and soil pose a serious threat to human safety worldwide. These ultimately have an impact on plants and animals since they are related to them. Industrial development, which includes the expansion of already-existing industries, produces industrial effluents that, if left untreated, pollute soil, water, and sediment. It is especially concerning to have high concentrations of heavy metals from industrial processes, especially Pb, Cr, and Fe, as these can cause chronic or water poisoning in aquatic animals. Elevated concentrations of contaminants, primarily organic matter, in river water lead to a rise in total dissolved solids, total suspended solids, fecal coli, chemical oxygen demand, and biological oxygen demand. They render water unfit for human consumption, farming, or any other purpose. The practice of using sewage effluent as fertilizer has become more popular in developing nations because it is thought to be a good source of organic matter and plant nutrients. Farmers are mostly focused on the broad advantages, such as higher agricultural yields, inexpensive water supplies, efficient methods of disposing of wastewater, nutrient sources, organic matter, etc., and are less cognizant of the negative consequences, such as soil and crop contamination by heavy metals and health-related quality issues. Studies have demonstrated that using this sewage effluent for irrigation over an extended period of time contaminates crops and soil to the point where it becomes toxic to plants and degrades soil. A significant amount of potentially hazardous materials are present in this, such as soluble salts and heavy metals like Pb^{2+}, Mn^{2+}, Zn^{2+}, Fe^{2+}, and Cu^{2+}. It is not desirable to have these heavy metals added. Heavy metals can build up in plant tissues at concentrations higher than allowed; this is thought to pose a risk to human health and the health of animals that eat these crops, as well as the possibility of contaminating the food chain. When irrigation water was mixed with industrial effluent, it was found that the soil and plants contained a large number of toxic metals. The concentrations of different chemical constituents, which are primarily determined by the geological data of the specific region, affect the quality of groundwater (Gupta 2009)[I]. Groundwater and surface water pollution are primarily caused by two sources: municipal solid waste and industrial waste. Excessive levels of heavy metals make available water unfit for human consumption in many regions of the nation. Summertime conditions worsen because of water scarcity and runoff from rainwater. One of the most dangerous major health issues is the contamination of water supplies used for drinking and household purposes with heavy metals, harmful microorganisms, and other elements. The majority of rivers found in developing nations' urban areas are the discharge points for industrial effluents. Rapid industrial growth is occurring in Asian and African nations, making environmental conservation challenging. Many trace metals are present in very small concentrations in seawater. Because many significant trace metals are present in extremely low concentrations, this matrix presents difficulties for analytical chemists. As a result, the review work provides an overall picture of natural water pollution in India and abroad, as well as the interrelationship between various physicochemical parameters, in order to study and control water pollution for the benefit of society as a whole.

V. CONCLUSION

Natural water is a complex mixture of gases, minerals, and organic essences that appear as true solutions, along with suspended and colloidal matter. It is a dynamic chemical mixture. Surface water chemical composition varies depending on land use, substrate type, and geological structure. Metals such as Al, Cd, Cr, Cu, Fe, Pb, and Zn are found in contaminated waters as a result of natural processes and direct and indirect human activity. Due to their high rates of morbidity and mortality, as well as their high treatment and prevention costs, chemical pollutants and waterborne pathogens are among the most serious threats to global, regional, and local health. The alarming rate at which the concentration levels of these pollutants are increasing renders the environment and habitat unfit for human habitation. Maintaining the security and purity of water is essential to averting permanent, long-term effects on human health.

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