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Consequence of Temperature, pH, Turbidity and Dissolved Oxygen Water Quality Parameters

Vijay S. Kale

Associate Professor, Department of Electronic Science, KTHM College, Nashik, Maharashtra, India

Abstract: Water is an important constituent for all the living beings. The water quality guidelines provide a limit value for each parameter for drinking water. It is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varied of water borne diseases. The availability of good quality water is a necessary feature for preventing diseases and improving quality of life. The different physico-chemical parameters are color, temperature, hardness, turbidity, pH, sulphate, chloride, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) etc. used for testing of water quality. Heavy metals like Pb, Cr, Fe, Hg etc. are of special concern or chronic poisoning in aquatic animals. This paper summarized the importance of monitoring temperature, turbidity, pH and dissolved oxygen parameters of drinking water and its adverse effect. A lot of drinking water quality parameters are described by world health organization (WHO). It gives the guidelines of parameters for comparing the value of real water sample from that we can decide the quality of water.

Keywords: Drinking water, Parameters, Temperature, Dissolved Oxygen, Turbidity, pH.

I. INTRODUCTION

Three sources are used to collect water, where we live in the world are:

- Ground water- its depth and quality varies from place to place. About half of the world's drinking water comes from the ground.
- Surface water- directly from a stream, river, lake, pond, spring etc. Its quality is generally unsafe to drink without treatment.
- Rainwater- is collected and stored using a roof top, ground surface or rock catchment.

The quality of rain water collected from a roof surface is usually better than a ground surface or rock catchment. Water is in continuous movement on, above and below the surface of the earth. As water is recycled through the earth, it picks up many things along its path [1]. Water quality varies from place to place, with the seasons and with various kinds of rock and soil which it moves through. 70% surface of earth is covered by water, majority of water available on the earth is saline in the nature and only 3 % of exists as fresh water. Fresh water has become a scare commodity due to over exploitation and pollution. Pollution of surface and ground water is great problem due to rapid urbanization and industrialization. The increasing number of human activities has gradually speed-up contamination and damage to fresh water resources [2].

It is important to judge the safety of water by taking three qualities into consideration:

- Microbiological- bacteria, viruses, protozoa and worms
- Chemical- minerals, metals and chemicals
- Physical- temperature, colour, smell, taste and turbidity

Safe drinking water should be: Free of pathogens, Low in concentrations of toxic chemicals, Clear, Tasteless and colourless (for aesthetic purposes) [3]

'Pure' water does not actually exist in nature, as all water contains some naturally occurring chemicals that have leached from the surrounding environment. In most cases, the levels of naturally occurring chemicals are either beneficial, or minimal and of little consequence. There are many human made chemicals that can contaminate water and affect its usability. Sources of chemical contaminants can be naturally occurring chemicals, chemicals from agricultural activities, chemicals from human settlements, chemicals from industrial activities and chemicals from water treatment and distribution [4].

Good quality of drinking water is very necessary for improving the life of people and to prevent from diseases. It is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varied of water borne diseases. It is necessary to know the details about different physico-chemical parameters, which are used for testing of water quality such as colour, temperature, hardness, pH, turbidity, sulphate, chloride, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) etc.. Heavy metals like Pb, Cr, Fe, Hg etc. are of special concern because they produce water or chronic poisoning in aquatic animals. There is lot of parameter for drinking water quality parameter described by world health organization (WHO), Indian Standard IS 12500:2012, Environmental Protection Agency (EPA), Environmental Quality Standards (EQA) [5]. The World Health

Organization (WHO) is part of the United Nations (UN) and it focuses on international public health. The WHO writes the Guidelines for Drinking Water Quality to make sure that people are drinking safe water around the world [6, 7]. P. Fowler et. Al. in their study recommended that temperature, turbidity, DO, and pH be monitored directly on a continuous basis since they tend to change rapidly and have a significant adverse effect on the human being if allowed to operate out-of-range [8].
Water is called the 'universal solvent' because it dissolves more substances than any other liquid. This means that wherever water goes, either through the ground or through our bodies, it takes along valuable chemicals, minerals, and nutrients. Pure water has a neutral pH of 7. The water molecule is highly cohesive. It is very sticky. Pure water, does not conduct electricity. Water becomes a conductor once it starts dissolving substances. Water has a high specific heat index. It absorbs a lot of heat before it begins to get hot [9]. This is why water is valuable to industries and in car's radiator as a coolant.

A drinking-water quality guideline value represents the concentration of a constituent that does not result in any significant health risk to the consumer over a lifetime of consumption. When a guideline value is exceeded, the cause should be investigated and corrective action to be taken. The amount by which and for how long, any guideline value can be exceeded without endangering human health depends on the specific substance involved [10]. In drawing up national standards for drinking water quality, it will be necessary to take into account various local, geographical, socioeconomic and cultural factors. As a result, national standards may differ appreciably from the WHO guideline values. Water quality monitoring and evaluation is therefore very critical for sustainable water resources and has increasingly attracted a great deal of research and development attention. The permissible limits of different parameter set by different agencies do not show uniformity [11]. This article summarized two physical (Temperature, Turbidity) and two chemical (pH, Dissolved Oxygen) water quality parameters. Guidelines of physic-chemical parameters also have been given for comparing the value of real water sample.

II. PHYSICAL WATER QUALITY PARAMETERS

Two physical parameters temperature and turbidity are described.

A. Temperature

Temperature refers to degree of hotness or coldness and it can be measured in degree Celsius. Water temperature needs to be monitored regularly as outside tolerable temperature range, disease and stress will become more prevalent. Among the consequences of temperature changes are; photosynthetic activity, diffusion rate or gases, amount of oxygen that can be dissolved etc. [12]. The aesthetic objective for temperature of less than or equal to 15 degrees Celsius is adopted from the 'Guidelines for Canadian Drinking Water', which has been accepted by the Ministry of Health Services for application in British Columbia.
Objectives are derived from criteria by considering the local water quality, water uses, water movement, waste discharges, and socioeconomic factors [13]. Temperature is important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature. Water, particularly groundwater, with higher temperatures can dissolve more minerals from the rocks. Therefore, it will have a higher electrical conductivity. Temperature exerts a major influence on biological activity and growth. Temperature governs the kinds of organisms that can live in rivers and lakes.
From the user's viewpoint, cool drinking water is preferable to warm; a temperature of 10□C is usually satisfactory. The figure of 19□C, often quoted as a 'limit' above which most consumers complain, is based on an empirical relationship derived about 60 years ago. Pangborn and Bertolero, using distilled water, solutions of mineral salts in distilled water and samples of drinking water, showed that the intensity of taste is greatest for water at room temperature and is significantly reduced by chilling or heating [9, 13].

Turbidity and colour are indirectly related to temperature, because temperature affects coagulation. The efficiency of coagulation is strongly temperature dependent and the optimum pH for coagulation decreases as temperature increases. Because of the complex combination of chemical equilibrium involved in coagulation, it is recommended that, in order to achieve the most economical use of coagulant, jar tests be carried out at the temperature of the treated water and not at room temperature. Corrosion rate is also a function of the dissolved oxygen concentration in water. The solubility of oxygen decreases with increasing temperature (10.15 mg/L at 15□C to 7.1 mg/L at 35□C). The change in dissolved oxygen with temperature is small compared with the larger change in corrosion rates. Warm water holds less dissolved oxygen than cool water and may not contain enough dissolved oxygen for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures [14].

Factors affecting water temperature:

- Air temperature
- Amount of shade
- Soil erosion increasing turbidity
- Thermal pollution from human activities
- Unknown chemical reactions those weren't previously occurring in the water.

Effects of water temperature:

- Solubility of dissolved oxygen– more gas can be dissolved in cold water than warm.
- Rate of plant growth– increased water temperature can cause an increase in the photosynthetic rate of aquatic plants and algae, which can lead to increased plant growth and algal blooms and harm the local ecosystems.

- Resistance in organisms– if water becomes too hot or too cold, organisms become stressed, lowering their resistance to pollutants, diseases and parasites [15].

B. Turbidity

Turbidity is a measure of the cloudiness/clarity of water. Cloudiness is caused by suspended solids mainly soil particles (sand, silt, clay), microscopic plants and animals that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of microscopic plants and animals present to fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Higher turbidity levels are often associated with higher levels of viruses, parasites and some bacteria because they can sometimes attach themselves to the dirt in the water. Therefore, we must be cautious of turbid water as it usually has more pathogens, so drinking it increases our chances of becoming sick. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight [16].
Nephelometers measure the intensity of light scattered by the suspended particles. The result is a measurement of turbidity in Nephelometric turbidity units (NTU). The WHO Guideline for turbidity in drinking water is less than 5 NTU. The turbidity in excess of 5 NTU or 5JTU may be noticeable and consequently objectionable to the consumers [17]. Highly turbid water reduces light penetration therefore affecting levels of photosynthesis, warming is increased due to absorption of sunlight, and it is generally aesthetically unpleasing. These particles decrease the passage of light through the water. Turbidity sensor measures the murkiness by measuring the quantity of light scattered at ninety degree. Normally, turbidity sensor makes use of LDR and LED.

Excessive turbidity or cloudiness, in drinking water is aesthetically unappealing and may also represent a health concern. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne diseases, which have caused significant cases of gastroenteritis. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa. The particles of turbidity provide shelter for microbes by reducing their exposure to attack by disinfectants. Fortunately, traditional water treatment processes have the ability to effectively remove turbidity when operated properly [18].

Causes of Turbidity:
- Soil erosion– silt and clay deposition
- Urban runoff– road grime, rooftops, parking areas
- Industrial waste– sewage treatment effluent, particulates
- Organic matter– microorganisms, decaying plants and animals, petrol, diesel or oil from roads

Effects of Turbidity:
- Reduces water clarity
- Aesthetically unpleasant
- Decreases rate of photosynthesis
- Increases water temperature

III. CHEMICAL WATER QUALITY PARAMETERS

Two chemical parameters pH and dissolved oxygen are described.

A. pH

The pH refers to the hydrogen ion concentration or how acidic or basic as water is and pH is defined as –log[H+]. pH value range from 0-14; pH 7 is neutral, pH<7 is acidic and pH>7 is basic. pH is a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically [19]. The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen and carbon) and heavy metals (lead, copper, cadmium etc.). In case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble. pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity. The reduced rate of photosynthetic activity, the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. Karanth in 1987, mentioned that, the higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition [20]. Very high pH (greater than 9.5) or very low pH (lower than 4.5) values are unsuitable for most aquatic organisms. Aquatic organisms are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels (9-14) can harm fish due to the fact that ammonia will turn to toxic ammonia at high pH (>9) [4].

The pH for drinking water generally lies between 6.5 and 8.0 at 25°C (80° F). The pH of the water in a stream, river, lake or underground flow will vary depending on a source of the water, type of soil, bedrock, types of contaminants the water encounters in its path etc. The effects of a specific type of water pollution on living plants and animals can vary greatly. No health-based guideline value is proposed for pH by the WHO. Although pH usually has no direct impact on consumers, it is one of the most important water quality parameters. For example, for effective disinfection with chlorine, the pH should preferably be less than 8. The optimum range for chlorine disinfection is between pH 5.5 and 7.5. High pH causes a bitter taste, water pipes and water-using appliances become coated with deposits and it depresses the effectiveness of the disinfection of chlorine, thereby causing the need for additional chlorine when pH is high. Low pH water will corrode or dissolve metals and other substances [21].

Factors that affect pH levels:

- Acidic rainfall- may have little effect if the region is rich in minerals that result in high alkalinity values i.e. higher concentrations of carbonate, bicarbonate, and hydroxide ions from limestone can provide a natural buffering capacity capable of neutralising many of the H+ ions from the acid. Other regions may have low concentrations of alkalinity ions to reduce the effects of acids in the rainfall area.
- Level of hard- water minerals
- Releases from industrial processes- depends on whether acids or bases are released
- Release of detergents into water
- Carbonic acid from decomposition
- Oxidation of sulphides in sediments (acidic)

B. Dissolved oxygen (DO)

DO describe the concentration of oxygen molecular in the water and it dependents on the temperature of the water and the biological demand of the system. DO is supplied to water through several method; direct diffusion of oxygen from the atmosphere, wind and wave action; and photosynthesis. It is used in aerobic decomposition of organic matter, respiration of aquatic organism and chemical oxidation of mineral. As DO is used by many organisms in the water, it tends to change rapidly [5].

The quantity of oxygen that the water can hold depends on the temperature salinity and pressure of the water. Gas solubility increases with decreasing salinity. Fresh water holds more oxygen than saltwater. Gas solubility decreases as pressure decreases. The amount of oxygen absorbed in water decreases as altitude increases because of the decrease in relative pressure. Levels of dissolved oxygen vary depending on factors including water temperature, time of day, season, depth, altitude, and rate of flow. Water at higher temperatures and altitudes will have less dissolved oxygen. Dissolved oxygen reaches its peak during the day. At night, it decreases as photosynthesis has stopped [10].

Rapidly moving water, such as in a mountain stream or large river, tends to contain a lot of dissolved oxygen, whereas stagnant water contains less. Bacteria in water can consume oxygen as organic matter decays. Thus, excess organic material in lakes and rivers can cause eutrophic conditions. Aquatic life can have a hard time in stagnant water that has a lot of rotting, organic material in it, especially in summer. Conditions may become especially serious during a period of hot, calm weather, resulting in the loss of many fish. Human factors that affect dissolved oxygen in streams include addition of oxygen consuming organic wastes such as sewage, addition of nutrients, changing the flow of water, raising the water temperature and the addition of chemicals [22].

Sources of dissolved oxygen are:

- Diffusion from the atmosphere and water at the surface
- Aeration as water flows over rocks & uneven surfaces
- Aeration through churning action of wind and waves
- Photosynthesis from aquatic plants

The concentration of dissolved oxygen is affected by [23]:

- Plant activity– DO levels fluctuate throughout the day, increasing during the morning and peaking in the afternoon. Decreases occur at night when photosynthesis ceases.
- Temperature– affects the ability of water to dissolve oxygen due to the different solubility's at different temperatures. Cooler water have a greater capacity to dissolve oxygen than warmer water
- Decaying organic matter in water– decomposition releases heat, warming water and decreasing dissolved oxygen capacity
- Stream flow – the faster the water moves and churns, the greater the amount of oxygen is dissolved
- Altitude/atmospheric pressure– high altitudes and atmospheric pressure reduce dissolved oxygen capacity
- Human activities – removal of shade or the release of warm water used in industrial processes can cause an increase in water temperature, resulting in lower dissolved oxygen capacity

IV. CONCLUSION

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physico-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water may contain different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Groundwater is the most important source of water supply for drinking, irrigation and industrial purposes. Increasing population and its necessities have lead to the deterioration of surface and sub surface water. The cause of ground water gets pollute and create health problems. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source it therefore becomes imperative to regularly monitor the quality of groundwater and to device a ways and means to protect it. So before using of water, investigate qualitative analysis of some physico-chemical parameters of water. This may be considered as reference for the society to get cautious about the impending deterioration of their environment and health.

The physical characteristics of water are usually things that we can measure with our own senses such as: turbidity, colour, taste, odour and temperature. In general, drinking water to have good physical qualities if it is clear, tastes good, has no smell and is cool. Physical contaminants generally do have not direct health effects themselves; however, their presence may relate to a higher risk of microbiological and chemical contamination which may be harmful to human health. The importance of temperature in water quality is derived mainly from its relationship with other water quality parameters. Most of these relationships have a bearing on the aesthetic aspects of water quality; some are indirectly related to health. The sweetness of drinking water is to some extent dependent on temperature. The figure of 19□C is often cited as a 'limit' above which most consumers complain (WHO). At temperatures above 15□C, in the distribution system becomes a problem and could lead to the development of unpleasant tastes and odours. The effect of low temperature on water treatment processes is controlled by altering the amounts of chemicals used in treatment; low temperature is not a barrier to the production of water of an acceptable quality. Turbidity is the cloudiness of water that is caused by suspended particles of sand, silt and clay which are not harmful in low amounts. Higher turbidity levels are often associated with higher levels of viruses, parasites and some bacteria. Since pathogens are the main source of water-related diseases, we must be cautious of turbid water. WHO Guideline for turbidity in drinking water is less than 5 NTU.

pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. Very high pH (greater than 9.5) or very low pH (lower than 4.5) values are unsuitable for most aquatic organisms. Aquatic organisms are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels (9-14) can harm fish due to the fact that ammonia will turn to toxic ammonia at high pH (>9). The pH for drinking water generally lies between 6.5 and 8.0 at 25°C. DO is supplied to water through several method; direct diffusion of oxygen from the atmosphere, wind and wave action; and photosynthesis. The concentration of dissolved oxygen is affected by plant activity, temperature, decaying organic matter in water, stream flow, altitude/atmospheric pressure and human activities.

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BIOGRAPHY

Vijay S. Kale (M.Sc, M.Phil, Ph.D, PGDIM, ADCSSA) is working as Associate Professor, Department of Electronic science, KTHM College, Nashik, Maharashtra, India. He has been in the teaching profession (UG and PG) since 28 years. He has been presented research paper in international conferences (USA, Bangkok). He published research papers in national and international journals. He received R. Chandrasekhar award from Indian Physics Association (IPA), Savitribai Phule Pune University. He has written six books. He worked on several academic committees of Savitribai Phule Pune University. He has worked as a resource person in refresher course, workshop etc. He is presently working on ARM microcontroller based sensor application, Wireless sensor application (water quality), e-CALLISTO etc.