NURSING EDUCATION AND PRACTICE

AIJNEP VOL 2 NO 1 (2021) E-ISSN 2694-3697

Available online at www.acseusa.org
Journal homepage: https://www.acseusa.org/journal/index.php/aijnep
Published by American Center of Science and Education, USA

SHOULD OPTIMUM pH RANGE FOR DIFFERENT SURFACE WATER BECOME FLUCTUATE WITH USAGE AND CONDITION IN PERSPECTIVE OF AQUATIC ENVIRONMENT AND HUMAN HEALTH EFFECTS?

Md. Iftakharul Muhib [(a)1] *Md. Humaun Kabir* [(b)]

[(a)] *Assistant Professor, General Education Department, Faculty of Science and Engineering, City University, Dhaka-1216, Bangladesh, E-mail: muhibiftakhar@gmail.com*
[(b)] *Professor & Engineer, Department of Textile Engineering, City University, Dhaka-1216, Bangladesh, E-mail: mdhumaunkabir628@gmail.com*

ARTICLE INFO

Article History:

Received: 27th October 2021
Accepted: 18th December 2021
Online Publication: 31st December 2021

Keywords:

pH, Carbon Dioxide, Bicarbonate, Carbonate, Health Effects

JEL Classification Codes:

Q53, I12

ABSTRACT

This short communication paper seeks attentions to rethink about the optimum pH range that can create anomalies in aquatic environment and human health. Optimizing pH value is one of the most important task in ranging the physico-chemical parameters especially for surface water quality. Aquatic system of a water body is profoundly dependent on pH range. Presence of free dissolved CO_2 which is a vital element for aquatic plants survival that is mostly dependent on water pH range value. In addition, pH range of an aquatic body can influence the O_2 availability, water body productivity, stress on fish health and ammonical as well as the metallic toxicity on human health. This short communication suggests that considering a universal optimum pH range for a water body e.g. 6.5-8.5 would not be wise rather this pH optimum range should be considered on the basis of site and water usage variations.

WHAT IS pH?

pH determines whether an aquatic body is acidic or basic. It is measured by a scale from 0-14 with neutral point 7. When pH is less than 7, the aquatic body will be acidic and when pH greater than 7, the aquatic body will be basic in nature (Figure 1) (Addy et al., 2004). pH is associated with the relative amount of free H^+ and OH^- ions in water. High H^+ ions indicate acidic system and high OH^- ion indicates basic system. Since pH is scaled in logarithmic units, water with pH 9 is ten times more basic than water with pH (USGS, 2002).

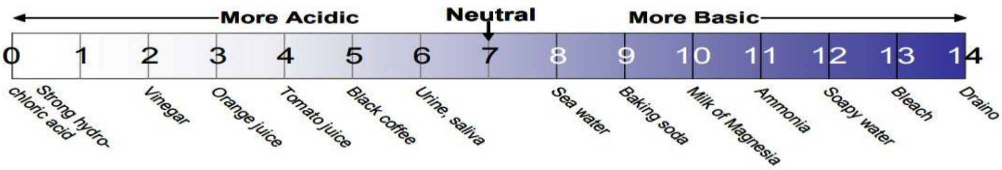

Figure 1. pH scale and examples of solutions at different pH's.

IMPORTANCE OF pH ON AQUATIC ENVIRONMENT

pH influences the chemical solubility and biological availability of primary nutrients (e.g. P & N) as well as the heavy metals (e.g. Cd, Pb, Cu etc.) For example, pH value of an aquatic body will determine whether presence of N or P are biologically available to uptake by the aquatic flora. Again the metallic toxicity is also pH dependent. The lower the pH of

[1] *Corresponding author: ORCID ID: 0000-0002-5143-2482*

https://doi.org/10.46545/aijnep.v2i1.249

To cite this article: Muhib, M. I., & Kabir, M. H. . (2021). SHOULD OPTIMUM pH RANGE FOR DIFFERENT SURFACE WATER BECOME FLUCTUATE WITH USAGE AND CONDITION IN PERSPECTIVE OF AQUATIC ENVIRONMENT AND HUMAN HEALTH EFFECTS? . *American International Journal of Nursing Education and Practice, 2*(1), 19-22. https://doi.org/10.46545/aijnep.v2i1.249

an aquatic body, the more dissociation of metal will happen and the aquatic body will become more toxic (Michaud, 1991). Table 1 represents the pH range and its effects on aquatic body.

Table 1. Effects of pH in in different values (LENNTECH, 2022)

Limiting pH values		Effects
Minimum	**Maximum**	
3.8	10.0	Young fish eggs deformed
4.0	10.1	Fish cannot survive in this range
4.1	9.5	Tolerable range of trout
4.3	-	Crop died in five days
6.0	7.2	Optimum range for fish breeding

Table 1 shows that pH variation in water body are vital because most of the organisms in the water body have to be adopted themselves on the water body specific pH range and may become die if it fluctuates slightly.

FACTORS AFFECTING THE pH OF AQUATIC ENVIRONMENT

pH range value of aquatic body is governed by both natural and anthropogenic factors. One of the vital influencer of water pH value is the bed rock and soil characteristics through which the water flows. Another vital influencer is the presence of plant growth and organic material in water body. CO_2 get mixed with water by both air pressure as well as by degradation of organisms and become turn to carbonic acid. This large amount of weak acid reduces the water pH value. Another influencer of pH level in water is the chemical effluent originated from industries and municipalities. The fourth factor of pH value range changer in aquatic body is the acid rain that react with water body and become changed in pH value. The occurrence of acid rain is due to excessive presence of air polluting agents in the atmosphere like SO_x and NO_x that are originated from automobile industry, coal fired power plants etc. (EPA, 2012; WRC, 2020).

pH AND ACIDITY IN AQUATIC ENVIRONMENT

Dissociation of substances is highly dependent of low pH level. The lower the pH, the greater the solubility and higher the availability of absorption tendency. For example, Fe with the 4 mg/L concentration in water is not harmful at pH 4.8. But if the pH turns to 5.5, only 0.9 mg/L concentration of Fe can lead fish to death. Again lower pH can asphyxiate fish gills thus reduce their size and weight. The low level of pH can also kill the adult fish and create hazardous condition to the invertebrate lives as well (LENNTECH, 2022). At low pH metals like Ca, Zn, Al etc. become more available in acidic environment and pose threat to aquatic flora and fauna (Wurts & Durborow, 1992).

pH AND ALKALINITY IN AQUATIC ENVIRONMENT

Alkalinity appraises the presence of bases in water. Some of the important bases mostly found in water body are bicarbonate, carbonate, hydroxide, phosphate, berates etc. The alkalinity of water body can be defined by the presence of H^+ ions that neutralizes by water buffer capacity before achieving a desired pH. The unit of total alkalinity is measured by mg/L $CaCO_3$. Generally, 20 mg/L $CaCO_3$ is considered to be optimum alkalinity for a water body (Wurts & Durborow, 1992). Alkalinity of water have influences on pH level of that water body. One of the examples in changes in water alkalinity is due to photosynthesis process of algae and other aquatic plants that utilizes the H+ in water thus increase the pH level. Most of the aquatic environment are capable to buffer these changes due to their alkalinity (Washington State Department of Ecology, 1991). However, highly alkaline water body lost its buffering capacity thus make damage to chemical metabolism in the water body and even cause death. For examples, ammonia is 10 times more toxic at pH 8 than pH 7 since this little change pose severe threat to aquatic lives (Wurts & Durborow, 1992).

RELATIONSHIP BETWEEN CO_2, pH AND DO IN AQUATIC ENVIRONMENT

Presence of CO_2 is one of the important reasons of water acidity (Bialkowski, 2006). The pH variation due to CO_2 in an aquatic body is regulated by photosynthesis, respiration and decomposition of organisms (Redke, 2006).

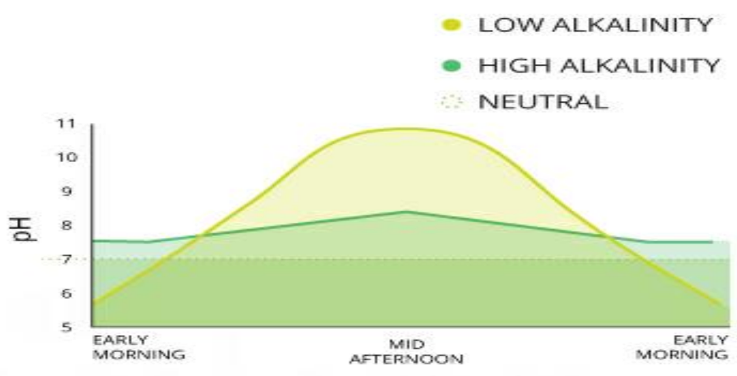

Figure 2. Fluctuation of pH level in 24 hours (FONDRIEST, 2020)

Figure 2 illustrates that pH level varied with daily photosynthesis and respiration rate in a water body. The degree of change relies on the water alkalinity (FONDRIEST, 2020). After the sunset, DO level starts to reduce, photosynthesis halt and all flora and fauna in water body starts to consume O_2 (respiration). In this process, free CO_2 reacts with water and form carbonic acid, thus lower the pH.

$$H_2O+CO_2=H_2CO_3=2H^++CO_3^{2-}$$

The following Table 2 illustrates relative changes in DO, CO2 and pH in 24 hours (Tucker, 1984).

Table 2. Variations in DO, CO_2 and pH with time

Time	Change		
	DO	**CO_2**	**pH**
Daylight	Increases	Decreases	Increases
Night time	Decreases	Increases	Decreases

CO2 merely create hazardous condition to aquatic fauna. However, in highly concentrated pond, pH limits the capacity of fish blood to carry O_2 by lowering blood pH at the gills. For examples, at 2 mg/L DO, fish may face suffocation when CO_2 level is high and seems unaffected when CO_2 is low (Wurts & Durborow, 1992).

INFLUENCE OF pH VARIABILITY ON AQUATIC ENVIRONMENT

Generally, pH unit is associated with the balance between CO_2, CO_3^{2-} and HCO_3^- presence in waste water. The deviation in the acid-base balance that is the pH of water body is influenced by industrial effluents, precipitation intensity and frequency as well as the photosynthesis and respiration of algae and other aquatic plants. pH fluctuation can create toxicity of metals, ammonia and nitrite. Universally the desired pH range is considered as 6.5-8.5 (Water Quality Assessments, 1996; Wurts & Durborow, 1992). Algae and other aquatic plants need free CO_2 to do photosynthesis. But the availability of free CO_2 switched to reduce its concentration when pH value started to increase over 8.0 and turn to HCO_3^-, CO_3^{2-} and sometimes OH^-. This conversion adversely affects the photosynthesis, respiration and gas exchange capacity of aquatic lives. This condition may even lead to death and should not cross the alkalinity level of 25 mg/l (Manahan, 2000).

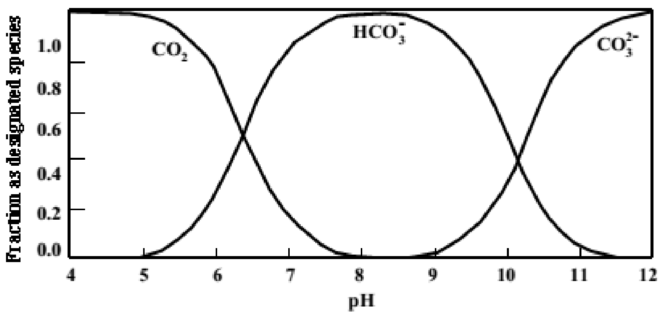

Figure 3. Distribution of species diagram for the CO_2–HCO_3^-–CO_3^{2-} system in water (Manahan, 2000)

Figure 3 illustrates that CO_2 is found to be dominated in acidic water while HCO_3^- is dominated in most water (Manahan, 2000). When pH deviates from their range, stress become started on aquatic flora and fauna thus pose hamper on their survival capacity. This stress level is dependent on the sensitivity of the nature of species in the aquatic body. Besides these, the elevated pH level typically raises the elemental solubility thus making toxic chemicals more available and accelerate the risk of adsorption by aquatic lives (EPA, 2012). However, some species like *H. verticillata*, *E. densa*, *E. Canadensis*, African Cichilds can survive in unusual pH environment (Kahara & Vermaat, 2003; Radke, 2003). Another important thing is that pH tolerance capacity in aquatic species is regulated by water buffer capacity (Kahara & Vermaat, 2003). In water with moderate to high alkalinity and similar hardness levels, pH remains neutral or slightly basic (7.0-8.1) and does not fluctuate widely and so does the other elements (Wurts & Durborow, 1992). So it is evident that optimum pH value of surface water pH should be optimized on the basis of use and ecological area by considering eco-toxicity testing and risk assessment.

INFLUENCE OF pH VARIABILITY ON HUMAN HEALTH

pH level is associated with metallic concentration in a water body. For example, if acidic water is distributed in piping systems containing lead exceeding 2µg/L, this could lead to an increased occurrence of adverse effects on the hematopoietic and central nervous system in women and in children (Steinnes, 1990). In acidified water cadmium concentrations are quite low (median level Cd, 0.2 µg/L). However, under certain conditions, such as roof-catchment systems that contain cadmium, may increase considerably and constitute a source of increased intake (Friberg et al., 1986). Again increased levels of aluminum in drinking water can occur as a result of acidification or improper water treatment with aluminum chemicals. Even small increases in aluminum concentrations in dialysis water may give rise to severe, even lethal effects in patients undergoing dialysis for extended periods of time. In persons with normal renal function absorbed aluminum is quickly excreted in urine and a possible adverse influence on health is not readily explainable (Flaten, 1986). The high concentrations of copper that may occur in drinking water as a result of contamination of acidic water by copper pipes are such that adverse effects on the gastrointestinal tract cannot be excluded. Also, the possibility exists that in infants and small children with special sensitivity, copper storage disease of the liver may develop, partly as a result of increased copper intake through acidic drinking source (Maggiore et al., 1987).

Author Contributions: Conceptualization, M.I.M. and M.H.K.; Data Curation, M.I.M.; Methodology, M.I.M.; Validation, M.I.M.; Visualization, M.I.M.; Formal Analysis, M.I.M. and M.H.K.; Investigation, M.I.M. and M.H.K.; Resources, M.I.M.; Writing – Original Draft, M.I.M. and M.H.K.; Writing – Review & Editing, M.I.M. and M.H.K.; Supervision, M.H.K..; Project Administration, M.I.M.; Funding Acquisition, M.I.M. and M.H.K. Authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: Ethical review and approval were waived for this study, due to that the research does not deal with vulnerable groups or sensitive issues.

Funding: The authors received no direct funding for this research.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Addy, K., Green, L., & Herron, E. (2004). pH and Alkalinity. *URI Watershed Watch*.

Bialkowski, S. (2006). Carbon Dioxide and Carbonic Acid (Environmental Chemistry). *Chemistry3650*.

EPA. (2012). pH. In Water: Monitoring and Assessment.

Flaten, T.P. (1986). An investigation of the chemical composition of Norwegian drinking water and its possible relationships with the epidemiology of some diseases. Ph.D. thesis, University of Trondheim, Norway.

FONDRIEST. (2020). Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water quality/ph/

Friberg, L., Elinder, C.G., Kjellstrom, T., & Nordberg, G. (1986). Cadmium and Health. A Toxicological and Epidemiological Appraisal- Vol 2. CRC Press, Boca Raton, FL.

LENNTECH. (2022). Acids and Alkalis in Fresh Water. Retrieved from https://www.lenntech.com/aquatic/acids-alkalis.htm.

Kahara, S. N., & Vermaat, J. E. (2003). The effect of Alkalinity on Photosynthesis-light curves and inorganic carbon extraction capacity of fresh water macrophytes. *Aquatic Botany*, *75*, 217-227.

Maggiore, G.D., Giacomo C., Cessa, F. & Burgio, G.R. (1987). Idiopathic hepatic copper toxicosis in a child. *Journal of Pediatric Gastroenterology and Nutrition*, *6*(6), 980- 983.

Manahan, S. (2000). Environmental Chemistry. 8th Edition, CRC Press, LLC.

Michaud, J. P. (1991). A Citizen's Guide to Understanding and Monitoring Lakes and Streams. Puget Sound Water Quality Authority, *66*.

Radke, L. (2003). pH of Coastal Waterways. *In Oz Coasts*.

Steinnes, E. (1990). Lead, cadmium, and other metals in Scandinavian surface and drinking waters, with emphasis on acidification and atmospheric deposition. *Environmental Toxicology and Chemistry*, *7*, 825-832.

Tucker, C. S. (1984). Carbon Dioxide in T.L. Wellborn Jr. and J.R MacMillan (eds.) For Fish Farmers. *Mississippi Co-operative Extension Service*. *84*(2).

USGS (2002) pH and Water. Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/ph-and-water?qt-science_center_objects=0#qt-science_center_objects, 2002.

Water Quality Assessments. (1996). Water Quality assessments: A guide to the use of biota, sediments and water in environmental modeling. Ed. D. Chapman.

Water Research Center. (2020). Retrieved from https://water-research.net/index.php/ph-in-the-environment 2020.

Wurts, W. A., & Durborow, M. (1992). Interaction of pH. Carbon Dioxide, Alkalinity and Hardness in Fish Ponds. *Southern Regional Aquaculture Center*, *484*, 1-4.

Publisher’s Note: ACSE stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.