Poll Res. 40 (1) : 296-302 (2021)
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ISSN 0257–8050

REVIEW OF ADVANCED TECHNIQUES TO CHECK POSSIBLE POLLUTANTS AND FOR AQUATIC QUALITY MANAGEMENT OF URBAN LAKES

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(Received 25 July, 2020; accepted 3 September, 2020)

ABSTRACT

Urban water bodies such as the lakes and ponds are more vulnerable to pollution in comparision to other fresh water sources due to ease of reach for human and other living beings. This article reviews important findings from previous works and adopted restoration policies for lake water management. Impact of environmental variations on physico-chemical parameters such as turbidity, dissolved Oxygen and the pH factor has been reproduced graphically. The article also discusses latest management techniques such as employment of sensors, Lidar, drones, submersible spectrofluorometer and electrolytic cell useful for aquatic quality management of urban lakes have been also discussed in brief.

KEY WORDS : Lake fundamentals, Management technique, Temperature effects on water quality parameters, Modern techniques for aquatic region management.

INTRODUCTION

Around the world, problems associated with fresh water resources arise significantly with the increase in aquatic pollution. Multiple sources of contaminations such as industries, agriculture waste and municipal sources (pesticide, herbicide, sewage, and litter) lead to the degradation of water quality of urban water bodies (Singh and Jain, 2018). Lakes are more vulnerable to pollution in comparision to other fresh water sources due to easy reach of human and other living beings. The pollution management in aquatic regions have been a challenging task in order to keep tracking of exact sources, quantity, projected lifetime and expected effects of pollutants. All these factors put urban water bodies such as the Lakes under severely poor conditions for aquatic habitat and humans with the production of harmful algal bloom and eutrophication of lake water (Singh and Jain, 2018, 2017; Bhateria and Jain, 2016). The choice of aquatic management techniques largely depends upon the operational costs and their ease of use. These days, environmentalists and researchers are targeting to define efficient cost effective methods for pollutants measurement and maintenance of the water bodies. In recent era due to degradation of natural resources, it is generally suggested that while adopting pollution prevention, we should keep an eye on the recycling of useful nutrients. Urban water bodies around the globe have been deteriorating since long due one or other reason, therefore this study have been done to provide a mirror reflection of current situation and to recommend useful curing steps to prevent further degradation. This article reviews important research work done in past and presents a study of useful techniques modern technologies for assessment of physico-chemical parameters.

Lakes: Fundamentals, types and source of contaminations

Lakes are those water bodies which don't have any direct connection with sea water generally. The ecosystem of water bodies like lake composed of

many physical, chemical and biological parameters in the lake. Lakes may be a source of fresh water or may be salty; they can be deep or shallow and may be permanent or temporary (Bhateria and Jain, 2016). Limnology is one of the disciplines that describe and categorizes about the lakes. Lakes are one of the most important sources for the observation of ecological system, the chemical and biological relations between different processes and the relation of aquatic species with organism on the land and the air. There is strong relation among all three ecosystems (land, air and water); some of the lakes are salty due to evaporation of ground water inputs. Lakes can occur anywhere in the basin of river. A headwater lake is contributes through many tributaries occurring through rainfall and ground water inflow.

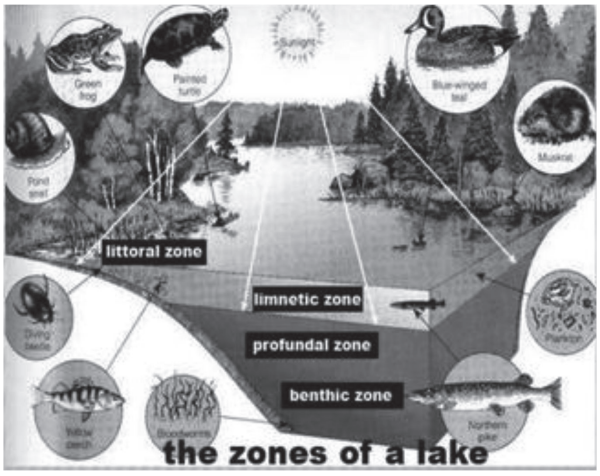


Fig. 1. Zonation of a lake, reproduced (Bhateria and Jain, 2016)

Generally lakes have one input and one put source through which it maintained the flow of fresh water. The lakes are very important ecosystems for maintaining the fresh water resources they contain nearly half of the world fresh water. Along with this it is an important source for many applications like irrigation, fisheries, water supply and even industries (Bhateria, 2016). The lakes can also be classified as basic types are glacial lakes, tectonic lakes, fluvial lakes, Shoreline lakes, dammed lakes, volcanic lakes, solution lakes, meteorite lakes etc (Berthold, 1995). Also the Lakes can be divided by the factors like salinity, chemistry and nutrient contains such as Oligotrophic, Mesotrophic, Eutrophic and the Hypereutrophic lakes (Nelson *et al*., 2002; Kang and Krishnan, 2013).

Most the human population settled around fresh water sources either it is lake, river or pond. It is because they have large impact on human growth. But all these sources are degraded in the current century due to excessive pollution in the society. Most of the water bodies have been affecting due to excess water pollution, the pollution from metallic waste and minerals proved to be very harmful and even in ppb range. There are many minerals whose small quantity is enough for human body any increase in quantity leads to toxicity. In agriculture many minerals are useful up to a prescribed quantity anything over than the prescribed growth can cause severe effects of plants. There are also many compounds like phenolic compounds, fluorides, radioactive substances which are harmful for both humans and animals. In south Asian countries including India, lot of pollution is increasing due to excessive pollution from industries and human waste and most of the large water bodies are now unsafe for drinking. Other major threats to urban water bodies such as lakes includes encroachment, illegal mining and tourism activities and the catchment area problems specially in the Indian subcontinent regions (Bhargava *et al.*, 2010).

Review of previous work done and recommended solutions

Around the globe, the researchers have studied the geographical distribution and water condition of many lakes. A detailed study (Larson, 1989) for large volcanic lakes (caldera) had been carried with literature inputs to study about 88 lakes from northern and southern hemisphere. Caldera lakes generally differentiated by the position, coverage area, depth and shoreline development. This study suggested that change in characteristics of the lake water is not only due to climatic change, their location, size but also due to secondary hydrothermal activities happening around the lakes. The western countries have taken serious steps to prevent the contamination of such lakes. In the era of early 90's, researchers (Hartig, 1992) have proposed a list of criteria for US and Canada lakes which are applicable for most lakes for making recommendation on areas of concern. Later on, outcome of a study (Yiping, 1996) elaborated important physico-chemical factors and listed strategies to protect water quality and to avoid eutrophication of lakes. With a case study, African researchers (Viner, 1969) noticed worsening situations of manmade reservoirs of the continents, caused by irregular distribution of water supply in

Africa. They also noticed higher growth of algal causing reduced level of Oxygen in the water, which perhaps led to the death of aquatic habitat. Impacts of the hypolimnetic aeration to restore the lake have been discussed by the researchers (Gupta *et al*., 2007), which may involve pumping of epilimnetic water into the bottom layer of water in a thermally-stratified lake. This process popularly termed as hypolimnion process, which may mitigate deep water oxygen depletion and its consequences in the water bodies. On the other side, many studies have been done to analyze the effect of channelization of physical habitat, low nutrients levels, flushing, dilution and climatic change on the water quality of lakes (Friberg *et al*., 2009; Laura *et al*., 2007). Similarly growth of algae and increase in abiotic component of pollution have been related with study of anthropogenic activities around the lakes (Michael *et al*., 2007). Many studies have shown the presence of plankton community resulted primarily from bacteria, flagellate and zooplankton (mainly copepods and cladocerans) and the carbon production. In the study of a Spanish reservoir (Marcé, 2000), authors have mentioned high concentration of nutrients specially NH_3 and system of rice intensification (SRI), which increases the chlorophyll contents in the reservoir.

Along with the studies around the globe, there have been many reports on Indian limnology too covering various lakes and rivers to understand their physiochemical parameter and biological condition for natural habitat. In one of the study (Thirupathaiah *et al*., 2012) of the Kamlapur Lake, the author's observed the change in the number of zooplankton from season to season researchers have observed 4 zooplankton in winter, while the number is quite low in summers. In other study Upper lake, Bhopal people (Vyas *et al*., 2011) emphasized on ILVM approach in relation to conservation and management of the Bhoj wetland and suggested possible options for the conservation community. In the study of the Priyadarshini Lake, the researchers (Khare, 2008) have analyzed slopes and points to study the historical importance of lake using hydro box and GPS methods. The diversity of plankton species and various fish species in the Pichhola Lake of Udaipur and the Mansagar (Jalmahal) lake of Jaipur have been elaborated in brief (Sharma *et al*., 2012; Sharma *et al*., 2007). In continuation of these studies, impact of Physico-chemical parameters on the lake water quality for a longer duration and requisite policies to conserve with applicable preventive restoration techniques for such lakes have been elaborated in (Raina, 2007; Pradhan, 2016). Beside all such research outcomes, effects of effluents from nearby industries have also been a major check point to determine the lake water quality. Many more reports have been made available in public domain to explain the soil conservation in the lake basin and to adopt management techniques to handle the lake deterioration.

Impact of environmental variations: — Temperature effects

The researchers from Kenya (Paaijmans *et al*., 2008) have studied the relation between temperature and turbidity of water for different water bodies. With their study, they have concluded with important relation between turbidity and the temperature of the water body. During midday hours, the water temperature increases with increasing turbidity and the temperature difference between most clear and most turbid water body may go upto *2.8* degree per ^oC increase in the temperature. In the evening hours there is decrease in water temperature with the increasing turbidity and the temperature difference between clearest and most turbid pool is 0.3 ^{o}C. But there is not much difference in the temperature during early morning hours, water turbidity varied significantly depth of pool, water layer near the bottom of the water body was more observed as more turbid than the top water layer as shown in Figure 2. Similarly the Figure 3(a) shows that daily turbidity of the water body turbidity variation in specific time periods. In another study (Mandal, 2014) of Indian water body author have shown the variation of turbidity with temperature variation through the year as shown in the Figure 3(b). The cooler water has more oxygen than warmer waters.

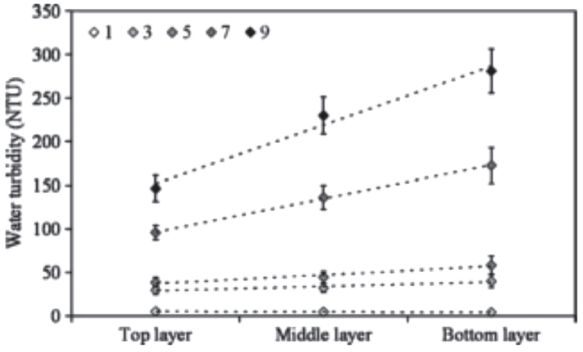
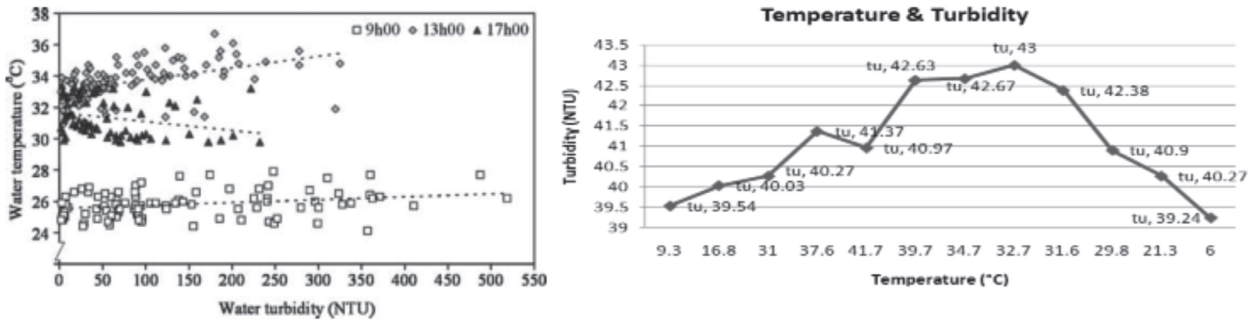


Fig. 2. Trends of water turbidity w.r.t the water level (layer) of the water bodies; ref. (Paaijmans *et al*., 2008)



(a) (b)

Fig. 3. Relationship between the water temperature (°C) and the average water turbidity ref. (Paaijmans *et al.*, 2008) and (b) Increasing trend in the Turbidity increases w.r.t the Temperature; *ref. (*Mandal., 2014*)*

Aquatic animals would have severe problems with the decreasing water oxygen.

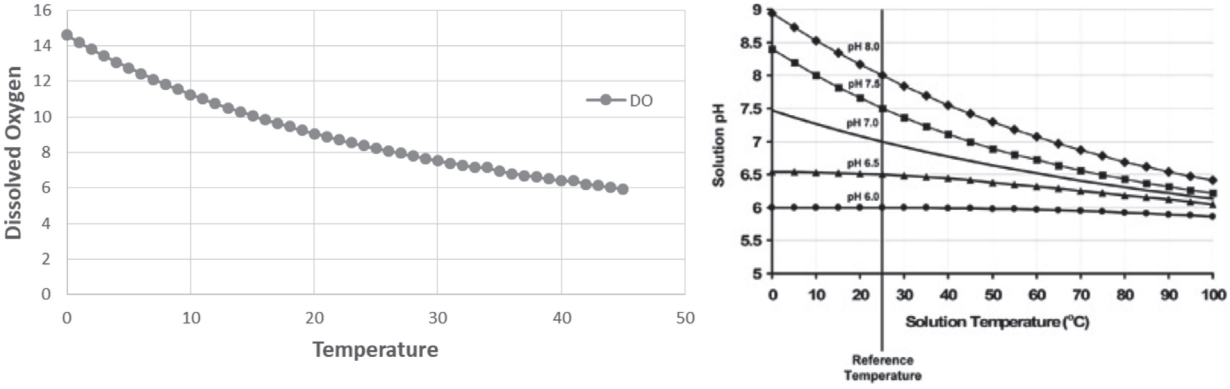
The values of dissolved oxygen vary from season to season and even over 24 hour period as shown in Figure 4(a). It also varies with water temperature and altitude. In hot summer's aquatic plant are not able to produce oxygen till sunset. The value of dissolved oxygen varies from the size of the water streams. The change of pH with temperature is due to the changes in dissociation constants with temperature. The effect of temperature on water body varies according to the pH of the lake. Generally pH values lies between 0.0 to 14.0. The effect of temperature on highly basic water solution is more than any other water. The temperature often varies as *-0.033* pH/ °C. The pH calculation gives the H^+ ion concentration of solution. Since the increase in temperature also increase the molecular vibration which increases the observable H^+ ions also increases. This increase is due to reduction tendency of forming hydrogen bonds which ultimately reduces pH. The pH of water at 0 °C generally fall around 7.4, while at 100 °C the pH of same water appears at 6.0. The variation has been shown in Figure 4(b).

Modern technologies for assessment of Physico-chemical parameters

Detection using sensors

The detection of pollution source using sensor networks has been studied in the last few years. In one of the article researchers have investigates pollution sources using localization methods based on diffusion model (Yang, 2016). The authors have used various algorithms for the monitoring of nodes and various detection methods for sampling of data. In another research (Meyer, 2018) people have used wet chemical analyzer and mobile sensors to setup a system which enable the real-time monitoring of various physiochemical parameters.

The resulting information gives idea about the situation of river water quality and various pollutants of the water body. The Figure 5(a) and 5(b) shows placement of sensing nodes to detect the sources of pollutants.



(a) (b)

Fig. 4. Variation of (a) Dissolved Oxygen with Temperature; ref. (USEPA, 2017) and (b) pH with Temperature; ref. (Macmillan *et al.*, 2010)

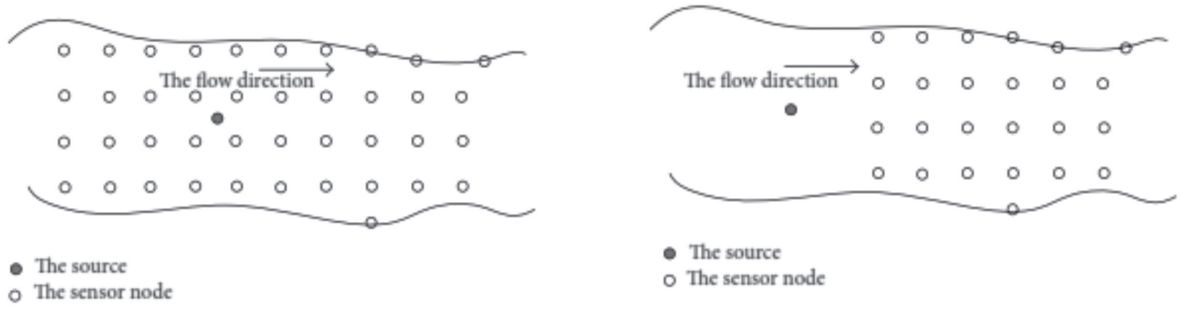


Fig. 5. The pollution source (a) IN and (b) OFF the monitoring area; reproduced from ref. (Meyer, 2018)

Use of Lidar/Dial techniques

This is one the laser based methods for the detection of pollution sources and various pollutants in the water bodies. This project has been implemented in the south of Italy. The researchers (Gaudio *et al*., 2015) have used CO_2 dial system and Yag-Nd LIDAR (Light detection and ranging) system for the measurement of parameters. The results obtained from the experiment confirm the sensitivity and effectiveness of the Lidar/Dial measurements. The authors have proposed three step approaches for the measurement of parameter and confirmation of results. The Figure 6(a) and 6(b) represent the measurement plots for both methods. The Figure 7(a) depicts the conventional Lidar detector inclusive of constituent components, which are capable for light induced florescence and light detection and ranging, this method (Utkin, 2011) proves to be more appropriate than other due to its measurement capabilities in tough conditions. The methods currently in use apply three-level water pollution method based on UV (Ultraviolet) and IR (Infrared) imaging methods. Most of the time scanners installed as sensors in the visible region of the spectrum.

Use of Drones and algorithms

In this method, people uses drone-mounted cameras as shown in figure 7(b) to take numbers of aerial photos. The photos taken then used in Artificial Intelligence (AI) algorithm for sorting of various mixtures such as plastic, pollutants, trash and bags. Such activity may involve many volunteers, scientists and scholars to get the accurate image of polluted coastlines of water bodies. This method has been used to keep eye on sea surfaces and seabed. The collection of drone oriented images can be used to extract features for pollution detection based on spectral shape variations (Utkin, 2011).

Use of submersible spectrofluorometer and electrolytic cell

In a work, the researchers (Puiu *et al*., 2015) have proposed a submersible spectrofluorometer for the real time sensing of water quality. This is suitable for

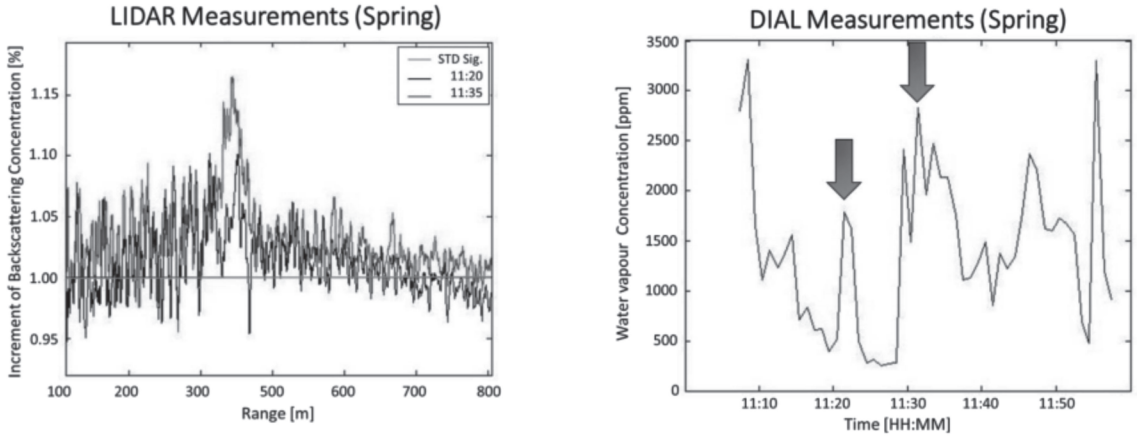


Fig. 6. LIDAR measurement/Dial signal detection in presence of (a) SMOKE and (b) FIRE (Gaudio *et al*., 2015)

(a) (b)

Fig. 7. (a) Principal sketch of a LIFI-LIDAR detector; ref. (Utkin, 2011] and (b) Drone photos are being used to train AI to recognize images of plastic trash, reproduced from ref. (Harris , 2018)

the observation of important ingredients for the ecological status of water. In the design, the filters and the pumps have been avoided to maintain the simplicity of the project and to maintain high signal to noise ratio. The use of LED (Light emitting diode) as a source in place of laser or Xe-lamps may results reduced weight and power consumption. Such devices have been used as testing equipment during field campaigns conducted at in the Italy and the Israel. The student from MIT demonstrates (Xiao Su *et al.,* 2017) a faraday cell, in which both cathode and anode can be utilized to remove micro pollutants up to 96%.

CONCLUSION

With this article, important findings and outlines from previous work done by the researchers and various organizations towards aquatic management of urban water bodies have been discussed. We have also elaborated latest equipments and techniques used around the world for managing the quality of a water body. We have also discussed requisite tradeoffs between various environmental factors, which are necessary to check the effects on the quality of water. Perhaps, the study revealed that, the joint and cooperative effort among major players such as researchers, environmentalists; the Government and private agencies are needed to tackle the issues related with management of aquatic regions and restoration of the urban water bodies. Setting up electronic and online effluent monitoring system may also help to check the discharge of pollutants in water sources in well mannered schedule. There is an urgent need to implement the national and wetland conservation plans across the globe.

REFERENCES

Berthold, P. 1995. *Control of Bird Migration* 1st edi., Springer Pub., Hardcover ISBN: 978-0-412-36380-1.

Bhargava, A.K., Singh, P.K., Mitra, V., Prasad, A. and Jayapalanockwave, M. 2010. Rainfall Variability and Probability Pattern for Crop, *Planning of Roorkee Region (Uttarakhand) of India Mausam.* 61(4) : 509-516.

Bhateria, R. and Jain D. 2016. Water quality assessment of lake water: a review, *Sustainable Water Resources Management.* 2 (2) : 161-173.

Friberg, N., Sandin, L. and Pedersen, M.L. 2009. Assessing the effects of hydromorphological degradation on macroinvertebrate indicators in rivers: examples, constraints, and outlook, *Integr Environ Assess Manag.* 5 : 86-96. doi:10.1897/IEAM_2008-042.1.

Gaudio, P., Gelfusa, M. and Malizia, A. 2015. Detection and monitoring of pollutant sources with Lidar/Dial techniques *Journal of Physics: Conference Series.* 658 012004 doi:10.1088/1742-6596/658/1/012004.

Gupta, P.K. and Nagdali, S.S. 2007. Water Chemistry of A National Lake of India: Lake Nainital, Uttarakhand, *Proceedings of Taal-2007: The 12th World Lake Conference.* 209-216.

Harris. B. retrived from https://www.weforum.org/agenda/2018/06/this-is-learning-to-recognize-ocean-plastic-using-drone-photos, 2018.

Hartig, J.H. and Zarull, M.A. Towards defining aquatic

ecosystem health for the Great Lakes. M. Munawar (ed.), Assessing Aquatic Ecosystem Health: Rationale, Challenges, and Strategies Kluwer Academic Publishers, Netherlands. 1992. *Journal of Aquatic Ecosystem Health*. 1 : 97-107), 1992.

Kang, A. and Krishnan, S. 2013. Legal, Institutional and Technical Framework for Lake/Wetland Protection Research Associate Water Advocacy.

Khare, N. 2008. Some morphometric Characteristic of Priyarshini water body at Schimacher Oasis, Central Dronning Moud land, Antarctica with special reference to its Bathymetry Indian. *Journal of Marine Sciences.* 37 (4) : 435-438.

Larson, G.L. 1989. Geographical distribution, morphology and water quality of caldera lakes: a review, Kluwer Academic Publishers. *Hydrobiologia.* 171 : 23-32.

Laura, F. and Sanna, S. 2007. Changes in Physical and Chemical Limnology and Plankton during the Spring Melt Period in a Subarctic Lake *International Review of Hydrobiology*. 92 : 301 - 325. 10.1002/iroh.200610928.

Mandal, H.K. 2014. Assessment of wastewater temperature and its relationship with turbidity *Recent Research in Science and Technology.* 6 (1): 258-262 ISSN: 2076-5061.

Marcé, R. and Comerma, M. 2000. Limnology of Foix Reservoir (Barcelona, Spain). *Limnética.* 19 : 175-191. .

McGlue, M.M. and Lezzar, K.E. 2007. Seismic records of late Pleistocene aridity in Lake Tanganyika. *Tropical East Africa* DOI 10.1007/s10933-007-9187-x Springer Science, 2007.

McMillan, G.V., Wang, T. and Montgomery, R. 2010. Opportunities for smart wireless pH, conductivity measurements.

Meyer, A.M., Klein, C., Funfrocken, E., Kautenburger, R. and Beck, H.P. 2018. Real-time monitoring of water quality to identify pollution pathways in small and middle scale rivers. *Science of The Total Environment.* 651 (2) : 2323-2333.

Nelson, G., Hairston, Jr. and Gregor, F. 2002. *Fussmann Lake Ecosystems Encyclopedia of Life Sciences.* Macmillan Publishers Ltd, Nature Publishing Group.

Paaijmans, K.P. and Takken, W. 2008.The effect of water turbidity on the near-surface water temperature of larval habitats of the malaria mosquito Anopheles gambiae. *Int J Biometeorol*. 52 : 747-753.

Pradhan, C. and Chauhan, S.S. 2016. Mansagar Lake:- Study of the water and associated Soil Quality, by analyzing their various Physico-Chemical Parameters. *International Journal of Scientific and Research Publications,* ISSN 2250-3153, 6 : 8.

Puiu, A., Fiorani, L., Menicucci, I., Pistilli, M. and Lai, A. 2015. Submersible Spectrofluorometer for Real-Time Sensing of Water Qualit. *Sensors (Basel).* 15 (6) : 14415-14434.

Raina, M. 2007. Conservation and Management of Mansagar Lake of Jaipur - *A Model Study Proceedings of Taal 2007*: *The 12th World Lake Conference:* 1944-1950.

Sharma, K.P. and Sharma, S. 2007. Mansagar Lake: Past, Present & Future. *Proceedings of Taal 2007*, 1530-1541.

Sharma, R. and Sharma, M.S. 2012. Study on Limnological characteristics, planktonic diversity and fishes (species) in Lake Pchhhola, Udaipur Rajasthan (India). *UJERT.* (3) : 274.

Singh, Y. and Jain, M.K. 2018. Assessment of water quality index: A case study of the Jalmahal lake area, Jaipur-Rajasthan *Eco. Env. & Cons. 24* (February Suppl.). 24 : S83-S88, ISSN 0971-765X.

Singh, Y. and Jain, M.K. 2017. Assessment of water quality in lake with respect to heavy and light metals: A case study of Jalmahal lake area, Jaipur-Rajasthan, In: *Proceeding of International Conference: Water Week 2017 (Sponsored & Organised by Government of India),* Vigyan Bhawan, October 10-14.

Thirupathaiah, M., Samatha Ch., Sammaiah, C. 2012. Analysis of water quality using physico-chemical parameters in lower manair reservoir of Karimnagar district, Andhra Pradesh *International Journal of Environmental Sciences*. ISSN 0976 –4402, Volume 3, No 1, 2012.

United States Environmental Protection agency (US-EPA) retrieved from tps://archive.epa.gov/water/archive/web/html/vms52.html, 2017.

Utkin, A. and Lavrov, A. 2011. Optical Methods for Water Pollution Monitoring Spatial and Organizational Dynamics, 129-146..

Viner, A. B. Hydrobiology of Lake Volta, Ghana "Stratification and Circulation of Water Volta Basin Research Project, Ghana. (1969).

Vyas, V. and Vishwakarma, M. 2011. Avian Diversity of Bhoj Wetland: *A Ramsar Site of Central India Our Nature.* 8. 10.3126/on.v8i1.4310.

Xiao, Su, and Kai-J.T. 2017. Asymmetric Faradaic systems for selective electrochemical separations. *Energy Environ. Sci.* 10 (5) : 1272-1283.

Yang, J. and Luo, X. 2016. A Study on Water Pollution Source Localization in Sensor Networks. *Journal of Sensors*, Article ID 9528050, 11 pages, http://dx.doi.org/10.1155/2016/9528050.

Yiping, H. and Zhu, M. 1996. The water quality of Lake Tailhu and its protection. *Geo Journal.* 40 : 1-2.