Poll Res. 40 (May Suppl. Issue) : S97-S103 (2021)

ISSN 0257–8050

QUANTIFICATION OF SURFACE WATER BODIES IN DEVELOPING COUNTRIES – THE NEED AND CHALLENGES

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(Received 29 October, 2020; accepted 5 December, 2020)

ABSTRACT

Water is understood to be the most essential yet fragile resource, which in recent years is being stressed with human activities, urbanization and industrialization making this resource-scarce both in terms of quality and quantity. Changes in quality of water in the present scenario has become dynamic with overwhelming pollutants being released into them, affecting the ecosystem and humans. Assessing the qualitative status of freshwaters is a fundamental aim of international society, as indicated in Sustainable Development Goals. With variations among regulatory requirements, standards of water quality, geological and geographical, land-use and other location-specific variations, management strategies as on-in-all is not applicable. Hence, continuous assessment of location-specific or local water bodies becomes mandatory. The first step in managing or protecting water resources is to evaluatewater quantity and quality towards chalking and implementing measures for water security. Dependable assessment of water quality is vital towards decision making through understanding, interpreting and using this data for management activities pointing at protecting water resource. Several challenges exist in monitoring water quality which was addressed previously in literature. This review focusses on the issue of the need for continuous evaluation of water quality, particularly in developing countries and also discusses some of the challenges towards assessing water quality.

KEY WORDS : Surface water, Restoration, Water quality, Assessment, Pollutants and challenges.

INTRODUCTION

The global water crisis is perceived as problem associated with water quantity, while water quality is still acknowledged as a crucial factor of water crisis (Panjabi, 2013; Jury and Vaux, 2007). Though international financial agencies and national governments address water quality as one of the crucial at top hierarchy issue, situation in developing countries varies significantly concerning governing factors like physical, social, economic and development stage. All countries face degraded water quality in some or other nature. In contrast, some states have degraded water quality in rivers, in other countries, it is groundwater, large lakes and a combination of three in others (Wilhite *et al.*, 2007). This variability is attributed to a wide range of pollutants, variable human activities along with socio-economic and environmental variables varied in various countries. Both discrete and non-point sources of pollution tend to affect quality of water (Abbaspour, 2011). Another facet of reasons affecting water quality includes droughts and floods, lack of awareness among stakeholders (Geetha and Gouthami, 2016).

Freshwater not only is one of the significant sources of water availability, but it also acts as the best sink for the discharge of various industrial and domestic wastes (Tukura *et al.*, 2009). Being a vital resource for living subsistence, a big concern for humankind is water quality (Brack *et al.*, 2017). Battle for water dates back to the evolution of life on earth, which has become more complex and challenging in the present scenario and will be even difficult in future. Water in the current scenario has become a commodity of distinctive significance, no longer a raw material; it has become a subject and tool for work. Further, it remains to benonpareil food for life (Djekovic *et al.*, 2016).

Point to be noted is that rate of enhancement in complexity and type of water quality problems are exceeding the rate of capability development for a longer duration to come. Hence, ensuring water quality towards intended uses along with allowing them to develop to a certain extent, becomes key to sustainable water resources (Jønch-Clausen and Fugl, 2000; Martius *et al*., 2009). Essentiality for tracking water quality changes cannot be exaggerated, which reveals the composition of water bodies both spatially and temporally. Monitoring and assessing water quality on a regular and continuous basis is the only way to ensure conserving water quality; it provides objective indication for making sound decisions to maintain water quality during the contemporary and future. Since surface water is the most accessible for almost all human activities, this review focusses on the importance of assessing surface water quality.

Surface water.quality

Industrialization presents both sides of the coin, with its own merits and demerits. Merits restricted to human, economic and social aspects, demerits are extended to ecosystems affecting everything. Pollution of surface water bodies deems to be a global challenge, precisely acting on a higher side in developing nations (Rana *et al*., 2017; Inyinbor *et al*., 2016).

One of the most prejudiced ecosystems on earth is surface water, unfortunately, prone to changes or deteriorations, resulting in extensive ecological degradation. The health of water body is governed by several factors like geological and geomorphology formations, hydrological regimes, nature of riparian and instream habitats and physicochemical and microbial water quality (Allan *et al.,* 1997).Water quality is illustrated by physical, chemical and biological properties of water which regulate its suitability to various uses (Chamier *et al.,* 2012). In managing water resources, surface waters require higher priority owing to their straight relationship to subsurface water, hydrological cycle and for consumption. Hence, appreciating physicochemical properties of surface water is basis for developing policy sustainable water resources (Poff *et al*., 2016).

Deterioration and effects of Surface Water Quality

In any given watershedvariations inland use and land cover (LULC) due to human activities exert unlimitedimpact on quality of water in water bodies, being chiefly influenced by changes in the hydrological system and runoff (Bai *et al.,* 2010; Hooper and Hubbart, 2016). Surface water quality rose as an environmental concern owing to toxic pollutants released from industrial effluents and rapid, intensified urbanization and changes in LULC (Reddy *et al*., 2017). Research on effects ofland use the land cover on surface water quality has been taken up in three stages or eras, which can be chronologically described as the studies started with understanding links among land cover changes and surface water quality, investigating effects of morphological features of watersheds on water quality characteristics like temperature, turbidity and dissolved oxygen during the 1960s (Giri and Qiu, 2016; Nichols *et al.,* 2016; Su *et al*., 2016; Zeiger and Hubbart, 2016)—followed by focussing on water quality analysis at watershed scale (Bormann *et al.,* 1969). While the studies of the contemporary adopt technology like remote sensing, GIS and statistical tools like multivariate analysis for exploring effects of land cover on nutrients, suspended sediments and ecological stability of water bodies (Haidary *et al*., 2013; Tafangenyasha and Dube, 2008). On the contrary, positive effects on water quality are attributed to the presence of forests which help in mitigating degradation (Yang *et al*., 2016; Ou *et al*., 2016), reduce sediment yield and pollution load into water bodies (Gonzales-Inca *et al*., 2015; De Oliveira *et al*., 2016; Singh and Mishra, 2014; Park and Lee, 2020).

Reduction in quality of water leads to enhanced treatment costs both for municipal and industrial water requirements. Using low-quality waters for cropping activities impact crop yield leading to food uncertainty. Further, existence, passage and fate of organic compounds and heavy metals in water bodies have become a serious concern worldwide. Moreover, pathogens in water bodies are the cause of diseases in humans and life (Edokpayi *et al*., 2017). Further, polluted water bodies pose a threat to the ecosystem, precisely the aquatic ecosystem (Palmate *et al.,* 2017). Hence, continuous analysis of water quality is indispensable towards sustainable development.

Challenges of Urban Water Quality

Importance of water to humans is owed to the fact that civilization and human settlements have initiated, intensified and flourished near various water bodies. Though the role played by water in the development of human society cannot be overrated, degradation of water due to modern social activities cannot be ignored. One of the vital elements of the organisation is the concept of development which resulted in intensified urbanization (Duan *et al*., 2016). Development of cities is accompanied by rapid changes in urban spatial structure, leading to enhanced sources of discrete and non-point sources of pollution (Xu *et al*., 2019, Xue *et al*., 2019).

Enhanced anthropogenic activities over previous decades have extensively prejudiced freshwater resources (Vörösmarty *et al*., 2010). Apart from urbanization, other factors affecting water quality include eutrophication, encroachment, ungoverned tourist activities, cultural misuse and illegal mining activities.

Pollution: Ironically, almost every urban water body in most of the developing nations suffers due to pollution. Some important pollutants include heavy metals like mercury, cadmium, cobalt, nickel and chromium, pesticides, traceminerals like copper, zinc, iron etc., radioactive substances apart from sewage and industrial pollution. This has led water in many large rivers and lakes not safe for consumption.

Encroachment: Enhanced migration of people to cities resulted in land scarcity in cities. Due to this, urban water bodies are being perceived as real estate rather than an ecosystem service.

Illegal Mining Activities: Mining activities both on the bed and catchment of water bodies severely affect the water body and its quality. The primary concern is with mine drainage, which is water rich in metal produced from reaction between rocks and water. Fundamental complications related with mine drainage include disrupted growth and contamination of aquatic flora and fauna apart from contamination of drinking water and corrosion of parts of infrastructure, i.e bridges.

Unplanned tourism activities: Tourism activities without any systematic regulation and planning have proved to be one among the significant threats to water bodies and their quality resulting in effecting biodiversity and local environment over a long-term (Bhateria and Jain, 2016).

Stimulating Sustainability of Water Resources in Urban areas

As access towards initiating good standard of living for the population is understood as sustainable development for any society. This not only includes the provision of solutions to social and economic challenges but also to environmental challenges, of which the availability of freshwater has a significant part (Ilin *et al*., 2016).

Intentions of Assessing Water Quality

Most fundamental intentions are identified as follows:

- Recognizing state and tendencies of water quality.
- Understanding loads/flow of pollutants or surface water
- Estimating water quality in compliance with usage classification and water quality standards
- Advance detection, warning and management of pollutants.

The data obtained from these analyses are applied for a wide variety of purposes including policy and management, to relate to national and international standards and for various research projects.

Challenges in Monitoring and Assessing Water Quality

Using water resources sustainably requires monitoring and assessment of surface water apart from management tools and decision making. Assessment of fluctuation in water quality becomes mandatory because they are the only sources to life from drinking, agriculture to industrial uses. Moreover, dynamic changes in water quality call for continuous analysis water quality, towards providing essential data for water usage, precisely in the zones having scarcity in availability of water (Duan *et al*., 2016; Iqbal *et al.*, 2019).

Water quality monitoring and assessment remain to be highly complex processes owing to a wide variety of factors which were addressed by several researchers previously (Park *et al.*, 2006; Ning and Chang, 2002; Chen *et al*., 2012), will include factors like representative sampling points selection, frequencies of sampling to be adapted both of which have constraints like topography, practical knowledge requirement, real-time conditions, practical difficulties like human resources

Table 1. Status of World's Rivers (Adapted with changes from Viswanathan and Schirmer, 2015)

Name of the River	Located in Country	Causes for degradation of water quality	Measures for restoration	Approaches adopted	Success indicators
Delaware River	United State of America	Anthropogenic pollution and sewage disposal led to dead zones in some parts of the river	Regional and Federal legislations, collaborations with states	Action plans at state levels with local initiatives	Enhanced water quality, return of fish and wildlife in large numbers
Cheonggyecheon River	South Korea	Anthropogenic activities and burial of river under 12 lane highway	Highway decommissioned Newriver channel excavated, combined sewer	Green belt with waterfront, ecological biotope creation	BOD decreased from >12 ppm to less than 5 ppm, DO enhanced from < 4 ppm to greater than 6 ppm
Izumi River	Japan	River bed prone to deep dug owing to frequent floods, steel sheet piles covered shore	River widening, rebuilding offlow path, growing woods in slopes	Clean up actions with voluntary participation of public,enhancing seweragecoverage	BOD >10 ppm in 1993; <5 ppm since 1996. Fish like Carassius and Loach reappeared.
Kissimmee River	Florida, USA	River channelization resulted in no flow leading to encroachment of vegetation	Removing structures controlling water, backfilling canal, flow and wetland restoration nutrients runoff	Stormwater treatment, adoption of best management practices of agriculture for controlling excess	DO increase (2.3–4.9 ppm), the abundance of waterfowl and wading birds enhanced
Ythan River	Scotland, UK	Effluents from sewage treatment, agricultural non-point source pollution	Providing variable flow through ripples and eddies, erosioncontrol through riparianfencing	Simple software for nutrient budgeting from crops, Public participation for monitoring and clean-up activities	Reduction in suspended solids, reduction in phosphate
Ganga River	India	Sewage and industrial discharges	Namami Gange-National Mission for Clean Ganga,	Trash skimmers for collecting surface waste. Open defecation free (ODF) villages on the bank of Ganga, Controlling industrial wastewaters	BOD was 1.7 in 1986; improved to 1 in 2017 DO was 8.1 in 1986; it increased to 10 in 2017

availability, technical and financial resources along with political and legal obligations (Moss, 2008; Madrid and Zayas, 2007), evolving issues, chemical pollutants present etc.(Fölster *et al.*, 2014; Altenburger *et al.*, 2015).

Further, the collection of representative samples is of great importance to get real-time water quality results. Although several approaches for the collection of samples are given, these are either too precise or too generalized, which confuse the researcher. Hence, pre-knowledge on the purpose of sampling and analysis is required which should be done on an accurate targeted basis approach of the project needs (Timmerman and Langaas, 2005; Strobl and Robillar, 2008; Gray, 2010; Khalil *et al.*, 2011; Behmel *et al*., 2016).

Technical encounters comprise of a selection of suitable elements comprising spatial and temporal sampling approaches, methods of data assortment and analysis facilitating significant characterization of water quality. Further, it is essential to carry out sampling and analysis frequently with an appropriate description of temporal features to track year wise and seasonal variations. Moreover, ancillary data to be included comprise of natural and human factors like geology, climate, chemical and water use, land use and legislations which help in explaining nature of water quality of particular water body as it is affected by these factors (Leopold, 1962; Khatri and Tyagi, 2015). A reference water body would be one which is comparatively unaffected by human activities and only affected by natural factors. Reference water body enables comparison of hydrological conditions and trends of effect from biological factors over social factors. These reference conditions are called background conditions. On the other hand, there exists baseline data which is preliminary set of quint essential explanations which are used towards evaluation or can be used as control (Myers and Ludtke, 2017) - owing to the above-discussed factors, water quality quantification is perceived to be a difficult task (Sahoo and Swain, 2020; Pericherla *et al*., 2020).

CONCLUSION

Conservation and sustainable accessibility of water cannot be overstated as it forms the core of the existence of life. Surface water continues to remain as a significant and alternative source for domestic water needs precisely in rural zones of the world. Good water quality availability is highly threatened by several anthropogenic activities, mainly by land use and land cover changes among others. It becomes the responsibility of every individual precisely industries to make sure that their wastewater is treated effectively before releasing into the natural water bodies so that it will not end up affecting the users dependent on these sources. Urbanization is such a dynamic process which cannot be slowed down owing to many factors. Hence, continuous monitoring and assessment of surface waters of urban zones are mandatory to have sustainable water resources to the urban zones, which mainly are dependent for all its communities needs on these sources. Though there are challenges in sampling and analysis, newer technologies have come to save time and human resources. Further, legislative enforcement must be in place towards protecting the environment and health of both water bodies and humans which be a step forward towards enhancing water quality.

Conflict of Interest

All the Authors declare no conflict of interest.

ACKNOWLEDGEMENTS

All the authors are thankful to GITAM (Deemed to be) University, Visakhapatnam, for providing access to E-library,which helps to carry out the study. Table – 1 Some case studies of successful restoration of surface water bodies around the world

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