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In-situ optical water quality monitoring sensors—applications, challenges, and future opportunities

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Water quality issues remain a major cause of global water insecurity, and real-time low-cost monitoring solutions are central to the remediation and management of water pollution. Optical sensors, based on fluorescence, absorbance, scattering and reflectance-based principles, provide effective water quality monitoring (WQM) solutions. However, substantial challenges remain to their wider adoption across scales and environments amid cost and calibration-related concerns. This review discusses the current and future challenges in optical water quality monitoring based on multi-peak fluorescence, full-spectrum absorbance, light-scattering and remotely sensed surface reflectance. We highlight that fluorescence-based sensors can detect relatively low concentrations of aromatic compounds (e.g., proteins and humic acids) and quantify and trace organic pollution (e.g., sewage or industrial effluents). Conversely, absorbance-based sensors (Ultraviolet-Visible-Infrared, UV-VIS-IR) are suitable for monitoring a wider range of physiochemical variables (e.g., nitrate, dissolved organic carbon and turbidity). Despite being accurate under optimal conditions, measuring fluorescence and absorbance can be demanding in dynamic environments due to ambient temperature and turbidity effects. Scattering-based turbidity sensors provide a detailed understanding of sediment transport and, in conjunction, improve the accuracy of fluorescence and absorbance measurements. Recent advances in micro-sensing components such as mini-spectrometers and light emitting diodes (LEDs), and deep computing provide exciting prospects of in-situ full-spectrum analysis of fluorescence (excitation-emission matrices) and absorbance for improved understanding of interferants to reduce the signal-to-noise ratio, improve detection accuracies of existing pollutants, and enable detection of newer contaminants. We examine the applications combining in-situ spectroscopy and remotely sensed reflectance for scaling Optical WQM in large rivers, lakes and marine bodies to scale from point observations to large water bodies and monitor algal blooms, sediment load, water temperature and oil spills. Lastly, we provide an overview of future applications of optical techniques in detecting emerging contaminants in treated and natural waters. We advocate for greater synergy between industry, academia and public policy for effective pollution control and water management.

KEYWORDS

optical spectroscopy, fluorescence, absorbance, water quality monitoring, sensors, in-situ

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Colour and Clarity of Natural Waters R. J. Davies-Colley, W. N. Vant, D. G. Smith, 1993 *The Fifth International Symposium on Society and Resource Management*, 1994 Colour and Clarity of Natural Waters R. J. Davies-Colley, W. N. Vant, D. G. Smith, 2003-04-30 Color and Clarity of Natural Waters introduces the basic concepts of aquatic optics and explains the relationships of different optical characteristics to the composition of the water and color and clarity phenomena This scientific understanding is the basis for management of the optical quality of waters *Journal of Marine Environmental Engineering*, 1997 Freshwater and Marine Aquarium, 1981 *Water Quality* Claude E. Boyd, 2000-06-30 Water Quality An Introduction provides an in depth but relatively simple treatment of water quality including a discussion of basic physical chemical and biological principles Effort has been made to use physical and chemical principles to explain the factors controlling the quality of natural waters Water Quality An Introduction is a text for a general course in water quality or as a guide for self study BOOK JACKET Color of Inland and Coastal Waters Dmitry Pozdnyakov, H. Grassl, 2003-01-31 The inorganic and organic water constituents often called color producing agents CPAs responsible for water color are generally referred to as water quality parameters Utilization of water color for assessment of water quality parameters can be achieved by using the established techniques in aquatic optics attained over many decades Aquatic optics can be subdivided according to whether the natural water body is salty marine inland or fresh limnological or coastal often brackish The authors describe the transformation of water color under varying natural and anthropogenically driven conditions and for the first time in a quantitative manner a closed circle of issues related to remote sensing of water quality in optically complex waters generally inherent to inland and marine coastal waters Primarily the text synthesizes the solutions of problems in remote sensing incorporating mathematics hydrobiology hydrochemistry atmospheric optics and ecology *Resource Management* New Zealand. Ministry for the Environment, 1994 Detection of Optical Water Quality Parameters for Eutrophic Waters by High Resolution Remote Sensing Arnold Graham Dekker, 1993* *Ecological Water Quality* Voudouris, 2012-05-16 This book attempts to cover various issues of water quality in the fields of Hydroecology and Hydrobiology and present various Water Treatment Technologies Sustainable choices of water use that prevent water quality problems aiming at the protection of available water resources and the enhancement of the aquatic ecosystems should be our main target *Bio-optical Properties of Indian Coastal Waters* Sourav Das, 2025-12-11 This book provides an introduction to bio optical properties of Indian coastal waters referring to the study of how light interacts with water and the materials in water to determine the health of the water by measuring oceanic biological activity The advent of satellite technology has given a substantial boost to ocean colour research and the ability of optical sensors to map the spatial and temporal patterns of ocean colour over regional and global scales has provided important insights into the fundamental bio optical properties and bio physical processes occurring in aquatic media However the satellite based retrieval of ocean colour parameters demands an accurate

bio optical algorithm especially in coastal waters and such algorithms require large in situ databases for a specific area To address these issues in Indian coastal line the Satellite Coastal and Oceanographic Research SATCORE programme was initiated by the Indian Government Indian National Centre for Ocean Information Services An Autonomous Body under the Ministry of Earth Sciences Govt of India INCOIS started coordinating SATCORE programme from XI five year plan with the aim of long term measurements of bio optical properties in the Bay of Bengal and Indian coastal waters This book summarizes the work and findings of SATCORE to aid students and researchers of marine science and oceanography in the specific field of aquatic bio optics and ocean colour *Use of Biological Assessments to Support Water Quality Management* Ian W. Sorenson,2013 In this book the role of biological assessments in a variety of water quality management program applications is discussed including reporting on the condition of aquatic biota establishing biological criteria and assessing the effectiveness of total maximum daily load determinations and pollutant source controls **An Introduction to Water Quality Science** Sourav Das,2023-10-24 This book discusses the significance of water quality parameters in aquatic ecosystems offering a concise and practical measurement methodology for early career researchers and post graduate students in the fields of environmental science oceanography and aquatic science The keys topics covered include aquatic sampling basics of physicochemical properties and carbonate chemistry of aquatic science the importance of nutrients in natural water bodies biological productivity in aquatic ecosystems aquatic pollution and statistical analyses of different types of water science data Several parameters such as microplastics dimethylsulfonylpropionate and polychlorinated biphenyls have also been incorporated in the book for comprehensive coverage of the topic The book is meant as a practical guide for beginners and young researchers using a clear writing style and practical examples highlighting the significance of water science parameters and their measurement protocols in aquatic environments **Optical Water Quality and Human Perceptions of Rivers** Amie October West,2016 Understanding water quality dynamics in recreational rivers is integral in shaping management strategies that maintain ecosystem health perceived value and appeal and regional economic significance in a changing environment Optical water quality describes the behavior of light in water as governed by its physical and chemical composition and is among the strongest influences on human perceptions of water quality Ethnohydrology is the study of culturally constructed knowledge and understanding of water This work is the culmination of an interdisciplinary approach to water resources research integrating optical water quality and ethnohydrology methods to recognize the intersection between measured water quality and visible characteristics influencing human perceptions Relationships among particulate concentrations as a function of the hydrograph during receding flow in five popular recreational rivers of the southwestern Ozarks of Arkansas USA were dependent upon catchment characteristics and optical water quality measures may be well suited for describing these dynamics in the absence of more intensive monitoring programs Measurement of horizontal black disk visibility was a particularly accessible and intuitive scientific tool for

characterizing optical water quality and suspended sediment variability Analyses of 167 surveys and pile sorts deployed at regional events indicated that despite some variability individuals may use similar cognitive processes to discern differences among images of aquatic conditions in rivers and these judgments can be directly linked to optical water quality measurements This work suggests important physical and chemical parameters of water quality may be communicated meaningfully across stakeholders in terms of how they relate to visible attributes thus expressing water quality in terms of its true meaning to society and the environment **Physical Processes and Water Quality in Natural Waters** ,2012

Characterisation of Visual Water Colour and Clarity in Individual Rivers Robert James Davies-Colley, New Zealand. Department of Conservation. Conservation Sciences Centre, Water Quality Centre (Hamilton, N.Z.), 1990

Colour And Clarity Of Natural Waters Science And Management Of Optical Water Quality Paperback Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has been apparent than ever. Its power to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Colour And Clarity Of Natural Waters Science And Management Of Optical Water Quality Paperback**," compiled by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we shall delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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