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DRINKING WATER QUALITY AND ITS IMPACT ON PUBLIC HEALTH: REVIEW

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Abstract

Despite the fact that water is necessary for life, contaminated water worsens people's health. The acquisition of potable water mostly stems from three main sources: surface water, groundwater, and precipitation. A significant portion of the population residing in developing nations continues to endure the proliferation of waterborne illnesses, a trend exacerbated by inadequate sanitation practices and limited availability of potable water. To facilitate the formulation of an effective approach towards mitigating the possible deterioration of water quality in susceptible regions, an extensive examination of scholarly literature pertaining to the management of water quality and the prevention of waterborne illnesses was conducted. In order to promote a sustainable and healthy environment, it is imperative to undertake comprehensive reforms within public health institutions. This includes revitalizing the monitoring and evaluation systems within relevant departments, implementing sustainable development techniques to enhance water quality, and disseminating awareness and health education initiatives among the populace.

Keywords: Water quality, sustainable development, public health .

Introduction

Water is widely recognized as the most abundant compound found on the planet Earth, owing to its presence in three distinct states of matter, namely liquid, solid, and gaseous phases. Undoubtedly, the provision of safe drinking water is vital for sustaining life and promoting human well-being[1,2]. It is widely acknowledged that access to clean water is a fundamental entitlement, universally applicable to everybody irrespective of their connections, beliefs, or nationalities. Nevertheless, the alteration of Earth's climate, along with the rapid urbanization, technological advancements, and industrial activities, poses a significant threat to the overall quality of drinking water. This peril arises from a multitude of natural and anthropogenic reasons [3,4]. The adverse impact of polluted drinking water on consumer health and the subsequent propagation of epidemic diseases have been widely acknowledged [5]. According to reports, a significant proportion of the global population, approximately two billion individuals, continue to rely on a drinking water supply that is contaminated with fecal matter [6]. Conversely, water is perceived as a crucial factor in human productivity and a potent instrument for fostering economic advancement [7] .

The escalating need for water resources coupled with the diminishing supply of water, primarily driven by population expansion and economic progress, particularly in rural regions, has the potential to result in substantial adverse consequences [8]. Water pollution is a significant environmental concern that poses economic and health risks to both people and other organisms. In numerous developing countries, there is a pressing issue with the contamination of the drinking water supply, leading to a significant decline in the quality of surface water [9,10]. The degradation of water quality, both in surface and groundwater sources, has been an enduring issue influenced by both natural and anthropogenic forces. The degradation of water quality, encompassing both surface and groundwater sources, has persisted over an extended period due to several natural variables, including hydrological and geological conditions, as well as climatic influences, among others, in addition to anthropogenic influences such as mining activities, waste disposal practices, and the release of heavy metals into the environment. Various sources of freshwater exist, including natural springs, rivers, lakes, and groundwater reservoirs. Groundwater sources are mostly utilized for drinking water purposes [11,12]. Numerous challenges are associated with the provision of drinking water in various regions, encompassing issues pertaining to the distribution network and the deteriorating condition of water supply infrastructure. In the past, the evaluation of water quality involved the comparison of measured values with established local criteria. Nevertheless, this methodology fails to offer insights into the geographical and temporal patterns of overall quality [13]. Consequently, contemporary advancements in technology have led to the development of tools such as the Water Quality Index (WQI). Numerous water quality indicators have been developed and established globally. The aforementioned indicators are derived from the comparison of various water quality measures, resulting in a singular numerical representation of the overall water quality of a certain source [14]. The water quality index serves as a concise representation of extensive water quality data, condensing it into a singular numerical value accompanied by a straightforward descriptor (e.g., excellent, good, poor). This facilitates the communication of complete information regarding the overall quality of water to various parties involved in water distribution, planning, management, and stakeholding [15]. The water quality index is a highly effective tool for quantifying and communicating water quality. It serves as a crucial criterion for evaluating and managing water sources, providing valuable insights into the temporal evolution of water quality [16,17]. Additional research is necessary to comprehensively ascertain the underlying factors and origins of water contamination, as it has exhibited a progressive decline in quality over an extended period. This study is designed to review the fundamental principles involved in addressing the issue of inadequate drinking water quality. Specifically, it aims to assess the extent to which drinking water meets the national and international standards outlined by the WQI. Additionally, the study aims to evaluate the efficacy of these principles in mitigating the presence of waterborne pathogens and alleviating associated burdens.

Water quality structure

The Water Quality Index (WQI) model can be readily characterized as a valuable instrument employed to assess the quality of surface water. Through the utilization of aggregation techniques, the extensive dataset pertaining to water quality is converted into a singular value or indication. The WQI model has been widely utilized on a global scale to evaluate the quality of surface and groundwater, utilizing local water quality standards as a basis for assessment [18,19]. The fundamental framework of the WQI models is outlined in Figure (1) as follows: water quality parameters, sub-indicators corresponding to each parameter, weighting values assigned to each sub-indicator, and an aggregation function employed to compute the comprehensive WQI [20] . The World Health Organization (WHO) has established exposure criteria or safe limits for chemical pollutants in drinking water, and the WQI method has been authorized due to its effectiveness in assessing water quality [21].

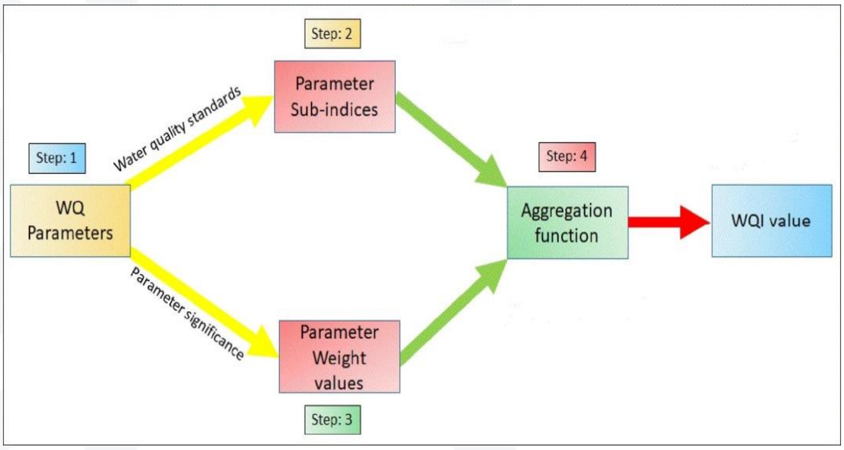

Figure 1: Basic structure of WQI models [22].

Water Quality Index

The assessment of water's appropriateness for human consumption involves the utilization of a mathematical equation that incorporates various specific parameters aimed at evaluating the overall quality of the water [23]. The development of the indicator for measuring water quality utilizing 10 commonly employed water characteristics was initially undertaken by Horton in 1965. The approach underwent subsequent modifications by a team of experts [24]. The indicators included in this study adhere to varying water quality criteria based on their quantity and kind. The weights assigned to each parameter are contingent upon the specific characteristics of those parameters [25].

These assigned weights serve to quantify the significance of the parameter as well as its impact on the indication in question. The evaluation of water quality entails the examination of several hydro-chemical characteristics that may provide challenges for those lacking basic expertise in water quality or for local communities who may struggle to comprehend or interpret such parameters. The primary aim of Water Quality Indicators is to offer a straightforward and comprehensible approach for evaluating the quality of water. The classification of water quality into distinct groups is facilitated by the Canadian Water Quality Index (CWQI), which assigns a numerical value to each water sample based on a specific computation (Table 1). The numerical scale of this parameter spans from zero to 100, encompassing a spectrum of water quality that goes from poor to outstanding [26] .

The pollution of the environment's air with poisonous gases is a significant risk factor that has an adverse effect on water quality, leading to the occurrence of acid rain pollution. Furthermore, the presence of agricultural, industrial, and chemical pollutants in the water that is in motion has the potential to be transported into reservoirs, leading to subsequent contamination. The amount of silt entering the water is also significantly increased by soil erosion [27].

Table 1: The five categories of the CWQI

NO	category	Value
1	Excellent	100-95
2	Good	94-80
3	Fair	79-65
4	Marginal	64-45
5	Poor	44-0

Drinking Water Quality Testing

In general, water is not regarded as safe to drink even if it looks to be pure, and there are simple qualitative readings that quickly establish whether the water is safe or harmful for ingestion. Nevertheless, numerous imperceptible components necessitate meticulous testing to ascertain the presence of impurities and establish the appropriate purification technique for each distinct category of contaminated water [28]. Field testing can be conducted through the utilization of portable test kits or dedicated laboratories, particularly in industrialized nations. Additionally, it is possible to gather samples and afterwards dispatch them to specialized laboratories. The assessment of water safety relies on the examination of three key factors: microbiological, chemical, and physical [29].

The properties of drinking water can be described as follows: it is transparent, lacking in flavor and color, possesses little or no presence of harmful substances, and is free from any microorganisms that may cause disease. The primary focus in assessing the quality of drinking water lies in the worry over microbiological contamination, as it is widely acknowledged as the leading cause of diseases associated with the consumption of untreated water [30]. The Water Quality Index pertains to the appropriateness of water for different applications based on its physical, chemical, biological, and organoleptic attributes, particularly in relation to taste. The measurement of water quality holds significant importance due to its direct impact on various aspects including as human consumption, health, industrial and household utilizations, and the preservation of the natural environment. The measurement of water quality is often conducted through the utilization of laboratory techniques or home test kits. Laboratory tests are capable of quantifying multiple parameters and yield the most precise outcomes, but at the expense of extended time duration [31-33]. Home test kits, which encompass test strips, offer expeditious outcomes but exhibit diminished accuracy. Water suppliers, encompassing both municipal entities and bottled water corporations, frequently disseminate their water quality data to the general public through their own websites. The adherence to water quality standards that have undergone testing is crucial, as these criteria are established by local governments, typically influenced by international norms set by industry or esteemed water quality organizations like WHO [34]. Water quality, as defined by the United States Geological Survey (USGS), refers to the evaluation of water's suitability for a certain purpose through the examination of its various physical, chemical, and biological attributes. Hence, it serves as an indicator of the state of water conditions with respect to human requirements, purposes, and the needs of diverse terrestrial or aquatic animal species [35].Three different water quality indexes are evaluated

(Figure 2). Firstly, a range of physical parameters encompassing colour, taste, aroma, temperature, turbidity, and dissolved solids levels. Additionally, chemical measurements encompass a range of parameters such as pH, hardness, dissolved oxygen, chemical and biological oxygen demands, chloride levels, residual chlorine, sulphate, nitrogen, fluoride, iron, manganese, copper, zinc, poisonous organic and inorganic compounds, and radioactive substances. Biological measures encompass the quantification of bacterial, algal, viral, and protozoan populations within a given water sample [36,37].

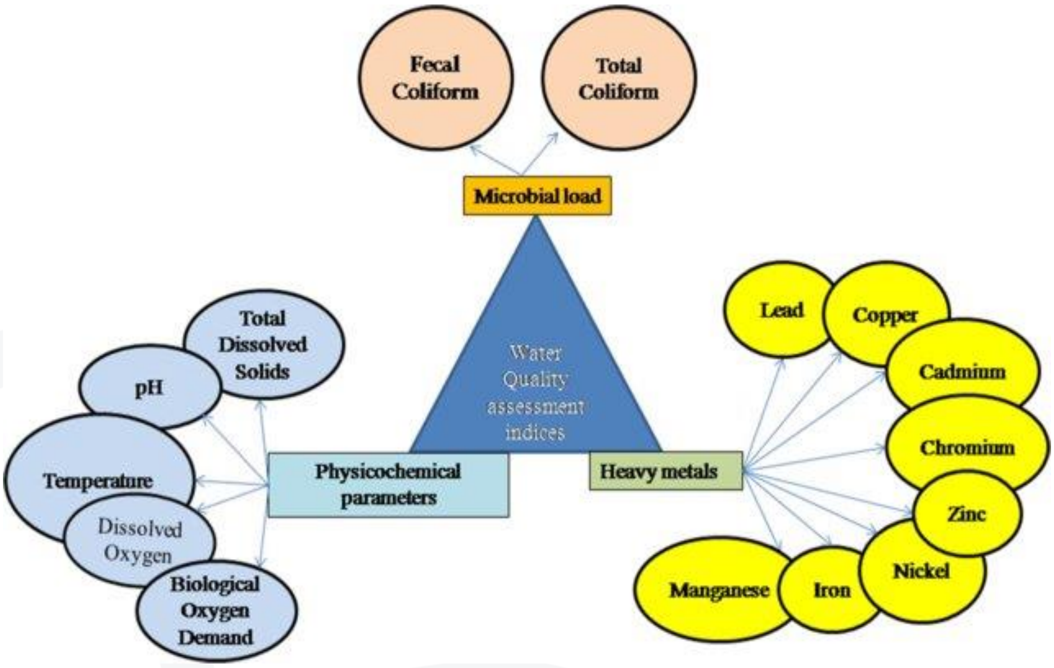

Figure 2: Main WQI assessments [38].

Chemical and physical examinations

Electrical Conductivity and dissolved solids: They are measured for drinking water samples using a multimeter, and the electrical conductivity results are read in microsiemens / cm unit, and the results of dissolved solids are in mg / liter unit.

Potential of hydrogen: PH is measured using a PH meter using standard solutions with different PH values.

Total (T) hardness: Total hardness is checked by calibration with Na2EDTA standard solution and by adopting Black Eriochrome dye as a color guide, and the results are read in mg/l units.

Calcium (Ca) hardness: The examination is by calibration with a standard Na_2EDTA solution, and Murexide dye is adopted as a color guide, and the results are read in mg/l units.

Hardness (Mg) Magnesium: Examination was done by calibration with a standard Na_2EDTA solution, and by performing the following mathematical equation: Hardness Mg = (hardness T - hardness Ca) × 0.243. The results were read in mg/L units.

Nitrate: Nitrate ions are measured using a spectrophotometer, and the results are read in mg/L units.

Sulphate: Sulphate ions are examined using turbidi-metric method with the addition of barium chloride crystals $BaCl_2$, and the extent of absorbance is measured by a spectrophotometer, and the results are read in mg / liter units.

Chlorides:
Chlorides are examined based on the index of potassium chromate K_2CrO_4 and titration with silver nitrate solution AgNO3 and read the results in units of mg / liter.

Sodium and potassium ions:
Sodium and potassium ions are examined using a flame spectrophotometer, and the results are read in mg/l units.

Microbiological analyses
Total Plate Count: The number of total bacteria present in a petri dish is calculated as x 1/dilution factor. The culture medium used is Nutrient agar.

Fecal Coliform count: By the method of multiple fermentation tubes and using medium E culture, the results are read on the basis of the most likely number / 100 ml of the water sample.

Escherichia coli bacteria: Using the method of multiple fermentation tubes and using the Mug-E implant, the results should be read from the drinking water table based on the most likely number / 100 ml of the water sample [39,40].

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Drinking water pollutants

Water pollution poses a threat to the environment in general and the life of living organisms in particular. Figure (3) briefly explains distribution of main pollutants according to water sources into three essential categories as follows: surface water, groundwater, and wastewater. Drinking water is exposed to chemical pollutants (such as arsenic) as well as various biological ones, as microbial pollution is the worst, especially in poor developing countries. According to the statistics of the WHO, Approximately 785 million individuals currently lack access to fundamental drinking water services, while more than two billion individuals are subjected to the use of water that is contaminated with fecal matter [41,42].

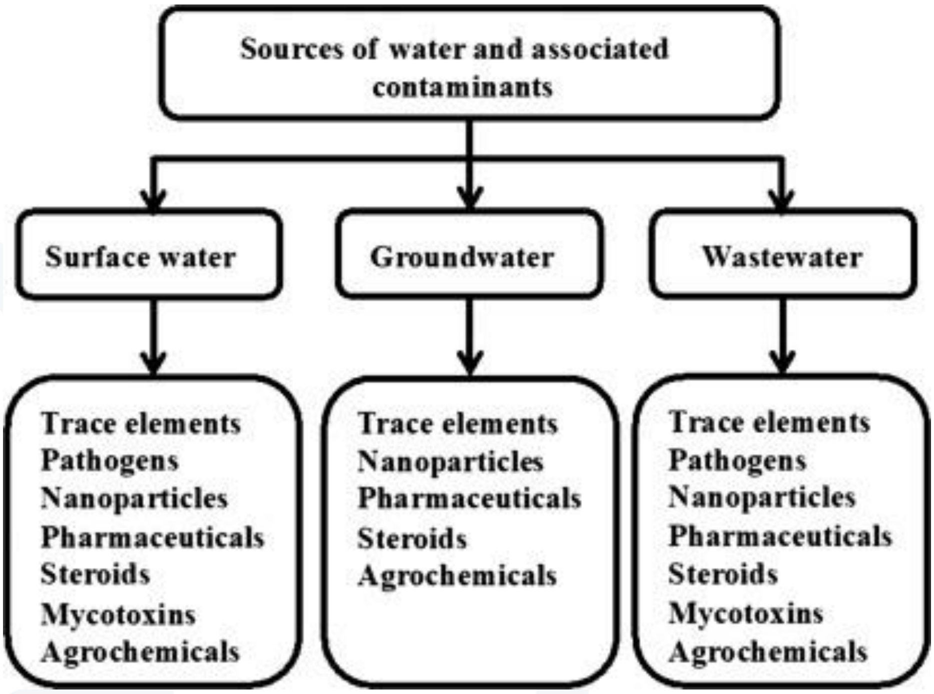

Figure 3: Water pollutants [43]

According to published reports, thousands of daily deaths are recorded among children due to diarrhea infection caused by contaminated water. Piped water sources are generally safer. However, there are temporary interventions, such as safe storage or household water treatment that significantly and measurably reduce microbial contamination even if it is not reduced to zero [44]. To avoid contaminated water especially in in relatively technologically advanced countries, a conceptual model was modified from source to sip, starting at the water source and ending at the point of consumption. All safe drinking water systems include five stages, as shown in Figure (4). In contrast, in areas below the poverty line, as well as developing countries, not all individuals have access to piped water, and obtain safe and unquestionable drinking water [45].

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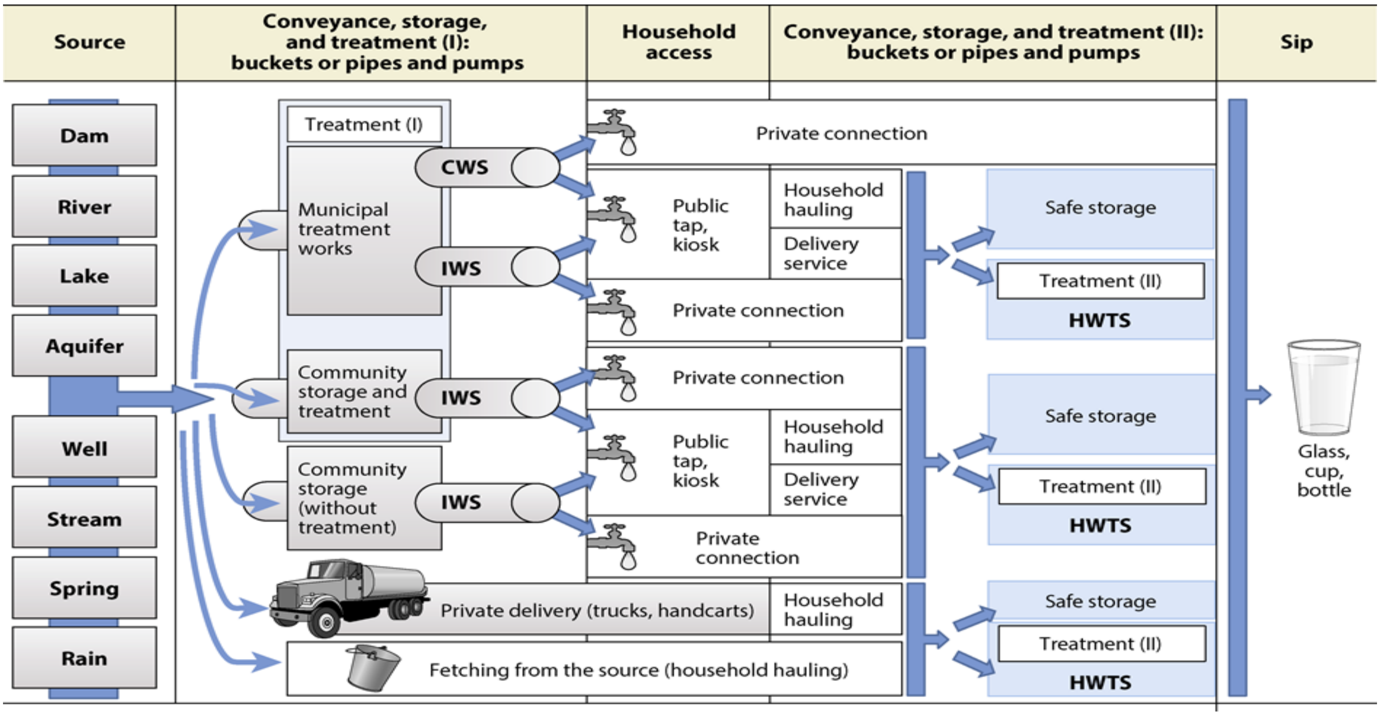

Figure 4: Source-to-sip approach [46] .

Drinking water and body health

The topic of water quality for human consumption pertains to the provision of safe drinking and cooking water, which is crucial for the preservation of human well-being and is an integral component of public health strategies. Water is well recognized as an essential element for the human body, comprising approximately 60% of its total weight (Figure 5). Moreover, nearly every cell within the body relies on water to sustain its fundamental functions and ensure its survival [47]. The recommended daily water intake for women is approximately 2.7 liters, while for males it is approximately 3.7 liters. This amount is important to ensure adequate consumption of essential electrolytes and minerals, including sodium, potassium, and chloride [48]. In affluent nations, the majority of water consumed by the population, approximately 80%, is attributed to the intake of potable water and other liquids, while the remaining 20% is derived from dietary sources. Nevertheless, this percentage exhibits variability contingent upon factors such as climatic conditions, physical exertion, and individual body mass. An instance of heightened daily water needs can arise due to heightened exposure to moisture, dehydration, elevated temperatures, or physical exertion [49].

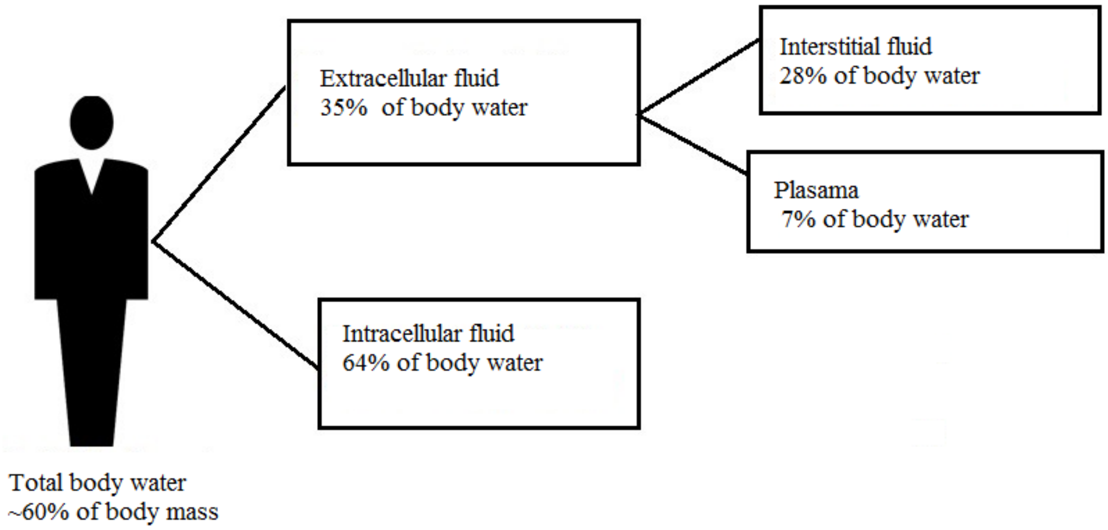

Figure 5: Distribution of water in the body [50] .

Figure 6 provides a concise overview of the advantages associated with the use of water in promoting overall bodily well-being. The significance of the elements resides in their role in attaining equilibrium of water and electrolytes, stimulation of metabolism, binding of oxygen, and facilitation of many physiological processes. When an element becomes depleted, the human body becomes susceptible to adverse consequences, leading to an increase in illness rates and death. When individuals experience a significant lack of water and fluids, their bodies undergo dehydration, resulting in reduced blood volume and impaired physical performance. Conversely, the consumption of an excessive amount of water can lead to water intoxication, resulting in an elevation of intracellular fluid volume, muscular spasms, seizures, and potentially deadly outcomes [51,52].

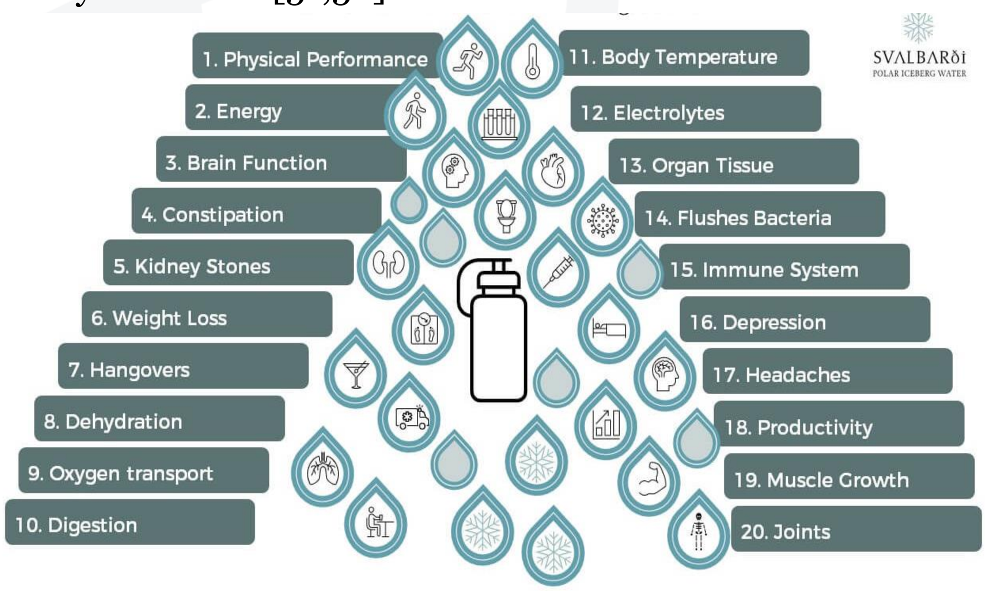

Figure 6 : Drinking water and body health care .

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Drinking water pollution and public health

Water challenges continue to be a significant focal point within the realm of international public health, warranting considerable attention and priority. According to data from WHO, it has been established that a significant proportion, namely 80%, of diseases are transmitted via water. This transmission occurs due to the presence of diverse bacterial, viral, and parasite infections that propagate through contaminated water sources. Moreover, the capacity of water to dissolve and transfer pollutants poses a potential hazard to the well-being of individuals. It is well acknowledged that water serves as a carrier for a multitude of detrimental environmental contaminants that pose significant risks to public health, including but not limited to petroleum products, arsenic, lead, and other similar substances. It is noteworthy to remark that WHO has estimated that a significant number of deaths occur each year due to water-related diseases, including but not limited to cholera, hepatitis, malaria, and several other infections [53, 54].

Water quality improvement

Regrettably, the presence of water pollution has deleterious consequences for both the environment and the flora and fauna inhabiting it. Incidents such as spills, improper waste disposal, and other anthropogenic activities contribute to the disruption of crucial biological processes within organisms. It is vital to acknowledge that eutrophication is a significant expression of environmental contamination that arises as a consequence of water pollution. The presence of nutrients in elevated levels leads to the occurrence of detrimental algal blooms, which have the capacity to deplete substantial quantities of oxygen and generate hypoxic dead zones, resulting in extensive fish mortality on a large scale [55-58]. There is little question that the increase in infectious diseases can be ascribed to a range of issues, such as the lack of attention given to healthcare and public health infrastructure, limited access to clean water, and insufficient sanitation practices. In order to provide a strong foundation for promoting positive changes, it is crucial to address and resolve fundamental issues related to water quality, sanitation techniques, and waste management [59]. Regular maintenance and periodic assessment of nutritional content are essential components of conventional water treatment processes, and appropriate supplementation is administered as necessary. The establishment of an appropriate and conducive healthy environment, together with the reformation of the public health system, necessitates the use of sustainable approaches to ensure water quality [60]. The accomplishment is achieved by means of the establishment and execution of initiatives focused on water quality and sustainable development, carried out in collaboration with the Food and Agriculture Organization of the United Nations [61]. When compared to governmental organizations, the efficiency and creativity of the private sector are typically higher, allowing them to provide financial aid and promote environmental sustainability. The dissemination of information through media channels has the potential to raise public consciousness regarding water health in order to effectively tackle significant issues. Home water treatment and proper storage of treated water are crucial components in preventing waterborne diseases [62]. The concept of point-of-use water treatment centers around the implementation of straightforward household techniques for water purification, including boiling, bleaching, sediment filtering using sand and gravel, and ultraviolet disinfection[63]. The process of boiling water in impoverished nations may pose challenges in terms of environmental sustainability, as well as the potential for re-contamination during the transit and storage of boiled water. Moreover, the utilization of chemical disinfectants may prove to be costly and impractical for household purposes [64].

Conclusions

Water has a significant role in the provision of nutrients and the potential for toxicity and severe health impacts, owing to its remarkable capacity to dissolve and transport a wide range of particles. There is considerable variation in water quality, nutritional composition, and availability across different countries worldwide. The disparity is contingent upon various factors, encompassing the climatic conditions, geographical placement, and economic circumstances of the nation. Water contamination is influenced by a multitude of reasons. Throughout previous ages, numerous nations experienced a significant decline in population due to a multitude of wars. These conflicts directly and indirectly aggravated the persistent issues surrounding waterborne diseases. There is an ongoing prevalence of waterborne disease outbreaks that are cause for concern. The integration of government reform and public health initiatives is necessary in order to effectively achieve and maintain enduring transformations. Achieving substantial and enduring reductions in waterborne diseases necessitates the implementation of comprehensive public health and healthcare reforms, enhancements in the accessibility of potable water, such as the re-mineralization of desalinated water, the establishment of robust monitoring and evaluation mechanisms, and the implementation of sustainable development initiatives. A sustained dedication to transformation can afford individuals the opportunity to avail themselves of potable water resources, thereby fostering public health on a nationwide scale.

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References

1. Sudhaik A, Raizada P, Shandilya P, Jeong DY, Lim JH, Singh P. Review on fabrication of graphitic carbon nitride based efficient nanocomposites for photodegradation of aqueous phase organic pollutants. Journal of Industrial and Engineering Chemistry. 2018;67:28-51.
2. Holzinger A, Keiblinger K, Holub P, Zatloukal K, Müller H. AI for life: Trends in artificial intelligence for biotechnology. New Biotechnology. 2023 May 25;74:16-24.
3. Ali QA, Ghareeb OA. Achieving Sustainable Development Goals by Wastewater Management . Zeta Repository. 2023 Jun 26;19:99-108.
4. Datry T, Truchy A, Olden JD, Busch MH, Stubbington R, Dodds WK, Zipper S, Yu S, Messager ML, Tonkin JD, Kaiser KE. Causes, responses, and implications of anthropogenic versus natural flow intermittence in river networks. BioScience. 2023 Jan;73(1):9-22.
5. Ghareeb OA, Ali QA. Waterborne Zoonotic Bacterial Pathogens. Texas Journal of Medical Science. 2023 Jun 20;21:63-69.
6. Kristanti RA, Hadibarata T, Syafrudin M, Yılmaz M, Abdullah S. Microbiological contaminants in drinking water: Current status and challenges. Water, Air, & Soil Pollution. 2022 Aug;233(8):299.
7. Ferreira DC, Graziele I, Marques RC, Gonçalves J. Investment in drinking water and sanitation infrastructure and its impact on waterborne diseases dissemination: The Brazilian case. Science of the Total Environment. 2021 Jul 20;779: 146279.
8. Adeola Fashae O, Abiola Ayorinde H, Oludapo Olusola A, Oluseyi Obateru R. Landuse and surface water quality in an emerging urban city. Applied Water Science. 2019 Mar;9:1-2.
9. Morin-Crini N, Lichtfouse E, Liu G, Balaram V, Ribeiro AR, Lu Z, Stock F, Carmona E, Teixeira MR, Picos-Corrales LA, Moreno-Pirajan JC. Worldwide cases of water pollution by emerging contaminants: a review. Environmental Chemistry Letters. 2022;20(4):2311-38.
10. Parvin F, Tareq SM. Impact of landfill leachate contamination on surface and groundwater of Bangladesh: a systematic review and possible public health risks assessment. Applied water science. 2021 Jun;11(6):100.
11. Tong S, Li H, Tudi M, Yuan X, Yang L. Comparison of characteristics, water quality and health risk assessment of trace elements in surface water and groundwater in China. Ecotoxicology and Environmental Safety. 2021 Aug 1;219:112283.
12. Karataş A, Karataş E. Environmental education as a solution tool for the prevention of water pollution. Journal of Survey in Fisheries Sciences. 2023 Jan 24:61-70.

13. Chaurasia AK, Pandey HK, Tiwari SK, Prakash R, Pandey P, Ram A. Groundwater quality assessment using water quality index (WQI) in parts of Varanasi District, Uttar Pradesh, India. Journal of the Geological Society of India. 2018 Jul;92:76-82.

14. Malistani HA, Jawadi HA, Sidle RC, Khawary M, Khan AA. Water Resources and Water Quality Assessment, Central Bamyan, Afghanistan. Water. 2022 Sep 28;14(19):3060.

15. Ewaid SH, Abed SA, Al-Ansari N, Salih RM. Development and evaluation of a water quality index for the Iraqi rivers. Hydrology. 2020 Sep 9;7(3):67.

16. Diop M, Mall I, Diop T, Badji L, Mbow C. Development and Application of Water Quality Index (WQI) for the Evaluation of the Physico-Chemical Quality of Groundwater in Gold Mining Areas of Southeastern Senegal. Journal of Water Resource and Protection. 2023 Feb 10;15(2):33-50.

17. Uddin MG, Nash S, Rahman A, Olbert AI. A comprehensive method for improvement of water quality index (WQI) models for coastal water quality assessment. Water Research. 2022 Jul 1;219:118532.

18. Nsabimana A, Li P. Hydrogeochemical characterization and appraisal of groundwater quality for industrial purpose using a novel industrial water quality index (IndWQI) in the Guanzhong Basin, China. Geochemistry. 2023 Apr 1;83(1):125922.

19. Çavuş A, Fazıl ŞE. Development of a water quality index for Lake Aygır in Bitlis, Turkey. Marine Science and Technology Bulletin. 2022;11(2):187-93.

20. Asadollah SB, Sharafati A, Motta D, Yaseen ZM. River water quality index prediction and uncertainty analysis: A comparative study of machine learning models. Journal of environmental chemical engineering. 2021 Feb 1;9(1):104599.

21. Jehan S, Ullah I, Khan S, Muhammad S, Khattak SA, Khan T. Evaluation of the Swat River, Northern Pakistan, water quality using multivariate statistical techniques and water quality index (WQI) model. Environmental Science and Pollution Research. 2020 Nov;27:38545-58.

22. Uddin MG, Nash S, Olbert AI. A review of water quality index models and their use for assessing surface water quality. Ecological Indicators. 2021 Mar 1; 122:107218.

23. Kamali Maskooni E, Naseri-Rad M, Berndtsson R, Nakagawa K. Use of heavy metal content and modified water quality index to assess groundwater quality in a semiarid area. Water. 2020 Apr 14;12(4):1115.

24. Kiptum C. Commonly Used Methods to Calculate Water Quality Indices. In Handbook of Research on Water Sciences and Society 2022 (pp. 271-292). IGI Global.

25. Asadollah SB, Sharafati A, Motta D, Yaseen ZM. River water quality index prediction and uncertainty analysis: A comparative study of machine learning models. Journal of environmental chemical engineering. 2021 Feb 1;9(1):104599.

26. Al-Tameemi IM, Hasan MB, Al-Mussawy HA, Al-Madhhachi AT. Groundwater Quality Assessment Using Water Quality Index Technique: A Case Study of Kirkuk Governorate, Iraq. InIOP Conference Series: Materials Science and Engineering .2020 Jul 1 ; 881(1): 012185

27. Marcus M. Testing the water: Drinking water quality, public notification, and child outcomes. Review of Economics and Statistics. 2022 Nov 14;104(6):1289-303.

28. World Health Organization. Guidelines for drinking-water quality: incorporating the first and second addenda. World Health Organization; 2022 Mar 31.

29. Moore J. Water quality monitoring in Canadian aboriginal communities. In Providing Safe Drinking Water in Small Systems 2019 Jan 15 : 387-393.

30. Zolnikov TR. The maladies of water and war: addressing poor water quality in Iraq. American journal of public health. 2013 Jun;103(6):980-7.

31. Omer NH. Water quality parameters. Water quality-science, assessments and policy. 2019 Oct 16;18:1-34.

32. Kadam AK, Wagh VM, Muley AA, Umrikar BN, Sankhua RN. Prediction of water quality index using artificial neural network and multiple linear regression modelling approach in Shivganga River basin, India. Modeling Earth Systems and Environment. 2019;5:951-62.

33. Chidiac S, El Najjar P, Ouaini N, El Rayess Y, El Azzi D. A comprehensive review of water quality indices (WQIs): history, models, attempts and perspectives. Reviews in Environmental Science and Bio/Technology. 2023 Jun;22(2):349-95.

34. Ptiček Siročić A, Ojdanić K, Dogančić D, Plantak L. Water Quality for Human Consumption from the Public Water Supply System. Environmental Sciences Proceedings. 2023 Mar 16;25(1):21.

35. Heddam S, Sanikhani H, Kisi O. Application of artificial intelligence to estimate phycocyanin pigment concentration using water quality data: a comparative study. Applied Water Science. 2019 Oct;9:1-6.

36. Kachroud M, Trolard F, Kefi M, Jebari S, Bourrié G. Water quality indices: Challenges and application limits in the literature. Water. 2019 Feb 20;11(2):361.

37. Nayar R. Assessment of water quality index and monitoring of pollutants by physico-chemical analysis in water bodies: a review. International Journal of Engineering Research and Technology. 2020;9(01).

38. Trombadore O, Nandi I, Shah K. Effective data convergence, mapping, and pollution categorization of ghats at Ganga River Front in Varanasi. Environmental Science and Pollution Research. 2020 May;27:15912-24.

39. Tyagi S, Sharma B, Singh P, Dobhal R. Water quality assessment in terms of water quality index. American Journal of water resources. 2013 Jan;1(3):34-8.

40. Wu Z, Wang X, Chen Y, Cai Y, Deng J. Assessing river water quality using water quality index in Lake Taihu Basin, China. Science of the Total Environment. 2018 Jan 15;612:914-22.

41. Patel E, Weinthal E. Rights, resilience, and water in turbulent times. Global Environmental Politics in a Turbulent Era. 2023 Mar 2:37-48.

42. Elhabashy A, Li J, Sokolova E. Water quality modeling of a eutrophic drinking water source: Impact of future climate on Cyanobacterial blooms. Ecological Modelling. 2023 Mar 1;477:110275.

43. Malakar A, Snow DD. Nanoparticles as sources of inorganic water pollutants. In Inorganic pollutants in water 2020 Jan 1 (3): 337-370. Elsevier.

44. Lee J, Perera D, Glickman T, Taing L. Water-related disasters and their health impacts: A global review. Progress in Disaster Science. 2020 Dec 1;8:100123.

45. Mercy M, Mkangombe KF, Yongji Z. Water availability, quality and treatment methods in Malawi: A review. International Journal of Scientific and Research Publications. 2021;11(6):542-53.

46. Amrose S, Burt Z, Ray I. Safe drinking water for low-income regions. Annual Review of Environment and Resources. 2015 Nov 4;40:203-31.

47. Cannas D, Loi E, Serra M, Firinu D, Valera P, Zavattari P. Relevance of essential trace elements in nutrition and drinking water for human health and autoimmune disease risk. Nutrients. 2020 Jul 13;12(7):2074.

48. Seal AD, Colburn AT, Johnson EC, Péronnet F, Jansen LT, Adams JD, Bardis CN, Guelinckx I, Perrier ET, Kavouras SA. Total water intake guidelines are sufficient for optimal hydration in United States adults. European Journal of Nutrition. 2023 Feb;62(1):221-6.

49. Sawka MN, Cheuvront SN, Carter R. Human water needs. Nutrition reviews. 2005 Jun 1;63(suppl_1):S30-9.

50. Asogwa CO, Lai DT. A review on opportunities to assess hydration in wireless body area networks. Electronics. 2017 Oct 12;6(4):82.

51. Qasemi M, Darvishian M, Nadimi H, Gholamzadeh M, Afsharnia M, Farhang M, Allahdadi M, Darvishian M, Zarei A. Characteristics, water quality index and human health risk from nitrate and fluoride in Kakhk city and its rural areas, Iran. Journal of Food Composition and Analysis. 2023 Jan 1;115:104870.

52. Boelee E, Geerling G, van der Zaan B, Blauw A, Vethaak AD. Water and health: From environmental pressures to integrated responses. Acta tropica. 2019 May 1;193:217-26.

53. Day NK. Characterization of stream flow and nutrient occurrence in the upper White River Basin, Colorado, 1980–2020. US Geological Survey; 2023.

54. Xagoraraki I, O'Brien E. Wastewater-based epidemiology for early detection of viral outbreaks. Women in water quality: Investigations by prominent female engineers. 2020:75-97.

55. Varshney R, Modi P, Sonkar AK, Singh P, Jamal A. Assessment of surface water quality in and around Singrauli coalfield, India and its remediation: An integrated approach of GIS, water quality index, multivariate statistics and phytoremediation. Arabian Journal of Geosciences. 2022 Sep;15(18):1530.

56. Salman MS, Alhares HS, Ali QA, M-Ridha MJ, Mohammed SJ, Abed KM. Cladophora algae modified with CuO nanoparticles for tetracycline removal from aqueous solutions. Water, Air, & Soil Pollution. 2022 Aug;233(8):321.

57. Ali QA, Shaban MA, Mohammed SJ, M-Ridha MJ, Abd-Almohi HH, Abed KM, Salleh MZ, Hasan HA. Date Palm Fibre Waste Exploitation for the Adsorption of Congo Redis Dye via Batch and Continuous Modes. Journal of Ecological Engineering. 2023;24(10):259-276.

58. Alhares HS, Ali QA, Shaban MA, Bohan HR, Mohammed SJ, Abed KM, Hasan HA. Rice husk coated with copper oxide nanoparticles for 17α-ethinylestradiol removal from an aqueous solution: adsorption mechanisms and kinetics. Environmental monitoring and assessment. 2023 Sep;195(9):1-20.

59. Patel PS, Pandya DM, Shah M. A systematic and comparative study of Water Quality Index (WQI) for groundwater quality analysis and assessment. Environmental Science and Pollution Research. 2023 Apr;30(19):54303-23.

60. Chaudhry FN, Malik MF. Factors affecting water pollution: a review. J. Ecosyst. Ecography. 2017 Mar;7(1):225-31.

61. Lin L, Yang H, Xu X. Effects of water pollution on human health and disease heterogeneity: a review. Frontiers in environmental science. 2022 Jun 30;10:880246.

62. Alcamo J. Water quality and its interlinkages with the Sustainable Development Goals. Current opinion in environmental sustainability. 2019 Feb 1;36:126-40.

63. Zheng L, Cui J, Deng Y. Emergency water treatment with combined ferrate (vi) and ferric salts for disasters and disease outbreaks. Environmental Science: Water Research & Technology. 2020;6(10):2816-31.

64. Gustafsson O, Manukyan L, Gustafsson S, Tummala GK, Zaman S, Begum A, Alfasane MA, Siddique-e-Rabbani K, Mihranyan A. Scalable and sustainable total pathogen removal filter paper for point-of-Use drinking water purification in Sustainable Chemistry & Engineering. 2019 Aug 6;7(17):14373-83.