International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Declining Spring Water Quality: Trends, Causes, and Management Challenges

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ABSTRACT

Springs are a critical source of freshwater in India, particularly in the Himalayan and sub-Himalayan regions, the Western Ghats, and parts of central and northeastern India, where they support drinking water, agriculture, and local ecosystems. In recent decades, the quality of spring water across the country has deteriorated significantly due to a combination of natural processes and increasing anthropogenic pressures. This review synthesizes available literature on the status and trends of spring water quality deterioration in India, with emphasis on key physicochemical and microbiological indicators. Major drivers of degradation include land-use change, deforestation, unplanned urbanization, agricultural runoff, improper waste disposal, sewage intrusion, and overexploitation of groundwater, compounded by climate-induced variability in rainfall and recharge patterns. Studies report elevated levels of nutrients, fluoride, iron, nitrates, heavy metals, and microbial contamination in several spring systems, often exceeding Bureau of Indian Standards (BIS) limits for drinking water. The consequences of declining spring water quality for public health, rural livelihoods, and spring-dependent ecosystems are increasingly evident. The review underscores the need for regular monitoring, spring-shed based management, community-led conservation initiatives, and policy integration to safeguard spring water resources. Strengthening scientific research and governance frameworks is essential to ensure the long-term sustainability and safety of spring water supplies in India.

Keywords: Springs, physicochemical parameters, water quality index, water quality deterioration,

INTRODUCTION

Spring water is widely regarded as a high-quality and naturally pure source of drinking water, making it an important resource for populations across the globe. During its movement through subsurface geological formations, water is naturally filtered by soil and rock layers, which reduces impurities and improves its sensory properties such as taste and clarity. Because it originates from underground aquifers, spring water is generally less exposed to surface-based pollutants, including industrial discharges, agricultural chemicals, and disease-causing microorganisms. This inherent protection often allows spring water to remain suitable for consumption with minimal treatment. In addition, spring water commonly contains naturally dissolved minerals that enhance its palatability and may contribute positively to human health, supporting the well-being of communities that depend on these sources. India has approximately 5 million springs, including nearly 3 million in the Indian Himalayan Region (IHR) alone. These springs are a source of freshwater for over 200 million people. An estimated 80–90% of the population in the Himalayas depends on springs for their daily use.

Despite their perceived purity, recent studies reveal increasing degradation of spring water quality due to increasing population pressure, land-use changes, and climatic variations which has led to a noticeable decline in both the quantity and quality of spring water. Deterioration of spring water quality poses serious risks to public health and threatens the sustainability of freshwater resources. The review highlights emerging concerns related to nutrient enrichment, microbial pollution, trends in spring water quality deterioration and the need for comprehensive monitoring frameworks and also discuss the major challenges associated with their management and conservation.

METHODOLOGY:

The present review is based on an analysis of peer-reviewed research articles, review papers, government reports, and case studies available in scientific databases such as Google Scholar, Scopus, and PubMed. Studies focusing on physico-chemical parameters like pH, Temperature, Turbidity, Electical Conductivity, Total Dissolved Solids(TDS), Alkalinity, Chloride, Hardness, Dissolved Oxygen, Biological Oxygen Demand, Nitrates, Phosphates and microbiological aspects of spring water quality, published over the last two decades, were primarily considered.

REVIEW OF LITERATURE:

In India groundwater is the most valuable source of freshwater accounting for 50-80% of all domestic water use and 45-50% of all irrigation in India (Roy et al., 2022).

Increased demand for groundwater and various anthropogenic interferences have already degraded groundwater reservoirs in many regions (Chowdhury et al., 2021; Wang and Li 2021: Zhao et al., 2021).

The quality of spring water is assessed by analyzing various physico-chemical parameters and the values obtained are compared with permissible/desired values prescribed in IS 10500:2012 and World Health Organization (WHO) guidelines to ensures the quality of groundwater for its use in domestic purposes.

Garg et al. (2000) investigated the physico-chemical characteristics of groundwater by analyzing thirty samples collected from shallow hand pumps in the eastern part of Hisar city, Haryana**.** Parameters such as pH, electrical conductivity, total dissolved solids, total hardness, total alkalinity, sodium, calcium, magnesium, chloride, and sulphate were evaluated. The results indicated that the concentrations of several chemical constituents in most samples exceeded the World Health Organization (WHO) permissible limits for drinking water**,** rendering the groundwater unsuitable for potable use.

Aurangabadkar *et al.* (2001) assessed the ground water around the municipal solid waste sites at Chennai by analysing various physico-chemical parameters such as pH, electrical conductivity, iron, magnesium, chloride, chemical oxygen demand and sulphates. They observed a higher levels of iron and magnesium in the ground water samples, indicating contamination of shallow groundwater and a potential risk to nearby spring and drinking water sources.

Devi and Kamble (2006) carried out sampling of water from dug wells and tube wells for groundwater fluoride concentration from 60 locations in East Imphal district of Manipur. Their study revealed that the concentration of fluoride in six groundwater samples were within the permissible limits of APHA and BIS whereas 54 groundwater samples were below desirable limits.

Shahid *et al.* (2008) examined concentration of fluoride in ground water in Jind district, Haryana and inferred overall quality of water is unsuitable for drinking purpose without any prior treatment while most of the waters tested can safely be used for irrigation purpose.

Ramakrishnaiah *et al*. (2009) assessed the water quality index (WQI) for the groundwater of Tumkur taluk. The analysis revealed that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

Drinking water quality in rural areas of northern Rajasthan was assessed by Suthar *et al.* (2009). He reported presence of *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, *Klebsiella sp*., *Proteus vulgaris*, *Alcaligenes faecalis*, *Bacillus cereus, Staphylococcus, Streptococcus lactis, and Micrococcus luteum* are among the Enterobacteriaceae family of bacteria which clearly suggest that the quality of drinking water has declined as a result of improper personal sanitation practices near water sources.

Vijayabhaskar *et al*. (2010) assessed pH, electric conductivity and heavy metals (Cd, Cu, Fe, Hg, Mn, Zn and Ni) in ground water and surface water of some locations around Tumkur. Their findings suggested that all the surface water samples had heavy metals within suitable limits for irrigation purpose except Honnudike and Hebbur samples which exceeded in Fe concentration for irrigation use.

Juned and Bhosle (2011) carried out Analysis of Chloride, Sodium and Potassium in groundwater samples of Nanded City in Maharashtra (India). Their studies indicated that groundwater in this area is moderately hard while its suitability for domestic industrial and irrigation purposes were also examined using WHO, Indian standards classification, which revealed the water to be unsuitable for domestic purpose and irrigation.

While studying the physico-chemical and bacteriological parameters of water samples from different sources of Ahmedabad, Gujarat, Saxena *et al*. (2011) concluded that the quality of water samples subjected to study was acceptable with respect to majority of physico-chemical parameters while as per the bacteriological standards, the water needs to be treated before using it for domestic purposes including drinking.

Nirmala *et al*. (2012) evaluated ground water quality of Mysore city for its suitability of drinking and irrigation and deduced that all parameters analyzed were well within the permissible limits of WHO except for TA, Chloride ions and TH in certain water samples.

Rudra (2012) conducted the geographical analysis of Purulia block, West Bengal and reported that the area was underlaid by Precambrian metamorphic rock like granitic gneisses which bears the fluoride containing minerals that leach into groundwater and contribute high fluoride concentration which was the main cause of the dental and skeletal fluorosis in the study area

Bhat *et al*. (2013) assessed a total of 59 water samples collected from different water sources viz., open wells, borewells and springs of District Srinagar and reported that groundwater in the Srinagar district is suitable for irrigation and domestic use. The dissolved ions are largely controlled by natural processes.

Tripathi *et al.* (2015) investigated physicochemical characteristics of selected spring water samples of Dehradun city, Uttarakhand and observed that except few parameters, most of them were within the permissible limit as per IS10500-2012.

Vetrimurugan *et al*. (2017) determined the ground water suitability for drinking use based on heavy metal concentration and the associated human exposure risk in intensively irrigated part of the Cauvery river basin, Tamil Nadu, India. They inferred that on the basis of heavy metal pollution index ground water quality of this area was poor to unsuitable. in ground water quality and its suitability for drinking and irrigation uses in Jaipur and concluded that quality of ground water is not suitable for drinking as well as irrigation purpose.

Patni *et al*. (2018) analysed physicochemical parameters of selected spring water samples used for drinking purpose at Pithoragarh city, Uttarakhand, India. They compared their result with standards prescribed by BIS (IS 10500: 2012) and observed that out of 12 parameters for 9 study sites, values of some parameters were below the acceptable limits, some were beyond the permissible limit, while some were in between the acceptable limit and permissible limit.

Chauhan *et al*. (2020) assessed potability of spring water and its health implication in a hilly village of Uttarakhand, India and observed that all selected parameters were found under prescribed limits as stated by Indian standard 10500 and Central Pollution Control Board guidelines and values for most probable number count were found above the permissible limit of drinking water indicating contamination of coliform at all study sites. Further, on the basis of water quality index, the water samples collected away from village were classified under excellent category as compared to supply water samples. Moreover, on the basis of reports of survey and the presence of coliform suggest that drinking water contamination was leading to waterborne diseases like cholera, dysentery and typhoid

CONCLUSION:

Springs are the natural gifts and greatest assets of nature but are under the constant threat of quality deterioration and extinction.The deterioration of spring water quality is a growing environmental concern driven mainly by anthropogenic pressures and climatic variability. Addressing this issue requires systematic monitoring, sustainable land-use practices, and active involvement of local communities. Effective management and policy interventions are essential to safeguard spring water resources for future generations.

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