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CONTENTS

Spring water and it's quality assessment for drinking purpose: A review

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ABSTRACT: Spring water is inexpensive and high quality, but once the groundwater emerges out as spring, it loses its natural protection provided by the overlying rock layers and therefore becomes more vulnerable to contamination threats from surface and atmospheric conditions. The increasing human population has led to urbanization and other development activity which has resulted in degradation of quality of groundwater. It is believed by huge number of people that spring water contains the perfect blend of minerals within a matrix of clean water. The myth that spring water is healthy is not entirely true as it picks up natural minerals as well as any naturally occurring metals some of which can cause serious harm. It is therefore necessary to assess and check the quality of spring water at regular interval of time. This has been explained clearly by the help of considerable number of references in this paper. The quality of water is described according to its physical and chemical characteristics. The present paper describes the importance of different physico-chemical parameters of water quality. To check the suitability of water fit for drinking purposes, Water Quality Index (WQI) method is also described.

Key words: Physico-chemical parameters, springs Water Quality Index (WQI)

Springs are one of the important water resources in the foothill and piedmont areas in the world in general and in India in particular (Malik *et al*., 2014). Rapid climb of human population, industrialization, use of fertilizers and anthropogenic activity has led to pollution of surface water as well as groundwater with different harmful contaminants. Once the groundwater is contaminated, it's quality cannot be restored by stopping the pollutants from the source (Shigut *et al*., 2017).

Spring water in simple language is nothing but groundwater which rises to the surface and emerges out from the opening as surface water. Groundwater that emerges out as a spring will reflect the land from which it comes. Among surface water, spring water is considered to be safe for drinking purpose, but this is not entirely true. When water resides within underground, it picks up natural minerals as well as any naturally occurring metals of which some can cause serious harm. Therefore, it is crucial to monitor and conserve these water sources for healthy living and assure an adequate supply of safe drinking water (Ameen, 2019).

The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region (Patil *et al*., 2012). The quality of spring/ground water is assessed by analyzing various physico-chemical parameters and the values obtained are compared with the permissible/desired values prescribed in IS 10500:2012 and World Health Organization (WHO) guidelines to ensure the quality of groundwater for its use in domestic purposes. Physical parameters such as Temperature, Electrical Conductivity, Total Dissolved solid and Chemical parameters like pH, Calcium hardness, Magnesium hardness, Total hardness, Total Alkalinity and Ionic parameters like Sodium, Potassium, Calcium, Magnesium, Chloride, Sulphate of water samples are analyzed. This paper reviews the study on the assessment of spring water for its quality with respect to potable drinking water.

Review of Literature

Sitakund hot springs are natural geothermal springs situated in Munger district of Bihar, India which are mainly used as a source of bathing and drinking purpose to cure gastrointestinal and skin infections. Hence, Prakash *et al*. (2017) have analysed twelve different physico-chemical parameters of water samples in three selected sites during an interval of four months from October 2014 to June 2016. It was observed from results that water is more polluted in pre-monsoon period than post-monsoon period which may be due to dilution of water either by raining or increasing the ground water level.

An assessment on quality and hygienic condition of total of 127 springs, 99 from rural areas and 28 from Ulaanbaatar (UB) city in Mongolia was undertaken by Badrakh *et al*. (2008). The study included hygienic conditions, physical, microbiological and chemical parameters of springs. Based on the results from laboratory analysis, the quality of springs was classified into five degrees of contamination. Poor hygienic conditions such as low flow rate, turbidity or pollution sources near the vicinity of springs was observed in majority of springs located in UB city. Not only this but water quality parameters such as hardness, total dissolved solids, oxygen demand, nitrogenous compounds, total microbial count, Escherichia coli were also significantly higher here. The study revealed poor hygiene in the vicinity of springs mostly in peri-urban and Central region of Mongolia and therefore recommends regular assessment of spring water and raise awareness among communities for further protection and upgrading of spring water resources.

Springs are considered one of the primary sources of water in entire Himalayan region but due to increased anthropogenic and other activities, it has resulted in degradation of groundwater. It is therefore recommended to regularly test and monitor the quality of spring water consumed by local community. Bui and Lodhi (2020) have collected water samples in two seasons, one during winter season and another in summer season from seven perennial springs present in the hilly areas of Arunachal Pradesh. The physico-chemical analysis was done for parameters such as pH, Temperature, Alkalinity, TDS, Potassium, Sodium, Chloride, Calcium, Magnesium and Total Hardness. Weighted arithmetic water quality index method was used to determine the suitability of spring water for human consumption. To compare any significant variations in the Water Quality Index (WQI) during two seasons paired t-test was performed and mean and standard deviations were computed using Microsoft Excel 2019. In general, parameters of all spring water samples were within range and therefore found to be potable, except the water sample of sixth spring which tasted saline due to the presence of significant amount of chloride (carbonate host rock) nearby. Water quality index values for all the water samples of springs for two seasons came under “excellent” category for drinking purposes. And paired t-test showed no significant differences of Water Quality Index during two seasons. This study also showed that quality of spring water also depends on its surrounding country rock.

Chauhan *et al*. (2020) have applied physicochemical, bacteriological and survey approach to understand the significance of the natural water resources and their management in hilly areas. Five sites were selected in Village Sumari, Pauri, Uttarakhand for collection of water samples. These water sampling sources included both natural water and supply water. The objectives of this research were to study the health status of villagers and to assess the water quality status of natural springs used as drinking water source by them. The result revealed that all the studied physicochemical parameters were within the permissible limits and therefore do not require any further treatment. However, the presence of colonies of coliform in all the samples stipulated a high bacteriological contamination due to which majority of people of Sumari were suffering from water borne diseases such as dysentery, diarrhoea and typhoid. Further, the water quality index of the water sample collected from natural supply source falls under “excellent” category, whereas water sample from municipal supply source falls under “good” and “moderately polluted” category, explaining the need of management practices to maintain and improve the quality.

Al-Barwary *et al*. (2018) compared concentrations of chemical and physical characteristics in water samples from twenty springs and twenty wells within the same aquifer in Soran Mountain District, Kurdistan region, Iraq. Samples were collected monthly from the wells and springs during March 2017 to February 2018. Water samples were assessed for electrical conductivity (EC), pH, turbidity, temperature, total alkalinity (TA), total dissolved solids (TDA), dissolved oxygen (DO), sulphate (SO_4^{2-}), nitrate (NO_3^-), total hardness (TH), chloride ion (Cl^-), calcium (Ca^{2+}) and magnesium (Mg^{2+}), as per the standard methods of American Public Health Association (APHA). Recorded data were analysed using Past3 software (Paleontological Statistics, Version 3.17). Analysis of Variance (ANOVA) test followed by two-sample parametric test by using Tukey's pairwise test was used for post hoc comparisons. The result showed significant differences between all data selected from springs and well except Mg and DO. From the findings, it was concluded that most of well water needed treatment for drinking uses due to total hardness and total dissolved solids which were present in a desirable level but most of spring water was found within the safe level for drinking.

Spring water samples collected from Arbaminch, Ethiopia were analysed for physicochemical parameters pH, electrical conductivity, total dissolved solids, total suspended solids, total alkalinity, total hardness, chloride, fluoride, nitrates, sodium, potassium, calcium, sulphate and magnesium by Reda (2015). The obtained values of each parameter were compared with the standard values set by World Health Organization (WHO), Standards Organization of Nigeria (SON), Indian Standards Institution (ISI) and United Nations Environmental Protection Agency (USEPA) drinking water quality standards. The result indicated higher concentration of chloride (Cl^-), total alkalinity and fluoride (F^-) than the permissible limits stated in WHO, SON and ISI standards but within the standard value of USEPA. But all the rest parameters were within the permissible limits and therefore safe for drinking and other domestic purposes at the physicochemical level.

Patni *et al*. (2021) focused on the seasonal variation of uranium concentration and other physico-chemical parameters in the spring water samples collected from nine sites of Pithoragarh city, Uttarakhand, India. The water samples were collected during pre-monsoon seasons (April-May 2018) and post-monsoon seasons (November-December 2017). Water quality index (WQI) following the standards prescribed by the Bureau of Indian Standards (BIS) and World Health Organizations (WHO), was evaluated to determine whether the water samples collected are safe for drinking or not. The occurrence of uranium and other physico-chemical parameters along with their correlation have also been discussed in this study. The result showed Total Dissolved solids (TDS) of two samples were higher than the prescribed limits oh WHO. Total alkalinity and total hardness were also found higher than the permissible limits. Uranium concentration was well within the range of prescribed value of WHO which means that the water samples were free from uranium toxicity and hence safe for drinking purpose. The Pearson coefficient correlation showed a significant correlation of TDS with electrical conductivity (EC), sulphate, total alkalinity and uranium during pre-monsoon season. WQI during pre-monsoon seasons indicated two spring water samples were in excellent category while others were in good category. Whereas, during post-monsoon seasons three spring water samples were found to be in excellent category and others in good category.

Assessment of Water Quality

The increasing human population has led to urbanization and other development activity resulting in degradation of groundwater (Gupta *et al*., 2019). It has been observed that the civilization has managed to pollute the water resources to an extent that water used for drinking has to be purified before using.

Kumar *et al*. (1997) highlighted that the population density leading to unplanned sewage disposal has a close relation with the deterioration of spring water quality. Higher concentrations of nitrates, chlorides, sulphates, sulphides and higher electrical conductivity was found in the springs located in densely populated areas of Almora town, Uttarakhand.

As per the study conducted by Jain *et al*. (2010), the chemical properties of the springs in Nainital District were within the maximum permissible limits but to a certain extent they were bacteriologically contaminated.

Therefore, it is very important to monitor the quality of water at regular intervals of time before consuming, otherwise it might lead to serious health issues.

Water Quality Parameters

To assess the quality of spring/ground water, physico-chemical parameters of water sample are analysed using standard methods given by American Public Health Association (APHA), Indian Standard (IS) 10500:2012 and World Health Organization (WHO). The obtained values should therefore not exceed the permissible limits mentioned in IS 10500:2012 and WHO.

The physical parameters like Temperature, Electrical conductivity (EC), Total Dissolved Solids (TDS) and Chemical parameters like pH, Hardness, Total Alkalinity (TA), Dissolved Oxygen (DO) and also Ionic parameters like Sodium, Potassium, Nitrate, Chloride, Fluoride and Sulphate are described below:

a) **Temperature:** It is a physical quantity which is mostly measured after collection of water sample on field with the help of potable pen type thermometer. It is measured in ^{0}C. It affects the conductivity and solubility of the water sample. Increased water temperature decreases the solubility of dissolved oxygen.

b) **Electrical Conductivity (EC):** It is a measure of the ability of an aqueous solution to carry an electric current that depends on the presence and total concentration of ions, their mobility and valance and on the temperature. It is a useful tool to assess the purity of water (Behailu *et al*., 2017). Conductivity meter is used for measuring electrical conductivity in terms micro-Siemens per centimetre (µS/cm). Solutions of most inorganic acids, bases and salts are relatively good conductors.

c) **Total Dissolved Solids (TDS):** TDS comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in water. TDS analysis of spring water samples are carried out by using evaporation method. In this method the water sample is taken in a clean and dry china dish and heated to evaporate, cool, desiccate and finally total dissolved solids of samples are calculated by weight loss method (Hegde, 2020). Its unit of measurement is mg/l. The acceptable limit of TDS as per IS 10500:2012 guidelines is 500 mg/l and 600 mg/l as per WHO (2017).

d) **pH:** pH is classed as one of the most important water quality parameters. In chemistry pH (potential of Hydrogen) is a logarithmic scale used to specify the acidity and basicity of an aqueous solution (sample). It is measured using pH meter. A sample is considered to be acidic if the pH is below 7.0. Meanwhile, it is alkaline if the pH is higher than 7.0. Acidic water can lead to corrosion of metal pipes and plumbing systems while alkaline water shows disinfection in water. The normal drinking water pH range mentioned in both IS 10500:2012 and WHO guidelines is between 6.5 and 8.5.

e) **Total Alkalinity (TA):** It is a measure of the ability of water to neutralize acids. The alkalinity of groundwater is mainly due to presence of carbonates, bicarbonates, phosphates and hydroxides (Gorde and Jadhav, 2013). Hegde (2020) stated that TA is the total concentration of bases and TDS in water expressed as parts per million (ppm) or milligrams per litre (mg/l) of Calcium Carbonate ($CaCO_3$).

$$\text{Total Alkalinity} = \frac{A \times B \times N}{\text{Sample Volume}}$$

Where, A = amount of acid used to reach neutralization point (ml)
B = equivalent weight of $CaCO_3$ in mg/l
N = normality of acid
The acceptable limit of Total Alkalinity specified both in IS 10500:2012 and WHO (2017) is 200 mg/l of $CaCO_3$.

f) **Hardness:** From the utility point of view for different purposes, hardness is one of the very important parameters of groundwater. In groundwater, hardness is mainly contributed by bicarbonates, carbonates, sulphates and chlorides of calcium and magnesium. Therefore, principal ions causing hardness are calcium and magnesium (Behailu, 2017). Hard drinking water may have moderate health benefits but can impose critical problems in industrial settings. Permissible limits of hardness specified in both IS 10500:2012 and WHO (2017) is 200mg/l of Calcium Carbonate ($CaCO_3$).

g) **Dissolved Oxygen (DO):** DO is a measure of how much gaseous oxygen is dissolved in the water. It is an important parameter in assessing water quality because of its influence on the organisms living within the body of water. Water temperature and the volume of moving water can affect dissolved oxygen levels. DO analysis is carried by using Modified Winkler's method. It's a titrimetric method of analysis described in IS 10500:2012 and also in Central Pollution Control Board (CPCB) guide manual for water and waste water analysis (Hegde, 2020). It is measured in mg/l.

h) **Sodium (Na^+) and Potassium (K^+):** Sodium and Potassium ions are analysed by using Flame photometer. The results are then formulated by comparing with the standard sodium and potassium graph. Acceptable limit of sodium ion in water mentioned in both IS 10500:2012 and WHO (2017) guidelines is 200 mg/l. High concentration of Sodium ions causes cardiovascular disease and kidney related diseases. However, major role of Potassium ion is in stimulation of nerve, muscle contractions, blood pressure regulation and protein dissolution (Prakash *et al.*, 2017). As per IS 10500:2012 guideline, acceptable limit of potassium is 12 mg/l.

i) **Nitrate (NO_3^-):** Nitrate is the final product of biochemical oxidation of natural nitrogen (Rehman *et al.*, 2020). It is highest oxidizable form of nitrogen and occurs in trace quantities in surface water but some ground water may attain high level of nitrates which becomes toxic when present in excessive amounts in drinking water. Mostly nitrate comes from industrial, agricultural chemicals and fertilizer application. The most common source of nitrate concentration is attributed to animals and human waste disposal practices and the use of agricultural fertilizer. Hegde (2020) used spectrophotometric method to determine the concentration of nitrates in spring water samples. Acceptable limit of nitrate in water mentioned in IS 10500:2012 is 45 mg/l and as per WHO (2017) guideline is 50 mg/l.

j) **Chloride (Cl^-) and Fluoride (F^-):** Chloride and fluoride are very common in water systems as they are added to drinking water for various health and sanitary purposes. However, excessive concentration of chloride and fluoride should be closely monitored as it may drastically affect the human health.

The chloride ion concentration of the water indicates possible pollution or contamination of water from human sewage, animal manure or industrial wastes. As per IS 10500:2012 and WHO (2017) guidelines, chloride ion's acceptable limit is 250mg/l. Whereas, acceptable limit of fluoride mentioned in both the guidelines is 1 mg/l. Presence of excessive amount of fluoride in groundwater is associated with dental and skeletal fluorosis.

k) **Sulphate (SO_4^{-2}):** Sulphates are present in almost all natural water resources. Its high concentration imparts bitter taste to water. However, chemically sulphate plays an important role in forming salt of calcium and magnesium to give permanent hardness to water. 200mg/l is the acceptable limit of sulphate mentioned in IS 10500:2012 and 250 mg/l in WHO (2017) guideline.

Water Quality Index (WQI)

Water Quality Index (WQI) is considered as the most effective method for measuring water quality and determining the suitability of water for drinking purpose. The WQI is a dimensionless number which was first measured by Horton in 1965 and was then subsequently modified by different experts. These indices used water quality parameters which vary by number and types. The weights in each parameter are based on its respective standards, and the assigned weight indicates the parameter's significance and impacts on the index (Akter *et al.*, 2016).

Weighted arithmetic method was used by Brown *et al.* (1972) for evaluating WQI of sampled spring water on the basis of measured values of physico-chemical parameters of spring water.

The calculation WQI involves the following steps:

1. Calculate unit weight (W_n) for each water quality parameter by using the formula:
   $\mathbf{W_n = K/S_n}$
   where,
   W_n = Unit weight
   S_n = Recommended standard of the i[th] parameter
   K = Constant of proportionality
   $\mathbf{= 1/\sum(1/Sn)}$
2. Calculate quality rating score (Q_n) for all the parameters (except pH) by dividing concentration of each parameter by its respective standard. The result is then multiplied by 100 as follows:
   $\mathbf{Q_n = [(V_n - V_i)/ (V_s - V_i)] \times 100}$
   where,
   V_n = Actual concentration of n[th] parameter present.
   V_i = Ideal value of the parameter
   = 0 (except for pH, V_i =7)
   V_s = Recommended standard or permissible limit for the n[th] water quality parameter.
   The above equation indicates that $Q_n = 0$ when a pollutant is absent from the water sample and $Q_n = 100$ when the value of this parameter is equal to its recommended value. Hence, the higher the value of Q_n, the higher the level of contamination.
3. Calculate overall WQI for each sample by using the formula:
   $\mathbf{WQI = \sum QnWn/\sum Wn}$
   where,
   Q_n = Quality rating of n[th] water quality parameter
   W_n = Unit weight of n[th] water quality parameter.
   The computed WQI values are then classified into five categories in order to determine the water quality status as shown in Table 1. Ranges are defined on the basis of Indian Standard 10500:2012 and Central Pollution Board (CPCB).

Table 1: Water Quality Index (WQI) Classification Range

RANGE	CATEGORY
0-25	Excellent
25-50	Good
50-75	Poor
76-100	Very poor
>100	Unfit for drinking

CONCLUSION

Albert Szent-Gyorgyi quoted "Water is life's matter and matrix, mother and medium. There is no life without water". Rise in population and economic development has led to decrease in provision of safe and potable water. Spring water though believed to have better quality is now losing quality at the selfish interests of man. Patterns of human settlement near the springs for easy availability of fresh water is observed since first recorded civilization. Ill-planned anthropogenic activities near the springs have not only affected quality of water but it has also drastically impacted human health.

Study of physico-chemical parameters gives an idea about the quality of spring water when compared with the standard values (prescribed in IS 10500:2012 and WHO). And on the other hand, Water Quality Index (WQI) evaluated based on the obtained values of studied parameters serve as a convenient tool to study the suitability of water for drinking purpose.

Monitoring groundwater sources has therefore become a necessity as it gives an idea about the water characteristics, the variability in water quality, emerging water problems, presence of invasion of hazardous waste and solution for treating the prevailing water pollution.

The authors intend to work on Scheme for Promotion of Academic and Research Collaboration (SPARC) project sponsored by MHRD, Govt of India on "Recharge Process of Springs and Its Management to mitigate anthropogenic and climate change impact for water security-A case study in part of Kumaun Lesser Himalaya, India" with international collaboration from Western Sydney University and Melbourne University. The study area covers Almora, Nainital and Bageshwar of Kumaun region in Uttarakhand state.

REFERENCES

Akter, T., Tuz Jhohura, F. and Rahman, M. (2016). Water Quality Index for measuring drinking water quality in rural Bangladesh: a cross-sectional study. *Journal of Health, Population and Nutrition,* 35:4.

Al-Barwary, M.R.A., Meshabaz, R.A., Hussein, N.J. and Ali, N.H. (2018). A comparison of water quality between well and spring samples selected from Soran District, Northern Erbil Governorate, Kurdistan Region- Iraq. IOP Conference Series: Materials Science and Engineering, 454.

Ameen, H. (2019). Spring water quality assessment using water quality index in villages of Barwari Bala, Duhok, Kurdistan Region, Iraq. *Applied Water Science*, 9:176.

Badrakh, A., Chultemdorji, T., Hagan, R., Govind, S., Tserendorj, T., Vanya, D., Dalaijamts, C. and Shinee, E. (2008). A study of the quality and hygienic conditions of spring water in Mongolia. *Journal of Water and Health*, 06.1: 143-148.

Behailu, T.W., Badessa, T.S., Tewodros, B.A. (2017). Analysis of Physical and Chemical Parameters in Ground Water used for Drinking around Konso Area, Southwestern Ethiopia. *Journal of Analytical and Bioanalytical Techniques*, 8(5): 379.

Brown, R., Mccleil and, N., Deiniger, R., Oconnor, M. (1972). Water quality index-crossing the physical barrier. In: Proceedings of international conference on water pollution research, Jerusalem, Pp 787–797.

Bui, Y. and Lodhi, M.S. (2020). Assessment of Spring Water Quality Using Water Quality Index Method-Study from Upper Subansiri District, Arunachal Pradesh, India. *International Journal of Science, Environment and Technology*, 9: 6, 898-908.

Chauhan, J.S., Badwal, T. and Badola, N. (2020). Assessment of potability of spring water and its health implication in a hilly village of Uttarakhand, India. *Applied Water Science*, 10:73.

CPCB guide manual for analysis of water and waste water, 2012, 1-186.

Gorde, S.P. and Jadhav, M.V. (2013). Assessment of Water Quality Parameters: A Review. *International Journal of Engineering Research and Applications*, 3 (6): 2029-2035.

Gupta, D., Gurudatta Singh, G., Patel, A.K., Shukla, R., Mishra, U. and Mishra, V.K. (2019). An Assessment of Groundwater Quality of Varanasi District using Water Quality Index and Multivariate Statistical Techniques. Environment and We- *An International Journal of Science and Technology*, 14: 143-157.

Hegde, G. (2020). Spring Water- A possible source of drinking water at the time of midsummer in coastal bank of Karnataka- A case study of Ramathirtha-Gokarna, India. *International Journal of Advanced Research*, 8 (05): 512-522.

Indian Standard DRINKING WATER – SPECIFICATION (Second Revision) IS 10500:2012.

Jain, C.K., Bandyopadhyay, A., Bhadra, A. (2010). Assessment of ground water quality for drinking purpose, District Nainital, Uttarakhand, India. *Environ Monit Assess,* 166:663–676

Kumar, K., Rawat, D.S. and Joshi, R. (1997). Chemistry of spring water in Almora, Central Himalaya, *India. Environ Geol.,* 31(3/4):150–156.

Malik, A., Grohmann, E. and Akhtar, R. (2014). Environmental Deterioration and Human Health. Springer Dordrecht Heidelberg, London, 347 p.

Patil, P.N., Sawant, D.V. and Deshmukh, R.N. (2012). Physico-chemical parameters for testing water- A review. *International Journal of Environmental Sciences*, Vol 3, No. 3, ISSN 0976-4402, 1194-1207.

Patni, K., Pande, C., Pande, A.P., Tiwari, G. and Joshi, T. (2021). Seasonal variation of uranium and physico-chemical parameters in spring water sources of Pithoragarh city, Uttarakhand, India. Journal of Radioanalytical and Nuclear Chemistry. DOI: 10.1007/s10967-021-07823-8.

Prakash P. and Gupta B.K. (2017). Analysis of Physico- Chemical Parameters of Sitakund Hot Water Spring at Munger District Bihar. *International Journal for Modern Trends in Science and Technology*, Volume:03, Issue No: 09, ISSN: 2455-3778, 63-69.

Reda, A.H. (2015). Assessment of Physicochemical Quality of Spring Water in Arbaminch, Ethiopia. *Journal of Environmental Analytical Chemistry*, 2:5, ISSN: 2380-2391.

Rehman, J.U., Ahmad, N., Ullah, N., Alam, I. and Ullah, H. (2020). Health Risks in Different Age Group of Nitrate in Spring Water Used for Drinking in Harnai, Balochistan, Pakistan. *Ecology of Food and Nutrition*, ISSN: 0367-0244. DOI: 10.1080/03670244.2020.1737044

Shigut, D.A., Liknew, G., Irge, D.D. and Ahmad, T. (2017). Assessment of physico-chemical quality of borehole and spring water sources supplied to Robe Town, Oromia region, Ethiopia. *Applied Water Scienc*e, 7:155-164.

World Health Organization (2017). Guidelines for drinking water quality (electronic resource): fourth edition incorporating the first addendum.

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