ASSESSMENT OF WATER QUALITY OF THE BHIMA RIVER FOR DRINKING PURPOSE BY WATER QUALITY INDEX

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ABSTRACT

The objective of this study is to determine various water characteristics of the Bhima River and its suitability for drinking, followed by a water quality index evaluation. For continuous monitoring, samples were taken at eight locations between October 2020 and September 2021. The physicochemical parameters, such as pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), chloride (Cl^-), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), and nitrate (NO_3^-) were measured. The measured values of these parameters were compared with Indian standards. Due to anthropogenic activities, values of parameters EC, TH, and TA at all the stations exceeded their BIS limits (The Bureau of Indian Standards). It was found that the river's total water quality index ranged from 45.23 to 75.43, indicating that the water quality varies from good to very poor. Correlation reveals that EC and TDS show remarkable similarities and a strong correlation was existed between total hardness and total alkalinity indicating anthropogenic activities. Therefore, it is important to assess physiochemical concentration of the river water before using it for drinking.

Keywords: *Bhima River, correlation, physicochemical parameters, water quality index*

INTRODUCTION

Water is the most abundant chemical in the human body. All biological activities occur in water, and it is an active participant in those reactions [1]. Without water, life cannot exist [1, 2]. Rivers serve as the primary supply of drinking water in both urban and rural areas, and they play a vital role in public health and environmental standards [3]. Water in a river is often gathered from rainfall, surface runoff, and the discharge of stored water in natural reservoirs such as a glacier. Rivers, in addition to being a rich source of fish, also indirectly benefit agriculture by providing water for irrigation [4]. Due to rapid increase in human population and industrialization, as well as wastewater disposal, water quality has deteriorated in recent years [5]. The rivers are one of the world's most contaminated landscapes. Because rivers pass through towns, industrial zones, and agricultural areas, they have long been used for disposal of sewage [6]. According to a World Health Organization (WHO) study, household waste accounts for 80 % of water contamination [7].

Water must be tested before it is used for drinking, residential, agricultural, or industrial reasons. It must be tested using various physicochemical parameters. Evaluation of parameters is necessary for the assessment of water quality and for the comparison of their values to reference standards [8]. Various indices have been developed for quick and concise summarisation od data of several parameters. In 1965, Horton [9] developed the water quality index (WQI) as a statistical technique for combining the results of many parameters to obtain a single score. Generalized WQI, which Brown [10] later developed in 1970, has now undergone fundamental changes and is now more suitable for different purposes [11]. The WQI is a more advanced environmental criterion that is the most active way to describe water quality for drinking purposes [12]. WQI is a value that shows the combined influence of many parameters [13]. Water quality can be observed using physical, chemical, and biological variables. These factors are harmful to human health if their values are higher than the set limits [14].

Many authors, such as Patni et al., [7], Lrk et al., [11], and Gupta et al., [15] have reported on the concentration of physiochemical parameters of river water from different places around the world, as well as the pollution status, using the WQI approach. In many areas, there is a serious water deficit and there are problems with the quality of drinking water. In semi-arid areas, such as Kalaburagi, Karnataka, where rainfall is erratic in both location and timing, it is important to assess the quality of the available water. This is why this area is interested in water quality monitoring. The objective of this study is to use physicochemical standards to assess the water quality status of the Bhima River.

MATERIALS AND METHODS

Study area

The Bhima River flows through the Karnataka district of Kalaburagi (Figure 1), which is located in the northern part of the state (76° 04" to 77° 42" longitude and 16° 12" to 17° 46" latitude) and is 454 m above mean sea level (MSL). The river is a major tributary of the Krishna River. The study area encompasses eight locations along the river bank. Table 1 shows the sampling locations together with their Global Positioning System (GPS) coordinates, and Figure 1 shows a map with indicated sampling locations.

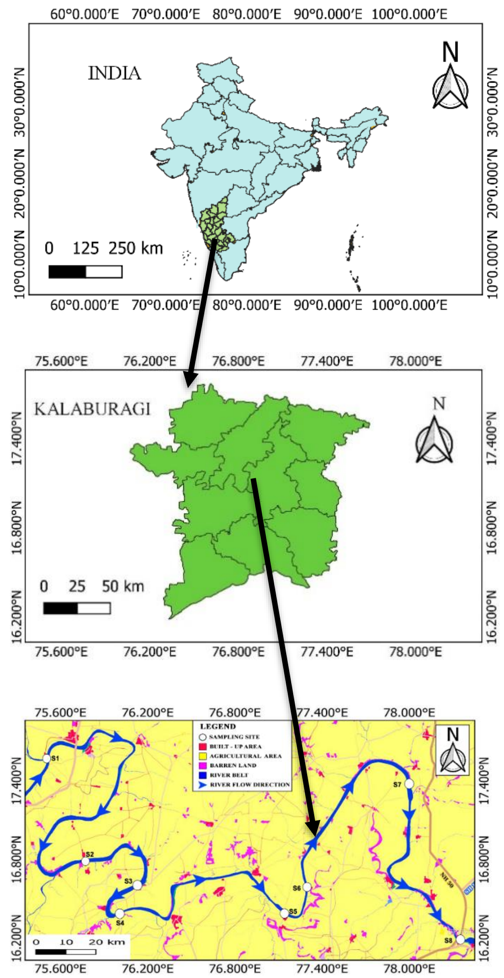

Figure 1. Map of Kalaburagi district showing eight sampling locations

Methodology

Sample collection

Water samples were collected at eight different river locations. For this investigation, ten physicochemical characteristics were determined: pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness

(TH), chloride (Cl^-), phosphate (PO_4^{3-}), nitrate (NO_3^-), sulphate (SO_4^{2-}), and dissolved oxygen (DO). On site, pH, EC, and TDS were measured with a digital pen-type meter. The titration technique was used to determine total alkalinity, total hardness, and chloride. Fixatives were added on site to measure dissolved oxygen, which was then examined using Winkler's technique. Parameters, such as phosphate, nitrate, and sulphate were analysed with a spectrophotometer. All parameters were examined using standardized procedures recommended by Trivedy and Goel [16] and the American Public Health Association (APHA) [17].

Water quality index

The water quality index (WQI) was computed by applying the weighted arithmetic index approach. This equation was used to determine the quality rating scale for each parameter. The WQI was determined using drinking water quality criteria specified by the Bureau of Indian Standards (BIS) [18].

Calculation of water quality index

Unit weight factor for each parameter is calculated by the following equation:

$$Wn = K/Sn \tag{1}$$

where Wn is the unit weight of each parameter, n represents a number of parameters, Sn indicates the standard permissible limit of the n^{th} parameter, and K is the proportionality constant.

Sub-index (Qn) is calculated by the following equation:

$$Qn=[(Vn-Vi) / (Vs - Vi)] \cdot 100 \tag{2}$$

where Vn is the obtained concentration of the i^{th} determinant, Vi is the ideal value of the i^{th} determinant in fresh water, and Vs is the standard value of the i^{th} determinant.

Except for pH and DO, where Vi = 7 and 14.6 respectively, zero is the optimal value for all determinants.

Combining equation 1 and 2, WQI is shown as follows:

$$WQI = Wn \cdot Qn \tag{3}$$

RESULTS AND DISCUSSION

Details of the physicochemical properties for specific study sites are listed in Table 1. The obtained results were compared with the standard specified by the Bureau of Indian Standards (BIS) as shown in Table 2. According to the BIS [18], the pH range is 6.5 to 8.5. The human body stops making vitamins and minerals when the pH drops below 6.4. Water tastes sourer when the pH exceeds 8.5, while above 11 it causes eye discomfort and skin problems. It is safe to consume water with a pH of 5.5 - 6. pH values in the range of 3.5 to 4.5 affect aquatic life [19 - 21]. The pH in this study ranges from 7.6 to 8.1, with an average value of 7.87, which is below the permissible limit of 8.5.

Electrical conductivity is the ability of water to conduct electric current. The majority of salts in water are in the ionic form [22]. Mean EC was 848.76 µS/cm, varying from 789.6 to 883 µS/cm. This shows that the EC of all the samples has exceeded the values of 300 µS/cm according to BIS. Total dissolved solids can be assessed indirectly by calculating EC. A higher concentration of salts in water conducts more electricity.

High TDS levels have a negative impact on public health by damaging the central nervous system and causes facial paralysis including tongue and lips [19, 23 - 25]. In this research, the obtained TDS values were in the range of 414.6 to 457.6 mg/l and a mean value was 453.08 mg/l. This means that the obtained TDS values are significantly below the BIS [18] permissible limit of 500 mg/l.

Chloride is one of the most common anions on the planet. The amount of chloride in the environment rises as a result of industrial waste, agricultural runoff and animal excretion. Water with high chloride content has a salty flavour. Chloride levels that exceed a certain threshold can lead to cardiac and renal problems [26] and increase the number of polymorphonuclear leukocytes [27]. The chloride concentration was found to be within the desirable limit of 250 mg/l, and the values varied from 159.22 to 187.86, with an average of 174.96 mg/l.

Dissolved oxygen indicates the quality of water for human life by revealing changes in biological parameters caused by aerobic or anaerobic phenomena [24]. Depending on the temperature, turbulence, altitude, and salinity, a range of 5 - 14 mg/l has been found to be suitable for freshwater. According to the BIS [18] standard, the DO range of 4 - 6 mg/l ensures healthier aquatic life in the water body [19, 23, 25, 28, 29]. An average DO value of 7.87 mg/l and a variation from 6.32 to 9.33 was observed in the study area.

The ability of water to form lather with soap is measured by its hardness. The two main ions that cause water hardness are calcium and magnesium, which can be found in many sedimentary rocks. Intake of hard water can induce stomach issues, cardiac disease, hypertension, osteoporosis, and the formation of calcium oxalate crystals in the urinary tract and obesity [30, 31]. The measured TH values showed that all the samples exceeded the BIS limit of 300 mg/l. Measured values ranged from 310.06 to 347.2, and the mean value was 334.77 mg/l.

The capability of water to neutralize strong acid is measured by alkalinity. It is caused by the presence of bicarbonate, carbonate, and salts of strong acids and bases, such as phosphates, silicates, and borates [32]. Alkaline water can cause gastrointestinal issues, as well as skin irritation. High alkalinity causes metabolic alkalosis and hypocalcemia by triggering the natural pH of the body [33]. A high level of alkalinity gives a harsh taste and is bad for agriculture because it damages the soil and reduces crop yields [34]. The measured alkalinity ranged from 270.2 to 317.1 mg/l, and the mean value was 297.81 mg/l. This is above the permissible limit of 120 mg/l.

The high concentration of phosphate in industrial, agricultural, and sewage waste causes contamination of the aquatic body, which encourages the proliferation of microorganisms. Muscle damage, respiratory problems, and renal failure are symptoms of a high phosphate levels [35]. Eutrophication and dissolved oxygen depletion are caused by an increased concentrations of phosphorus in reservoirs and lakes [25, 36]. The obtained values of phosphate were within the permissible limit of 5 mg/l, and ranged from 1.33 to 3.17 mg/l with a mean value of 2.27 mg/l.

The concentration of nitrate in natural water is increasing as a result of various agricultural activities [37]. Increased nitrate levels in surface water cause a variety of problems, including reduced oxygen levels in the water, which affects aquatic flora and fauna [15]. A blue baby syndrome occurs in the human body as a result of the reaction of iron and nitrate in red blood cells, whereby methaemoglobin is formed, which prevents the increase in oxygen levels. Infants under one year of age are exposed to a high risk of developing methemoglobinemia due to consumption of water containing high levels of nitrates [21, 35]. The values of nitrates in this study ranged from 1.11 to 1.58 mg/l, and the mean value was 1.4 mg/l. These values are considerably below the permissible limit of 45 mg/l.

Sulphate is another significant chemical parameter, it is a natural substance and is abundant in the environment. It is largely obtained from weathering of rocks and anthropogenic activities [38]. Water with high sulphate levels can have a harsh flavour and a laxative effect resulting in diarrhea and dehydration [39]. Infants are particularly sensitive to its effect [40]. The permissible limit of sulphate is 150 mg/l. The concentration of sulphate in the examined samples was significantly below the permissible limit of 150 mg/l. Measured values ranged from 54.33 to 78.33, and the mean value was 70.27 mg/l.

Table 1. Water quality parameters of the Bhima River, expressed as mean values

Sites code	Site name	Coordinates	pH	EC (µS/cm)	TDS (mg/l)	DO (mg/l)	TA (mg/l)	TH (mg/l)	Cl^- (mg/l)	PO_4^{3-} (mg/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)
S1	Gangapur	17° 10' 06" N 76° 30' 57" E	7.7	875	418.6	8.24	301.73	342.78	165.33	1.74	67	1.38
S2	Sagnur	17° 05' 57" N 76° 32' 34" E	7.6	860	414.6	8.99	270.2	310.06	160.02	1.33	63	1.21
S3	Chinamalla	17° 04' 53" N 76° 34' 57" E	7.6	805.6	457.6	9.33	300.6	332.16	159.22	1.53	54.33	1.11
S4	Nelogi	17° 03' 45" N 76° 34' 02" E	7.9	861.3	444	7.74	309.03	346.63	183.3	2.51	77.33	1.52
S5	Harwal	17° 03' 39" N 76° 41' 12" E	8.1	883	439.3	6.44	313.46	347.2	186.47	3.17	78.33	1.52
S6	Rasangi	17° 04' 51" N 76° 42' 15" E	7.9	871.3	457.3	8.21	275.76	313.3	170.41	2.27	71	1.3
S7	Saradgi-B	17° 09' 02" N 76° 46' 39" E	8.1	789.6	456.3	6.32	294.66	339.4	187.86	3.15	74	1.56
S8	Jevargi	17° 02' 34" N 76° 48' 50" E	8.1	844.3	447	7.76	317.1	346.63	187.1	2.46	77.2	1.58
Average			7.87	848.76	453.08	7.87	297.81	334.77	174.96	2.27	70.27	1.4
BIS			8.5	300	500	5	120	300	250	5	150	45

EC - Electrical conductivity, TDS - Total dissolved solids, DO - Dissolved oxygen, TA - Total alkalinity, TH - Total hardness, Cl^- - Chloride, SO_4^{2-} - Sulphate, PO_4^{3-} - Phosphate, NO_3^- - Nitrate

Table 2. Drinking water standards according to BIS 2012

Sl. No	Parameters, unit	BIS Standards	Relative weight (*Wi*)
1	pH	8.5	0.207294
2	EC, µS/cm	300	0.005873
3	TDS, mg/l	500	0.003524
4	DO, mg/l	5	0.352401
5	TA, mg/l	120	0.014683
6	TH, mg/l	300	0.005873
7	Cl^-, mg/l	250	0.007048
8	PO_4^{3-}, mg/l	5	0.352401
9	SO_4^{2-}, mg/l	150	0.011747
10	NO_3^-, mg/l	45	0.039156
			ΣWi= 1.00

Water quality index

The WQI enables a broad investigation of water quality at different levels that affect a river's ability to support life and determines whether the general condition of water bodies poses a possible risk for different water uses [21].

The results in Table 3 show that the water quality from all eight sampling sites is within the range of good to very poor (26 < WQI < 100), making it suitable for irrigation and industry. According to Table 4, out of the eight locations, the water quality was good at S2 and S3, poor at S1, S4, S6, and S8, and very poor at S5 and S7. The geographic location of the research area, which was characterized by anthropogenic activities, agricultural runoff, the use of lead batteries, and bridge construction activities, may be the cause of water quality degradation.

Table 3. WQI ranges, status and possible use of the water

WQI range	Water quality status (WQS)	Possible use
0 - 25	Excellent water quality	Drinking, irrigation and industrial purposes
26 - 50	Good water quality	Drinking, irrigation and industrial purposes
51 - 75	Poor water quality	Irrigation and industrial purposes
76 - 100	Very poor water quality	Irrigation
Above 100	Not suitable for drinking	Appropriate treatment is required before use

Table 4. WQI values of samples

Sites	WQI	Water quality status
S1	52.76	Poor
S2	45.63	Good
S3	45.81	Good
S4	66.68	Poor
S5	75.31	Very poor
S6	60.23	Poor
S7	75.43	Very poor
S8	68.33	Poor

Correlation

A correlation analysis is a statistical technique that shows the relationship between two variables. When the correlation coefficient is closer to +1 or -1, a linear relationship between the variables x and y is more likely to occur [25]. Correlation was performed in Microsoft Excel. The physicochemical connections between the different parameters represented in Table 5 show strong correlation (> 0.7 - 0.9), moderate (> 0.5 - 0.7), and weak correlation (> 0.3 - 0.5). Strong correlations exist between pH and phosphate, nitrate, sulphate, and chloride. Electrical conductivity and TDS show a significant correlation. Strong correlations exist between total hardness and total alkalinity. Positive correlations exist between chloride, nitrate, phosphate, and sulphate. The few correlation parameters that are still present are moderately to negatively correlated. Agricultural runoff is the main source of nitrates, phosphates, sulphates, and chlorides. Total hardness and total alkalinity are possible outcomes of human activity.

CONCLUSION

In order to assess the physicochemical characteristics of the water from the Bhima River, eight different sample locations along the length of the river were carefully selected. The total amount of water pollution in the river was calculated using the WQI. The average river water quality index (WQI) was found to be 61.27, which means that overall quality of the river water is poor and unsafe for drinking. The water quality index for the Bhima River ranges from 45.63 to 75.43 depending on the sampling location, indicating that it is good to very poor for drinking. Large-scale human activities, such as the discharge of household sewage and effluent, may be responsible for this. Therefore, it is important to protect river water by frequent monitoring and inspections of water quality to reduce human activities in this region.

Table 5. Correlation matrix of physicochemical parameters of Bhima River

	pH	EC	TDS	DO	TA	TH	Cl^-	SO_4^{2-}	PO_4^{3-}	NO_3^-
pH	1									
EC	- 0.72	1								
TDS	- 0.37	*0.71	1							
DO	- 0.88	**0.66	***0.38	1						
TA	0.50	- 0.54	- 0.71	- 0.42	1					
TH	0.53	- 0.64	- 0.76	- 0.55	*0.95	1				
Cl^-	*0.96	- 0.70	- 0.39	- 0.88	**0.60	**0.66	1			
SO_4^{2-}	*0.94	- 0.73	- 0.41	- 0.95	***0.47	**0.56	*0.93	1		
PO_4^{3-}	*0.88	- 0.53	- 0.37	- 0.81	***0.45	**0.52	*0.91	*0.82	1	
NO_3^-	*0.88	- 0.68	- 0.47	- 0.85	**0.60	*0.70	*0.94	*0.83	*0.93	1

* Strong correlation (> 0.9 - 0.7), ** Moderate correlation (0.5 - 0.7), *** Weak correlation (0.3 - 0.5),
EC - Electrical conductivity, TDS - Total dissolved solids, DO - Dissolved oxygen, TA - Total alkalinity, TH - Total hardness, Cl^- - Chloride, SO_4^{2-} - Sulphate, PO_4^{3-} - Phosphate, NO_3^- - Nitrate

REFERENCES

[1] S.M. Kleiner, Water: an essential but overlooked nutrient, Journal of the American Dietetic Association 99(1999) 2, 200-206. https://doi.org/10.1016/S0002-8223(99)00048-6

[2] M.S Hashem, X. Qi, Treated wastewater irrigation - A review, Water 13(2021) 11, Article number: 1527. https://doi.org/10.3390/w13111527

[3] F. Falah, A. Haghizadeh, Hydrochemical evaluation of river water quality - a case study: Horroud River, Applied Water Science 7(2017) 8, 4725-4733. https://doi.org/10.1007/s13201-017-0635-0

[4] A. Kumar, A. Dua, Water quality index for assessment of water quality of river Ravi at Madhopur (India), Global journal of Environmental Sciences 8(2009) 1, 49-57. https://doi.org/10.4314/gjes.v8i1.50824

[5] Y. Teng, J. Yang, R. Zuo, J. Wang, Impact of urbanization and industrialization upon surface water quality: A pilot study of Panzhihua mining town, Journal of Earth Science 22(2011) 5, Article number: 658. https://doi.org/10.1007/s12583-011-0217-2

[6] A. Qishlaqi, S. Kordian, A. Parsaie, Hydrochemical evaluation of river water quality - a case study, Applied Water Science 7(2017) 5, 2337-2342. https://doi.org/10.1007/s13201-016-0409-0

[7] K. Patni, A.P. Pande, C. Pande, Physicochemical investigation of some primitive water sources in district Champawat for potability and preservation of historical aesthetics, Uttarakhand, India, The Holistic Approach to Environment 12(2022) 1, 1-8. https://doi.org/10.33765/thate.12.1.1

[8] P.N. Patil, D.V. Sawant, R.N. Deshmukh, Physico-chemical parameters for testing of water - a review, International Journal of Environmental Sciences 3(2012) 3, 1194-1207.

[9] R.K. Horton, An index number system for rating water quality, Journal of the Water Pollution Control Federation 37(1965) 3, 300-306.

[10] R.M. Brown, N.I. McClelland, R.A. Deininger, R.G. Tozer, A water quality index - do we dare? Water Sew Works 117(1970) 10, 339-343.

[11] A. Lkr, M.R. Singh, N. Puro, Assessment of water quality status of Doyang river, Nagaland, India, using water quality index, Applied Water Science 10(2020) 1, Article number: 46. https://doi.org/10.1007/s13201-019-1133-3

[12] B.S. Kamble, P.R. Saxena, R.M. Kurakalva, K. Shankar, Evaluation of seasonal and temporal variations of groundwater quality around Jawaharnagar municipal solid waste dumpsite of Hyderabad city, India, SN Applied Sciences 2(2020) 3, Article number: 498. https://doi.org/10.1007/s42452-020-2199-0

[13] J. Yisa, T. Jimoh, Analytical studies on water quality index of river Landzu, American Journal of Applied Sciences 7(2010) 4, 453-458. https://doi.org/10.3844/ajassp.2010.453.458

[14] S. Tyagi, B. Sharma, P. Singh, R. Dobhal, Water quality assessment in terms of water quality index, American Journal of water resources 1(2013) 3, 34-38. https://doi.org/10.12691/ajwr-1-3-3

[15] D. Gupta, R. Shukla, M.P. Barya, G. Singh, V.K. Mishra, Water quality assessment of Narmada River along the different topographical regions of the central India, Water Science 34(2020) 1, 202-212. https://doi.org/10.1080/11104929.2020.1839345

[16] R.K. Trivedi, P.K. Goel, Chemical and biological methods for water pollution studies, Environmental Publication, Karad, 1986.

[17] APHA, Standard Methods for Examination of Water and Wastewater, American Public Health Association, 2005.

[18] BIS-10500, Indian standard drinking water specifications, Bureau of Indian Standards, New Delhi, India, 2012.

[19] Handbook of Water Analysis, ed. L.M.L. Nollet, Marcel Dekker, Inc., New York, 2000.

[20] S.M. Avvannavar, S. Shrihari, Evaluation of water quality index for drinking purposes for river Netravathi, Mangalore, South India, Environmental Monitoring and Assessment 143(2008) 1, 279-290. https://doi.org/10.1007/s10661-007-9977-7

[21] K.A. Shah, G.S. Joshi, Evaluation of water quality index for River Sabarmati, Gujarat, India, Applied Water Science 7(2017) 3, 1349-1358. https://doi.org/10.1007/s13201-015-0318-7

[22] M.R. Murthuzasab, M. Rajashekhar, K. Vijaykumar, N.S. Haliked, Seasonal variation in physico-chemical parameters of Hirahalla Reservoir, Koppal District Karnataka, International Journal of Systems Biology 2(2010) 2, 16-20.

[23] C.N. Sawyer, P.L. McCarty, G.F. Parkin, Chemistry for Environmental, 4th Edition, McGraw-Hill, New York, 1994.

[24] H. Chang, Spatial and temporal variations of water quality in the Han River and its tributaries, Seoul, Korea, 1993 - 2002, Water, Air, and Soil Pollution 161(2005), 267-284. https://doi.org/10.1007/s11270-005-4286-7

[25] N. Gupta, P. Pandey, J. Hussain, Effect of physicochemical and biological parameters on the quality of river water of Narmada, Madhya Pradesh, India, Water Science 31(2017) 1, 11-23. https://doi.org/10.1016/j.wsj.2017.03.002

[26] O.T. Dede, I.T. Telci, M.M. Aral, The use of water quality index models for the evaluation of surface water quality: a case study for Kirmir Basin, Ankara, Turkey, Water Quality, Exposure and Health 5(2013) 1, 41-56. https://doi.org/10.1007/s12403-013-0085-3

[27] M.T. Bashir, S. Ali, A. Bashir, Health Effects from Exposure to Sulphates and Chlorides in Drinking Water, Pakistan Journal of Medical and Health Science 6(2012) 3, 648-652.

[28] Environmental Monitoring Handbook, ed. F.R. Burden, U. Forstner, I.D. McKelvie, A. Guenther, 1st Edition, McGraw-Hill, New York, 2002.

[29] A.K. De, Environmental chemistry, 5th Edition, New Age International Publisher, New Delhi, 2003.

[30] A.M. Shivanna, G. Nagendrappa, Water quality index (WQI) approach to evaluate the water quality of certain tank waters of Tipur taluk in Tumkur district, Karnataka, India, Current World Environment 10(2015) 1, 189-198. https://doi.org/10.12944/CWE.10.1.22

[31] S. Akram, F. -ur-Rehman, Hardness in drinking-water, its sources, its effects on humans and its household treatment, Journal of Chemistry and Application 4(2018) 1, 1-4.

[32] P. Ravikumar, M.A. Mehmood, R.K. Somashekar, Water quality index to determine the surface water quality of Sankey tank and Mallathahalli lake, Bangalore urban district, Karnataka, India, Applied Water Science 3(2013) 1, 247-261. https://doi.org/10.1007/s13201-013-0077-2

[33] H.A.-L. Mousa, Health Effects of Alkaline Diet and Water, Reduction of Digestive-tract Bacterial Load, and Earthing, Alternative Therapies in Health & Medicine 22(2016) 1, 24-33.

[34] M.L. Sundar, M.K. Saseetharan, Ground water quality in Coimbatore, Tamil Nadu along Noyyal river, Journal of Environmental Science Engineering 50(2008) 3, 187-190.

[35] J. Nyamangara, N. Jeke, J. Rurinda, Long-term nitrate and phosphate loading of river water in the Upper

Manyame Catchment, Zimbabwe, Water SA 39(2013) 5, 637-642. https://doi.org/10.4314/wsa.v39i5.7

[36] T. Davie, Fundamental of Hydrology, Routledge, New York, 2003.

[37] B. Nas, A. Berktay, Groundwater contamination by nitrates in the city of Konya, (Turkey): A GIS perspective, Journal of Environmental Management 79(2006) 1, 30-37. https://doi.org/10.1016/j.jenvman.2005.05.010

[38] D. Ziani, B. Abderrahmane, A. Boumazbeur, L. Benaabidate, Water quality assessment for drinking and irrigation using major ions chemistry in the Semiarid Region: case of Djacer Spring, Algeria, Asian Journal of Earth Science 10(2017) 1, 9-21. https://doi.org/10.3923/ajes.2017.9.21

[39] WHO, Guidelines for Drinking-Water Quality, World Health Organization, Geneva, 2011.

[40] I.S. Akoteyon, A.O. Omotayo, O. Soladoye, H.O. Olaoye, Determination of water quality index and suitability of urban river for municipal water supply in Lagos-Nigeria, European Journal of Scientific Research 54(2011) 2, 263-271.

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