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ORIGINAL PAPER

Spatial distribution of groundwater quality around Hamedan municipal solid waste landfill, Iran

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ABSTRACT

Municipal solid waste management is an essential part of urban services, which is often managed by local governments. The present study aimed to investigate the spatial variation of the groundwater quality factors in Hamedan Municipal Solid Waste Landfill (HMSWL) site in Hamedan, Iran. In total, 20 wells were randomly selected for the collection of groundwater samples in the vicinity of the landfill. The quality of the well water samples was evaluated by measuring nitrate (NO^-_3), phosphate (PO^-_4), chemical oxygen demand (COD), five-day biochemical oxygen demand (BOD_5), turbidity, pH, total dissolved solid, and fecal coliform. According to the results, the mean concentration of BOD_5 and COD in the collected samples was 6.25±11.72 and 7.90±11.50 mg/l, respectively. Maps of the distribution levels of pollution parameters around the landfill have been presented in figures. The issue of solid waste management in Hamedan city should be addressed through integrated management and improving the environment.

Keywords: Solid Waste, Pollution, Water

Introduction

Urbanization and industrialization have caused a dramatic increase in the generation of municipal solid waste (MSW) in many countries, including Iran. According to the World Bank Report, 1.3 billion tons of solid waste was produced by the global urban population each year by 2012, and this rate has been predicted to rise to 2.2 billion in 2025.[1] Several methods are applied for MSW management. Landfills are a common waste management option in this regard. In a study, Nabizadeh *et al*. estimated the average generation rate of MSW in Iran, stating that 84% of the produced MSW is disposed in landfills.[2]

A landfill is an installation designed exclusively for waste disposal in order to protect human health and the environment.[3] According to some experts, landfills are among the basic threats to groundwater resources.[4,5] The dumped solid waste in landfills gradually releases liquids containing various organic and inorganic compounds known as leachate. Landfill leachate is one of the main sources of groundwater pollution, and it is crucial to properly collect, treat, and dispose of this pollutant. Landfill leachate may remain on the surface of landfills and permeate into the soil, causing soil and groundwater pollution.[4] The main contaminants in MSW landfill leachate are heavy metals, organic compounds, and ammonia, which are highly important to the environment.[6]

The present study aimed to investigate the spatial variation of the groundwater quality factors in Hamedan municipal solid waste landfill site so as to predict the major pollutants in the study area. Furthermore, we attempted to assess the effects of groundwater contamination due to the percolation of leachate on the surrounding soil and groundwater in the vicinity of the landfill site.

Materials and Methods

The research was conducted during 2015-2016 in Hamedan city, located in the west of Iran. A pretest was performed to check the applicability and estimate the minimum sample

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size required to achieve the research objectives. Based on the pretest results, the minimum sample size was estimated at 20 cases.

In total, 20 wells were randomly selected for the collection of groundwater samples from the vicinity of the landfill. The selected wells were located at various distances to the landfill. For data collection, 20 sampling spots (selected wells) were situated within an 11-kilometer radius of the landfill site.

Hamedan municipal solid waste landfill (HMSWL) is about 40 years old, and there is no space for agricultural or industrial activities within the region. Therefore, the origin of groundwater pollution in the area has been the unscientific dumping of solid waste within the past years. In this research, sampling and analysis were accomplished for the past two years. Groundwater samples were collected from the wells and transferred to the laboratory under standard conditions.[7] The quality parameters of the samples were measured, including nitrate (NO^{-}_{3}), phosphate (PO^{-}_{4}), chemical oxygen demand (COD), five-day biochemical oxygen demand (BOD_5), turbidity, pH, total dissolved solid (TDS), and fecal coliform (FC). All the samples were assayed based on standard methods.[7]

In order to join the attribute obtained data to the spatial data points of the wells and determine the zoning of the pollutants, we used the GIS-based inverse distance weighting method. Moreover, ArcGIS software (version 10.1) was employed to classify the layers and prepare the maps.

The mean concentration of each parameter was measured and compared with the standard level. Data analysis was performed in Microsoft Excel (2007) and SPSS version 18.0.

Results and Discussion

Site Description

HMSWL was founded in 1981 and is currently the largest landfill site in Hamedan province. With an area of 1.64 square kilometers (km^2), HMSWL is located in the southeast of Hamedan city at a distance of 25 kilometers from the city.

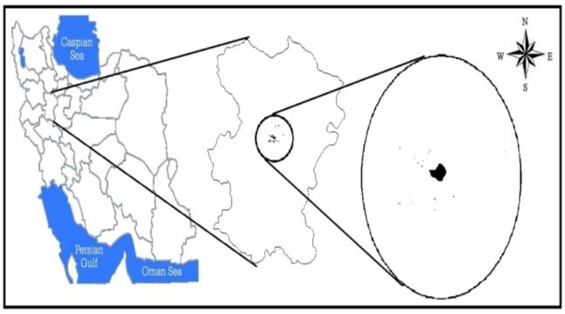

Fig. 1. Location of selected water wells and landfill in study area

In this area, leachate is produced from approximately 750 tons/day of municipal solid waste disposed in the landfill, and the solid waste predominantly contains organic materials. Raw leachate is directly disposed from the landfill to the natural environment without any specific treatment.[8] The location of each water well in the study site is illustrated in Fig. 1.

Analysis of Groundwater Samples

Initially, Kolmogorov-Smirnov test was used to assess the normality of data distribution, and the results indicated the normal distribution of data. The data of the selected water wells are presented in Table 1.

According to the obtained results, the mean concentrations of BOD_5, COD, and TDS in the collected samples were 6.25±11.72, 7.90±15.50, and 1373.10±1685.81 mg/l, respectively.

Figures 2-5 show the distribution levels of turbidity, FC, TDS, BOD_5, pH, PO^{-}_{4}, NO^{-}_{3}, and COD in the groundwater samples of the wells in the vicinity of the landfill using the interpolation method in the GIS environment. Based on these maps, the trend of change in BOD_5 in the study site was similar to that of COD, with the highest concentration observed in the northwest and near the landfill. Furthermore, the results indicated a significant difference between the mean FC in the groundwater samples of the study site and test value, which was higher than the maximum permissible limits for drinking water in Iran ($P<0.05$) (Table 2).

A significant difference was observed between the mean turbidity and test value ($P<0.05$). In other words, the mean concentration of turbidity in the groundwater of the study site was higher than the maximum permissible Iranian standards (Table 2). In terms of BOD_5, COD, and PO_4 concentrations in drinking water, there are no standard limits for the mentioned parameters in the drinking water in Iran. Other comparisons in this regard are shown in Table 2.

Table 1. Distance of selected wells from Hamedan's landfill and its groundwater quality during the summer months

Station No.	Distance (m)	pH	TDS (mg/L)	Turbidity (NTU)	BOD_5 (mg/l)	COD (mg/l)	FC (N/100cc)	NO_3 (mg/l)	PO_4 (mg/l)
1	986.00	7.05	919.00	25.00	9.00	13.00	39.00	30.24	0.25
2	2440.7	7.00	564.00	0.90	7.00	8.00	4.00	15.04	0.14
3	2608.2	6.98	887.00	0.90	7.00	5.00	0.00	17.20	0.15
4	6309.7	6.90	1103.00	0.10	7.00	5.00	43.00	31.48	0.54
5	2893.3	6.91	1454.00	0.90	5.00	3.00	9.00	15.23	0.13
6	11331.7	7.20	910.00	0.90	0.00	1.00	4.00	43.68	0.50
7	9616.1	7.20	1141.00	7.60	0.00	1.00	0.00	11.06	0.10
8	6565.3	7.20	1077.00	1.00	0.00	1.00	240.00	23.74	0.49
9	3199.7	7.80	731.00	0.70	0.00	1.00	150.00	5.35	0.08
10	5564.3	7.30	505.00	0.40	0.00	1.00	53.00	6.73	0.06
11	3539.7	7.10	1520.00	0.90	5.00	6.00	9.00	9.23	0.04
12	2608.2	7.20	1461.00	0.90	4.00	6.00	8.00	8.11	0.03
13	2605.5	7.10	873.00	0.90	6.00	7.00	2.00	14.85	0.10
14	2507.2	7.00	551.00	0.90	7.00	8.00	3.00	13.22	0.10
15	3286.6	6.90	1130.00	0.20	7.00	8.00	3.00	8.13	0.08
16	3975.6	7.00	1116.00	0.10	7.00	9.00	4.00	11.28	0.15
17	6875.3	7.10	991.00	1.00	0.00	1.00	154.00	22.75	0.40
18	5004.9	7.00	1092.00	1.00	0.00	1.00	6.00	5.40	0.04
19	4948.9	6.90	1003.00	0.70	0.00	1.00	8.00	6.12	0.04
20	10100.5	7.00	8434.00	1.20	54.00	72.00	43.00	7.30	0.03

Table 2. Comparison of average groundwater quality parameters of the study area and drinking water standard in Iran

Variable	n	Mean	SD	Test- Value	t	P-value	P-value
TDS (mg/l)	20	1373.10	1685.81	1500.00	-7.95	0.01*	0.01*
NO_3 (mg/l)	20	15.30	10.30	50.00	15.05	0.01*	0.01*
pH	20	7.09	0.20	6.5-9	12.97	0.01*	0.01*
FC(N/100cc)	20	39.10	65.56	0.00	2.74	0.01*	0.01*
Turbidity (NTU)	20	2.31	5.56	5.00	10.56	0.02*	0.02*

*Significant, p<0.05

Table 3. Pearson's Correlation-Coefficients for Groundwater Quality with Distance of Wells from Landfill

Variable	Correlation Coefficient (r)	P- value
COD (mg/l)	-0.66	0.01
BOD_5 (mg/l)	-0.67	0.01
TDS (mg/l)	-0.03	0.88
NO_3 (mg/l)	0.29	0.20
PO_4 (mg/l)	0.38	0.09
pH	0.08	0.72
FC(N/100cc)	0.48	0.17
Turbidity (NTU)	-0.19	0.41

*Significant, p<0.05

Our findings indicated a negative, statistically significant correlation between the distance of the well from the landfill and BOD_5 concentration ($r=-0.67$; $P<0.05$). In addition, a negative, statistically significant correlation was observed between the distance of the well from the landfill and COD concentration ($r=-0.66$; $P<0.05$). The results of other correlation analyses are presented in Table 3. In the present study, the groundwater of the study site was assessed with an emphasis on landfill leachate. Various parameters and results are discussed in the following sections.

FC

Several studies have been focused on the presence of FC in the polluted groundwater by landfill leachate.[10-12, 14, 15, 17] In the present study, the number of FC in the groundwater was lower compared to the results obtained by Sharma and Ganguly, while higher than the values obtained by Aderemi Adeolu *et al*.[10, 14] The spatial distribution of FC in the groundwater of the study site is shown in Figure 2.

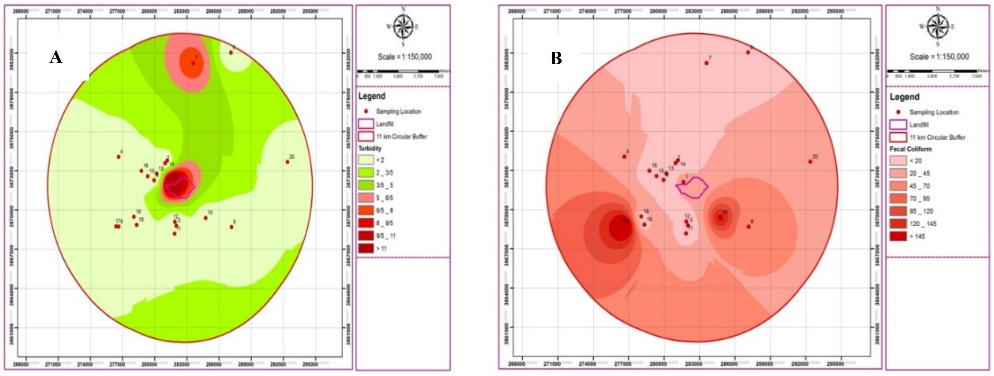

Fig. 2. Spatial Variation of (A) Turbidity, (B) fecal coliforn in groundwater resources in the study area

BOD5 and COD

According to the literature, BOD_5 and COD values of the landfill leachate have been reported within the range of 20-57,000 and 140-15,200 mg/l, respectively.[9] COD concentration was within the range of 0.50-13.00 mg/l in the groundwater sources in the study site and was significantly higher in the northwest and near the landfill. These values indicated the presence of organic pollutants, which may have been caused by the leachate from the landfill. Our findings in this regard are comparable with the previous studies in other countries.[8, 10-14] For instance, Aderemi Adeolu *et al*. investigated the parameters of leachate and groundwater samples obtained at different locations near Lagos municipal solid waste landfill. According to the results, COD levels were 8.5-33.6 mg/l in the water samples, while a value of 160 mg/l was obtained for the leachate.[14]

TDS

In the current research, TDS was within the range of 505-1,520 mg/l. A special variation map of TDS is depicted in Figure 3. Several studies have been focused on this subject.[8, 11, 14-19] For instance, Nagarajan *et al*. investigated the presence of contaminants in groundwater, particularly near the landfill sites in Tamil Nadu (India). The mentioned results revealed that the concentration of TDS was 22,961 mg/l, and the TDS zonation map was prepared in the GIS environment.[18]

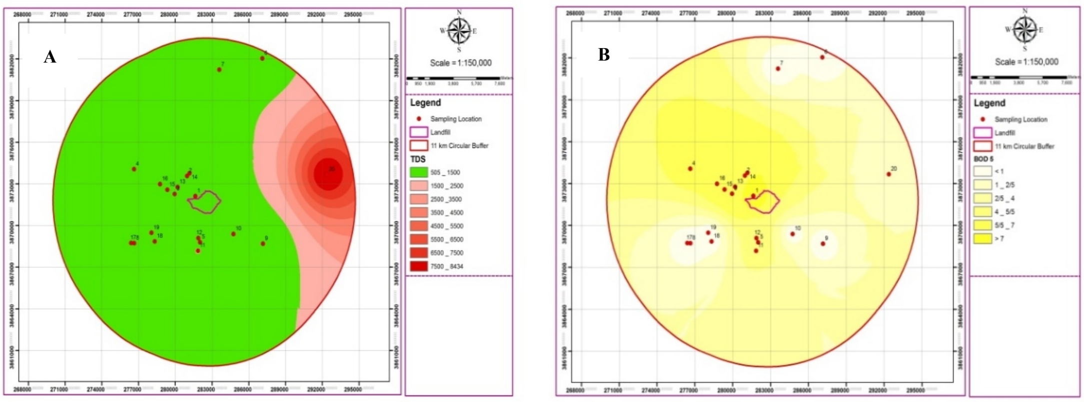

Fig. 3. Spatial Variation of (A) TDS, (B) BOD_5 in groundwater resources in the study area

Phosphate

The spatial variation map of phosphate in the study area is shown in Figure 4. Similar studies on phosphate and its pollution have been conducted by other researchers.[4, 15, 17] It is notable that the applied frameworks and methodologies used in these studies vary depending on the study and regions.

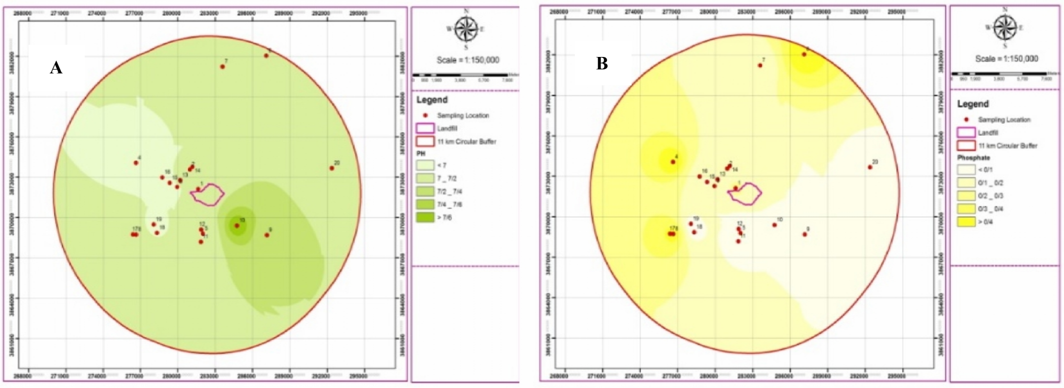

Fig. 4. Spatial Variation of (A) pH, (B) PO_4 in groundwater resources in the study area

Nitrate

Nitrate pollution in the study area was within the range of 5.35-43.68 mg/l, which could be due to the leachate seepage from the landfill toward groundwater. The spatial distribution of nitrate concentration in the groundwater of the study area is illustrated in Figure 5. This finding is consistent with the previous studies conducted in different regions.[4, 10, 11, 20, 21] In a study in 2016, the potential pollution of the leachate was evaluated in a landfill site in Solan (India). According to the mentioned study, nitrate concentration was 27 mg/l in the leachate sample and below the detection limit in groundwater.[10]

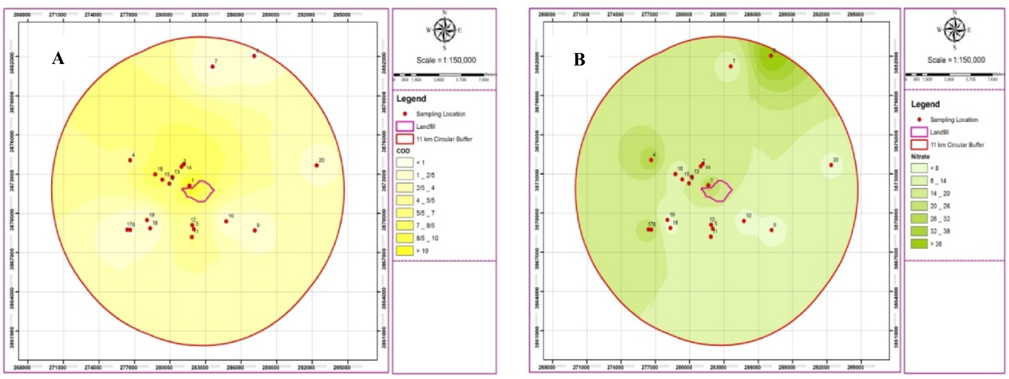

Fig. 5. Spatial Variation of (A) COD, (B) NO_3 in groundwater resources in the study area

pH

The pH limit for drinking water is specified as 6.5-8.5.[8] The pH values in the groundwater samples collected in the study area were within the range of 6.9-7.8. The spatial distribution of the pH concentrations in groundwater in the study area are depicted in Figure 4. These values showed that all the samples displayed a pH value within the maximum permissible range, which is in line with the previous studies in this regard.[9, 15, 16, 18, 22]

Turbidity

In the current research, the turbidity values in the groundwater samples collected from the study site were within the range of 0.1-25 NTU, and the spatial distribution is illustrated in Figure 2. According to the findings, the maximum turbidity was observed in the center and north of the study area in St. No. 7 and St. No. 1. Moreover, the minimum turbidity was observed in the west and east of the site. In a study performed in Lahore (Pakistan), Malik Muhammad and Zhonghua performed the turbidity test to assess the groundwater quality near the landfill sites. According to the obtained results, the turbidity values of groundwater in the study area were below the practical quantification limit (5 NTU).[16]

Conclusion

Hamedan landfill site is a traditional landfill without engineering, leachate collection or treatment systems for leachate infiltration. Consequently, the generated leachate is fully dissipated into the surrounding environment and groundwater. The issue of solid waste management in Hamedan should be addressed through integrated management and improving the environment. Furthermore, the upgrading of Hamedan landfill is particularly recommended using the best available technology in order to design an engineered, sustainable, sanitary landfill site in this city.

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References

1. Hoornweg D, Bhada –Tata P. What a Waste: A Global Review of Solid Waste Management. Urban Development Series, World Bank, Washington, DC.2012. https://openknowledge.worldbank.org/handle/10986/17388
2. Hassanvand M, Nabizadeh R, Heidari M. Municipal solid waste analysis in Iran. Iranian J Health Environ 2008; 1 (1) :9-18
3. Nageswara Rao L, Kamalakar D. Integrated Solid Waste Management-An Innovative Approach. Int J Eng Sci Res Tech 2014; 3(9): 147-155.
4. Venkata Ramaiah G, Krishnaiah S. Leachate Characterization and Assessment of Groundwater Pollution near MSW Dumpsite of Mavallipura, Bangalore. Int J Eng Res Appl 2014; 4(1): 267-271.
5. Silva AV, Curi N, José J, Marques G, Carvalho L, Santos W. Soil maps, field knowledge, forest inventory and ecological-economic zoning as a basis for agricultural suitability of lands in minas gerais elaborated in GIS. Ciência Agrotecnol 2013; 37(6): 538-549.
6. Raboni M, Torretta T, Viotti P, Urbini G. Experimental plant for the physical-chemical treatment of groundwater polluted by Municipal Solid Waste (MSW) leachate, with ammonia recovery. Rev Ambiente Água 2013; 8(3): 22-32.
7. American Public Health Association (APHA). Standard methods for the examination of water and wastewater. Rochester, NY: Scholar's Choice; 2015. https://www.mwa.co.th/download/file_upload/SMWW_10900end.pdf
8. Esfahani Kashitarash Z, Samadi MT, Naddafi K, Afkhami A, Rahmani, A. Application of iron nanoaparticles in landfill leachate treatment - case study: Hamedan landfill leachate. Iranian J Environ Health Sci Eng 2012; 9(36): 1-5.
9. Lee AH, Nikraz H. BOD: COD Ratio as an Indicator for Pollutants Leaching from Landfill. J Clean Energy Technol 2014; 2(3): 263-266.
10. Sharma D, Ganguly R. Parametric Analysis of Leachate and Water Resources around Municipal Solid Waste Landfill area in Solan. Proceeding of 3rd International Conference on Advanced Engineering and Technology (3rd ICAET); 2016; December 16-18; Incheon, South Korea.
11. Al Sabahi, E, Abdul Rahim S, Wan Zuhairi WY, Al Nozaily F, Alshaebi F. The Characteristics of Leachate and Groundwater Pollution at Municipal Solid Waste Landfill of Ibb City, Yemen. Am J Environ Sci 2009; 5 (3): 256-266.
12. Zafar L, Javed A, Shahid Ali S, Anwar Z, Zaman Khan Khattak J. Potential of Waste Water Sludge as Environmental-Friendly Manure after UV-Treatment. Res J Environ Earth Sci 2012; 4(10): 917-922.
13. Sholichin M. Field Investigation of Groundwater Contamination from Solid Waste Landfill in Malang, Indonesia. Int J Civil Environ Eng 2012; 12 (2): 74-83.
14. Aderemi Adeolu O, Oriaku Ada V, Adewumi Gbenga A, Otitoloju Adebayo A. Assessment of groundwater contamination by leachate near a municipal solid waste landfill. Afr J Environ Sci Technol 2011; 5(11): 933-940.
15. Suryawanshi R, Khan IA. Assessment of

Groundwater Quality and its Spatial Distribution Near Old Landfill Site of Kothrud, Pune. Int J Sci Technol 2014; 2(4): 201-207.
16. Malik Muhammad A, Zhonghua T. Municipal Solid Waste and its Relation with Groundwater Contamination in Lahore, Pakstan. Res J Appl Sci Eng Techol 2013; 7(8): 1551-1560.
17. Raju MVS. Contamination of Groundwater Due To Landfill Leachate. Int J Eng Res 2012; 1(2): 48-53.
18. Nagarajan R, Thirumalaisamy S, Lakshumanan L. Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India. Iranian J Environ Health Sci Eng 2012; 7(12): 12-22.
19. Shenbagarani S. Analysis of groundwater quality near the solid waste dumping site. journal of environmental science. J Environ Sci Toxicol Food Technol 2013; 4(2): 1-5.
20. Sonel M, Mourya M. Contamination of groundwater layers in Bhanpur Bhopal(MP) due to improper solid waste disposal. Int J Innov Eng Technol 2016; 6(3): 134-137.
21. Ohwoghere–Asuma O, Aweto KE. Leachate Characterization and Assessment of Groundwater and Surface Water Qualities near Municipal Solid Waste Dump Site in Effurun, Delta State, Nigeria. J Environ Earth Sci 2013; 3(9): 126-135.
22. Bodrud-Dozaa MD, Towfiqul Islamb ARM, Ahmed A, Dasd S, Saha N, Safiur Rahman M. Characterization of groundwater quality using water evaluation indices, multivariate statistics and geostatistics in central Bangladesh. Water Sci 2016; 30(1): 19–40.